Exploring the Impact of a Teacher Education Program on the Mathematical Anxieties of Elementary Pre-Service Teachers

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Abstract

Mathematics education in Ontario has been a topic of significant focus in recent years. One concern is the lack of strong elementary mathematics teachers, in part due to the high levels of mathematics anxiety amongst this population (Gresham, 2007; Novak & Tassell, 2017). This study investigated the impact of a teacher education program on elementary pre-service teachers' mathematical anxieties. The study examined the main components of a consecutive teacher education program, namely mathematics methods courses and field experiences, their interrelationships, and their connections with pre-service teachers' background experiences. This explanatory sequential mixed methods approach emphasized qualitative methods (i.e., quan → QUAL) and involved two distinct phases. In Phase 1, quantitative questionnaire data were collected from the nine elementary pre-service teacher participants and analyzed using descriptive statistics. These results were then connected to the individual interview protocols employed in Phase 2 to collect qualitative data, which were analyzed thematically using the constant comparative method to uncover six themes: (a) prior experiences with mathematics, (b) anxieties towards mathematics, (c) the influence of mathematics methods courses on mathematical anxieties, (d) the influence of field experiences on mathematical anxieties, (e) the synthesis of mathematics methods courses and field experiences, and (f) anticipated future mathematics teaching style. This study's results address gaps in the existing literature and highlight the key impacts of teacher education programs on pre-service teachers' state and trait mathematical anxieties. Suggestions are provided for the practice of teacher educators, faculty administrators, and mentor teachers, as well as implications for theory and recommendations for future research.

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CHAPTER ONE: INTRODUCTION TO THE STUDY

This mixed methods thesis project examined mathematics anxiety (MA) in elementary pre-service teachers (EPSTs). Improving mathematics education in Ontario has been a major priority to education stakeholders in recent years, most evident in the Ontario Ministry of Education's (2016, 2019) renewed math strategies. A significant issue at the elementary level is a lack of strong mathematics teachers (Casey, 2017b), in part due to the high rates of MA within this population (Brady & Bowd, 2005; Gresham, 2007; Novak & Tassell, 2017). In order to address this issue, this research investigated the impact of a teacher education program on EPSTs' MA. Based in Spielberger's (1966) conception of trait anxiety versus state anxiety, this study utilized an explanatory sequential mixed methods approach to explore participants' histories with MA and how their experiences in mathematics methods courses and field placements have impacted their anxieties. Data were collected through individual, semi-structured interviews guided by pre-interview questionnaires. Data were analyzed using descriptive statistics and qualitative thematic analysis, and results of both analyses were integrated in the interpretation of findings. This research contributes to the knowledge on the mathematical anxieties of elementary teachers during their pre-service training, highlighting implications for teacher educators, mentor teachers, faculty administrators, and provincial policy makers.

Background of the Problem

The improvement of mathematics education in Ontario has been a significant focus in recent years, particularly regarding student achievement. Each year, the province's Education Quality and Accountability Office (EQAO) conducts assessments

of Grade 3 and 6 students in reading, writing, and mathematics to measure students' capabilities in these core subjects in comparison with provincial standards. In the past decade, the results of both the Grade 3 and 6 level assessments have demonstrated a decline in mathematics scores. While 71% of Grade 3 students met or exceeded the provincial standard in the 2009/2010 school year (EQAO, 2013), this percentage has steadily decreased to only 58% of students in the most recent 2018/2019 assessment (EQAO, 2019). These percentages are even lower in Grade 6; while 61% of these students met or exceeded the provincial standard in 2009/2010 (EQAO, 2013), the results of the 2018/2019 test demonstrate a record low of only 48% of students achieving at this level (EQAO, 2019). These results represent a decrease of 4% and 1% from the previous 3-year average for Grade 3 and 6 respectively (EQAO, 2019). Test results also indicate that students' weaknesses in mathematics lie primarily in application and critical thinking skills (Alphonso, 2019a). Furthermore, the EQAO surveys students about their attitudes towards mathematics, and results demonstrate a negative trend as students progress through elementary school. While 57% of Grade 3 participants in the 2019 EQAO assessment claimed they like mathematics and 55% believe they are good at math, these percentages decrease to 50% and 52% respectively for students in Grade 6 (EQAO, 2019).

The declining trend in elementary EQAO mathematics scores is also reflected in Ontario's results on national and international assessments. Since 2007, the Council of Ministers of Education, Canada has administered the Pan-Canadian Assessment Program (PCAP) test, assessing reading, science, and mathematics achievement on a national level. The PCAP test is administered every 3 years to Grade 8 students from each Canadian province. PCAP results have consistently ranked Ontario as second only to

Quebec in terms of mathematics achievement; however, scores from the most recent test in 2016 demonstrate cause for concern. While still ranking relatively highly against other provinces, Ontario's mathematics scores declined from 512 in 2013 (O'Grady & Houme, 2014) to 508 in 2016 (O'Grady et al., 2018), making Ontario the sole province without a positive change in scores from the 2013 PCAP test. This negative trend can also be observed when comparing Ontario students on an international scale. Every 4 years, the International Association for the Evaluation of Educational Achievement conducts the Trends in International Mathematics and Science Study (TIMSS), an assessment designed to evaluate the mathematics and science performance of students in Grades 4 and 8. Historically, Ontario has ranked well amongst the countries and benchmarking entities that participate in the TIMSS assessment, and demonstrated a continual increase in mathematics scores (Mullis et al., 2016). Though results of the 2015 TIMSS assessment demonstrated a continuation of this positive trend for Grade 8 mathematics scores, Ontario's Grade 4 students scored only 512, a decrease of 6 points from the 2011 test (Mullis et al., 2016). This result reflects the first instance of declining mathematics scores for Ontario students since the initial TIMSS assessment in 1995.

Overall, low EQAO scores and the negative trend in national and international mathematics assessments have been a cause of concern for Ontario's Ministry of Education, leading to the launch of a $60 million strategy in September 2016 and a $200 million strategy in August 2019 aiming to improve mathematics achievement (Ontario Ministry of Education, 2016, 2019). Several elements the 2016 renewed math strategy targeted elementary level education, including a minimum of 60 minutes per day dedicated to math instruction in Grades 1–8, introducing lead teachers for mathematics in

all elementary schools, and opportunities for educators to improve their skills in teaching mathematics (Ontario Ministry of Education, 2016). Much of the 2019 strategy focused on building mathematical confidence in teachers, including the hiring of math-learning leads by school boards and providing funding for professional development and additional mathematics courses for teachers (Ontario Ministry of Education, 2019). Furthermore, this 2019 strategy included the introduction of the Math Proficiency Test (MPT) for all newly certified K–12 teachers as of March 31, 2020 (EQAO, 2020), making Ontario the first province to introduce such a test (Alphonso, 2019b). Administered by EQAO, the MPT contains questions covering content from the Grade 3 to 9 math curricula as well as both general and mathematics-specific pedagogical knowledge (EQAO, 2020) included in the 2019 math strategy to "ensure new teachers entering the profession have the skills to teach math" (Ontario Ministry of Education, 2019, para. 4).

As highlighted by the Ministry's 2016 renewed math strategy, a key factor to improving elementary mathematics education in Ontario is to support the province's elementary teachers (Ontario Ministry of Education, 2016). Unlike their secondary level counterparts, who are specialists in a few subject areas, elementary teachers are generalists and thus responsible for teaching all curriculum material regardless of their comfort with individual subjects. In Ontario, this is a problem as the majority of elementary teachers' educational backgrounds are in the humanities (Brown, 2013), with 82% having majors unrelated to mathematics (Casey, 2017b). In fact, only 2% of Ontario elementary teachers are graduates of mathematics major programs (Casey, 2017b), demonstrating a lack of specialists in this subject area. Even for new teachers certified to

teach Grades 4 to 10, who obtain qualifications in one teaching subject, mathematics is not among the top five of these subject specialties (Ontario College of Teachers, 2019). Potentially more significant, however, is the high rate of MA within this population (Brady & Bowd, 2005; Gresham, 2007). MA has been described as "a general fear of contact with mathematics" (Hembree, 1990, p. 34). Many elementary teachers suffer from MA, often stemming from negative past experiences with mathematics (Brady & Bowd, 2005), which can have significant damaging impacts on their sense of self-efficacy towards their teaching practice (Gresham, 2008). Furthermore, teachers' MA has not only personal consequences but can also impact their choice of pedagogical approaches and their students' achievement in and attitudes towards mathematics. Because of the impacts on both teachers and students, alleviating teachers' MA is a critical component towards improving elementary mathematics education in Ontario.

Statement of the Problem Situation

This research focused on the impact of a teacher education program on EPSTs' mathematical anxieties in order to understand how this issue is addressed as teachers are preparing to begin their careers. EPSTs have been found to experience high rates of mathematical anxiety (Gresham, 2008; Novak & Tassell, 2017), which can negatively affect their sense of confidence and teaching efficacy (Bates et al., 2013; Gresham, 2008). These anxious sentiments can have damaging impacts in EPSTs' future practice, including a reliance on traditional pedagogical strategies (Gresham, 2008), difficulties engaging students (Brown et al., 2011), passing on negative mathematical attitudes (Boaler, 2016), and lower student achievement (Chang & Beilock, 2016). An improved understanding of the impacts of initial teacher education programs is thus a critical

component in developing preventative strategies to address these issues. To be eligible to teach in the province's public education system, a teacher must complete an accredited teacher education program, offered either concurrently with or consecutively following an initial undergraduate degree. The present study focused on a consecutive program certifying candidates to teach in the primary/junior (Grades K–6) and junior/intermediate divisions (Grades 4–10) at one Ontario university, as detailed in Chapter 3.

In 2013, it was announced that teacher education in Ontario would experience significant structural changes which began in September 2015 (Ontario Ministry of Education, 2013). Prior to 2015, consecutive teacher education programs were two semesters in length, consisting of both coursework and a minimum of 40 days in classroom teaching placements. These requirements were doubled for the new program, increasing its length to four semesters with a minimum of 80 days of field experiences (Ontario Ministry of Education, 2013). Participants recruited for this project, beginning in January 2019, were in their first or second year of study and thus the third and fourth cohorts of students in this new teacher education program. As a result, this study provided the opportunity to study the unique context of this enhanced 2-year teacher education program and its impacts on EPSTs' MA.

Purpose of the Study

The purpose of this thesis study was to examine the impact of a teacher education program on EPSTs' mathematical anxieties. This study focused on teachers during their pre-service training in order to better understand how EPSTs' MA is affected at this early stage in their careers, with potential implications for teacher preparation programs and education stakeholders. This aim was achieved using an explanatory sequential mixed

methods approach with data collected from participant questionnaires and individual interviews.

Teacher education in Ontario is comprised of two major elements: coursework and student teaching placements. Thus, this research studied the impacts of both elements on EPSTs' MA. As the literature demonstrates that both methods courses and field experiences (practicums) can have significant impact on EPSTs' anxieties towards mathematics, these two components were studied both for their separate effects, as well as how their synthesis and relationship with EPSTs' background characteristics may impact the mathematical anxieties felt by members of this population. Emphasis was placed on the relationship between participants' MA and their past educational experiences with mathematics, as well as how their experiences in their teacher education program related to their mathematical histories, as negative past experiences are commonly connected with teacher MA (Brady & Bowd, 2005). Finally, because EPSTs at the junior/intermediate level are each required to have one teachable subject area, MA was explored in EPSTs with various teachable subjects in order to explore any differences in the experiences across these participants.

Research Questions

The central question that guided this thesis project was: In what ways does the examined teacher education program impact the mathematical anxieties of elementary pre-service teachers? Three further research questions focusing on mathematics methods courses and/or field experiences supported this inquiry by examining these two core components of mathematics teacher education. Two of these three questions were each supported by a subquestion exploring EPSTs' MA in relation to their background

characteristics, including factors such as gender, experiences as K–12 math students, level of postsecondary mathematics education, and teachable subject area. The final question addressed how EPSTs' MA is impacted by the synthesis of the different components in their teacher education program and their background characteristics. These three research questions are as follows:

1. (a) In what ways do *mathematics methods courses* impact the mathematical anxieties of elementary pre-service teachers?

   (b) How are mathematical anxieties influenced by the relationships between these methods courses and pre-service teachers' background characteristics?
2. (a) In what ways do *field experiences* impact the mathematical anxieties of elementary pre-service teachers?

   (b) How are mathematical anxieties influenced by the relationships between these field experiences and pre-service teachers' background characteristics?
3. How are mathematical anxieties influenced by the interrelationships between these methods courses, field experiences, and pre-service teachers' background characteristics?

Conceptual Framework

Spielberger's (1966, 1972) conceptualization of state anxiety and trait anxiety, a valuable distinction in anxiety theory (Zeidner, 2008), served as the conceptual framework through which to examine the phenomenon of study in this research (Wu & Volker, 2009). Spielberger (1966) describes the distinction between these forms of anxiety as "anxiety as a transitory state that fluctuates over time and as a personality trait that remains relatively stable over time" (p. 15). State anxiety is concerned with one's

feelings in a specific situation; if an individual perceives their environment or scenario as threatening, even without the presence of real danger, state anxiety reactions are induced (Spielberger, 1966, 1972). These responses are idiosyncratic in nature and evidenced most commonly in the psychological literature through introspective reports—that is, when individuals state that they are anxious (Spielberger, 1966). Spielberger (1966) notes the importance of determining the likeliness of various stimuli to invoke an anxious response. Alternatively, trait anxiety examines overall trends in an individual's anxious reactions as a habitual personality trait (Spielberger, 1972). A relatively permanent measure, an individual's level of trait anxiety reflects the probability that they will experience state anxiety responses under specific circumstances (Spielberger, 1966, 1972). Spielberger (1966) describes trait anxiety as an acquired disposition influencing an individual's perception of the world, largely influenced by one's past experiences as early as childhood. This conceptualization of anxiety as both a temporary state and a habitual trait has been utilized for decades and remains widely employed in the psychological literature (Wilt et al., 2011; Zeidner, 2008).

Mathematics anxiety, which is distinct from but related to general anxiety (Hannula, 2018), may be a habitual trait anxiety or a state anxiety related only to specific contexts involving mathematics (Radišić et al., 2015). This conceptual distinction has been found to be beneficial (Orbach et al., 2019) and is frequently employed in studies of mathematics-related affect, though MA as a trait anxiety is more common in the literature (Hannula, 2012, 2018; Roos et al., 2015). Accordingly, there is a lack of research on MA as a temporary state anxiety which merits further examination (Goetz et al., 2013; Orbach et al., 2019). The present study addressed this gap in the literature by utilizing the conceptualization of trait and state anxiety to examine the effects of a teacher education

program on EPSTs' MA. This research aimed to gain an understanding of EPSTs' trait mathematics anxieties and how they have been influenced during their pre-service experiences, as well as uncovering themes regarding specific situations in teacher education programs that do or do not evoke state anxious reactions in EPSTs. Furthermore, because of the relationship of anxiety and one's past experiences (Spielberger, 1966), particularly regarding teacher MA (Brady & Bowd, 2005), these findings were also examined to uncover relationships with participants' background experiences.

Importance of the Study

The results of this study have implications for a variety of education stakeholders, primarily those involved with teacher education. As this research focused on the impacts of both mathematics methods courses and student teaching placements on EPSTs' MA, findings from this study suggest how both methods course instructors and associate teachers can better support math-anxious teacher candidates in overcoming their specific fears. This research also addressed a gap in the knowledge base, discussed in Chapter 2, regarding how placement experiences and their synthesis (or lack thereof) with mathematics methods courses impact EPSTs' MA. Faculty administrators also stand to benefit from this research. As described above, this study will be conducted with participants in the third and fourth cohorts of Ontario's extended teacher education program, providing the opportunity to study the effects of this new program in preparing elementary mathematics teachers.

This research has implications at the provincial level in terms of addressing various aims of the Ontario Ministry of Education. Firstly, the Ministry's goals to improve mathematics education as outlined its renewed math strategies (Ontario Ministry

of Education, 2016, 2019) highlight the importance of having teachers who are strong in mathematics, particularly at the elementary level. By studying pre-service teachers' characteristics and how teacher education impacts their mathematical anxieties, which can have significant negative implications on their self-efficacy and teaching practice, the results of this research indicate ways to help teachers overcome these anxieties early in their careers and increase their confidence in teaching mathematics. This research also addressed the Ministry's renewed goals for education: achieving excellence, ensuring equity, promoting well-being, and enhancing public confidence (Ontario Ministry of Education, 2014), as teacher MA relates to their choice of instructional strategies and their students' mathematical attitudes and achievement. Gaining a better understanding of how teacher education programs impact EPSTs' anxieties can help alleviate MA and its negative effects on future teachers' efficacy (Gresham, 2008). As a result, these teachers will be better equipped to provide quality learning opportunities for all students, promote students' sense of self-efficacy in mathematics, and help students perform at high levels, thereby increasing public confidence in Ontario's mathematics education.

Scope and Limitations of the Study

This thesis study employed an explanatory sequential mixed methods approach, with emphasis on qualitative methods informed by a constructivist epistemology (Kahlke, 2014), aiming to explore the unique perspectives of participants in a particular context. As such, the results of this study are specific to the participants and teacher education program of focus and are not intended to generalize to other settings; instead, this study aimed to achieve resonance through transferability and naturalistic generalization to other settings (Tracy, 2010). Furthermore, due to the primacy of qualitative methods in the research design, the quantitative survey data played a supportive role (Morse, 2016). As

a result, it was not necessary to have a large sample, but because of this study's small sample size of nine participants as outlined in Chapter 3, its findings cannot be generalized to the larger population (Plano Clark & Creswell, 2015). Finally, this study was limited by my positioning as the researcher, as my experiences and perspectives inevitably impacted how I conducted the study and my interpretation of the data (Watt, 2007). I am a recent graduate of an intermediate/senior consecutive teacher education program in Ontario, thus while I am attuned to the experiences of pre-service teachers enrolled in methods courses and field placements, my experience was targeted towards teaching at the secondary level. Furthermore, one of my undergraduate major programs was in mathematics, and one of my two certified teachable subject areas is mathematics. These qualifications suggest that I have a stronger background in mathematics and less MA than many of the participants involved with this research, thus I am not able to directly relate to some of the negative experiences they have faced with mathematics. While I attempted to bracket my experiences and remain neutral while conducting this study, it was critical that I was self-reflective about the inevitable influence of my positioning throughout the research process and in the reporting of findings (Watt, 2007).

CHAPTER TWO: REVIEW OF RELATED LITERATURE

In recent years, the improvement of mathematics education has been a priority in the province of Ontario. At the elementary level, the province's annual testing of Grade 3 and 6 students in mathematics, conducted by the EQAO, has been demonstrating a decline in mathematics scores in recent years, with only 48% of Grade 6 students meeting or exceeding the provincial standard in the 2018/2019 year (EQAO, 2019). The Ministry of Education's (2016, 2019) renewed math strategies emphasize an increase in dedicated mathematics instruction time and demonstrate the need to have strong mathematics teachers at the elementary level. Unfortunately, the majority of Ontario's elementary teachers do not have a strong background in mathematics (Casey, 2017b), but perhaps more significant is the high rate of MA within this population (Brady & Bowd, 2005; Gresham, 2007; Novak & Tassell, 2017). MA not only has personal consequences for these teachers but also can be a serious impediment to their students' learning and enjoyment of mathematics.

In order to address these problems in mathematics education, it is beneficial to examine how MA can be addressed while teachers are completing their teacher education programs in order to alleviate EPSTs'MA early in their professional careers. This review will provide an overview of MA, its prevalence in pre-service teachers, and how their MA relates to their own experiences in math education. Next, the literature on how teacher education impacts EPSTs' MA will be discussed. Finally, this review will outline the potential impacts of teachers' MA on their students' mathematical attitudes and performance, demonstrating the importance of addressing EPSTs' MA as a factor in improving mathematics education at the elementary level.

What Is Mathematics Anxiety?

The academic study of MA has its origins in the mid-20th century. Mary Fides Gough introduced the term *mathemaphobia* during the 1950s to describe phobia-like sentiments towards the subject of mathematics (Suárez-Pellicioni et al., 2016). Dreger and Aiken (1957) used the term *number anxiety* to label a similar phenomenon, describing it as "a syndrome of emotional reactions to arithmetic and mathematics" (p. 344). They claimed that number anxiety was a distinct form of anxiety unrelated to an individual's overall intelligence (Dreger & Aiken, 1957). Today, MA is a popular subject of study in education research, and Ashcraft's (2002) definition of MA has been commonly cited in much of the related literature; he describes MA as "a feeling of tension, apprehension, or fear that interferes with math performance" (p. 181). While MA is not classified as a distinct mental disorder by the American Psychiatric Association (2013), it is often related to generalized anxiety disorder or social anxiety disorder (Luttenberger et al., 2018). In the present study, the term "mathematical anxieties" is used to describe both habitual trait and transitory state anxieties related to the learning, doing, and teaching of mathematics, thereby encompassing the range of anxieties felt by EPSTs towards this subject as outlined in the following section.

A variety of factors can lead to the development of MA, which, to some extent, affects 93% of American adults (Blazer, 2011; Luttenberger et al., 2018), but it is commonly triggered by a negative past experience with math and the associated emotions (Ashcraft & Krause, 2007). Fiore (1999) describes these experiences as *math abuse*, or "any negative experience related to an individual's doing mathematics" (p. 403), often related to the actions of teachers. Students with early deficiencies or poor performance in mathematics are also more susceptible to developing MA (Maloney & Beilock, 2012). A

general consensus exists among researchers that MA can be present already between the ages of 10–14 (Suárez-Pellicioni et al., 2016); however, others argue that MA can begin as early as Grade 1 (Maloney & Beilock, 2012). Though most who suffer from MA likely would not have severe enough symptoms to be diagnosed with an anxiety disorder (Luttenberger et al., 2018), MA can manifest in a variety of physiological, psychological, and behavioural ways (Blazer, 2011; Luttenberger et al., 2018), with negative personal and educational consequences (Hembree, 1990). When present in teachers, MA can have significant negative effects on students' attitudes towards and performance in mathematics (Chang & Beilock, 2016; Gunderson et al., 2012).

Mathematics Anxiety in Elementary Pre-Service Teachers

While MA is frequently studied in students, its prevalence in elementary teachers is of interest in this review, particularly elementary teachers during their pre-service training. MA is found at disproportionately high levels in EPSTs (Gresham, 2007), and studies have illustrated that this group is more likely to have MA than postsecondary students in other major fields (Hembree, 1990). Women tend to have higher levels of MA than their male counterparts (Stoehr, 2017a), which is of particular note for this group as over 80% of Ontario elementary teachers (Little, 2017) and 84% of Canadian elementary teachers (Statistics Canada, 2018) are female. Furthermore, the majority of elementary teachers have a formal education background that is unrelated to mathematics (Casey, 2017b), another potential contributor to their levels of MA. Many EPSTs opt to pursue a career in teaching, where they are required to teach mathematics, despite their own personal experiences of MA (Stoehr, 2017b). This high prevalence is generally not found in secondary teachers, likely due to the specialized nature of secondary level teaching. Unlike elementary teachers, who are generalists and responsible for teaching all subjects,

secondary teachers specialize in a few subjects. As a result, secondary mathematics teachers tend to have more mathematics content knowledge (Quinn, 1997) and more positive attitudes towards mathematics (Kalder & Lesik, 2011) than their elementary level counterparts.

Elementary pre-service teachers' MA tends to have an impact on their confidence and self-efficaciousness towards their future teaching practice. EPSTs frequently enter their teacher education programs with entrenched beliefs about mathematics (Lake & Kelly, 2014). If these beliefs are negative, EPSTs may be less confident and more anxious about their teaching practice (Haciomeroglu, 2013). High MA also has a positive, moderate relationship with mathematics *teaching* anxiety (MTA), or anxieties specifically related to the teaching of mathematics (Hadley & Dorward, 2011; Peker & Ertekin, 2011). As noted by Olson and Stoehr (2019), MA relates to learning and doing mathematics, while MTA relates to instructing others in mathematics, and these two concepts can be distinguished by individuals experiencing such anxiety (Brown et al., 2011). While Brown et al. (2011) illustrated that there are instances where EPSTs have MA but no MTA (or MTA but no MA), it is more common for these constructs to be related. Studies frequently examine the impact of MA on teachers' self-efficacy, or their belief in their ability to be successful as an educator, as these two concepts have been found to have a negative correlation (Gonzalez-De Hass et al., 2017). For example, a major theme of Bates et al.'s (2013) study of the fears of math-anxious EPSTs was a lack of confidence in teaching ability. Olson and Stoehr (2019) note that teachers with high MTA tend to worry about confusing their students, and over 80% of EPSTs do not look forward to teaching math. MA has also been found to have a moderate negative

relationship with mathematics teacher efficacy in multiple studies (Gresham, 2008; Swars et al., 2006). Highly math-anxious teachers tend to struggle with giving instruction, engaging students, and differentiating content to meet the needs of students with various abilities (Brown et al., 2011).

Past Experiences in Mathematics Education

As discussed above, much of EPSTs' MA has origins in their past experiences with mathematics, often at the K–12 level. Many EPSTs have faced *math abuse* (Brady & Bowd, 2005; Fiore, 1999) which has a direct influence on MA, as EPSTs who have clear recollections of a harmful experience have been found to be more math anxious than their peers (Bekdemir, 2010). Studies examining EPSTs' experiences as K–12 mathematics students demonstrate themes of a teacher's behaviour leading to MA development (Bekdemir, 2010; Finlayson, 2014), highlighting memories of unsympathetic teachers who failed to provide necessary support for their learning (Brown et al., 2011) which tends to be more common at a secondary level (Brady & Bowd, 2005). Recently, Stoehr (2017a) has utilized a narrative approach to examine how one female EPST connected her experiences as a mathematics student into a personal history of MA. In this study, she uncovered fears related to both performance and social engagement throughout an EPSTs' years as a mathematics student. Similarly, Wilson (2018) highlights how memories of being evaluated in front of one's peers often have noteworthy impacts on EPSTs' MA. According to Olson and Stoehr (2019), EPSTs' mathematical anxieties tend to be influenced by the cumulative effect of these negative experiences and the MA they felt as students, suggesting the potential benefits of exploring EPSTs' past experiences in mathematics as highlighted in the present study.

Beyond K–12 schooling, research concerning EPSTs' MA has increasingly focused on their content knowledge and level of education in postsecondary mathematics. In Ontario, the majority of elementary teachers are graduates of humanities programs and may not have taken any mathematics courses since their senior years of secondary school (Brown, 2013). A recent survey of Ontario elementary teachers found that 82% graduated from majors unrelated to mathematics, with only 2% having a mathematics major or specialist degree (Casey, 2017b), likely limiting their mathematical content knowledge. In their recommendations for the extended Ontario teacher education program (Ontario Ministry of Education, 2013), Kajander et al. (2013) suggested that P/J and J/I teachers should mave a minimum background in mathematics of one undergraduate course. A common theme of EPSTs' mathematics-related fears is in fact a lack of content knowledge (Bates et al., 2013) and many EPSTs experience anxiety related to learning math content (Stoehr & Olson, 2017).

With regards to elementary teachers' mathematics knowledge, researchers tend to discuss not only the amount of necessary math training but also what kind of content knowledge is required for teaching. Thames and Ball (2010) argued that teachers require a specialized mathematics knowledge connected to both content and pedagogy. Shulman (1987) categorized this combined understanding as pedagogical content knowledge, which "represents the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organized, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction" (p. 8). As a result, requiring EPSTs to complete traditional postsecondary math courses may not be the solution; instead, it may be more beneficial for universities to offer courses addressing the specific pedagogical content knowledge required for elementary teaching (Orpwood

& Sandford Brown, 2015). Many teacher education programs in Ontario have recognized that EPSTs often lack confidence with math content and have implemented strategies, such as diagnostic tests, review courses, and supplementary training to address this issue (Alphonso, 2019b; Brown, 2016; Reid & Reid, 2017).

Effects of Teacher Education Programs

Researchers in mathematics education aiming to alleviate MA in EPSTs frequently study how MA may be reduced during mathematics methods courses. Generally, methods courses for EPSTs are not only concerned with teaching mathematics content but also connecting content to pedagogy and an understanding of how students learn. Studies have found that courses focusing on the connection between math content and pedagogy address various anxieties felt by EPSTs (Tooke & Lindstrom, 1998) and lead to decreased MA when compared with content-only courses (Beilock & Maloney, 2015). Kajander et al.'s (2013) recommendations for mathematics education in the extended Ontario teacher education program (Ontario Ministry of Education, 2013) specifically highlighted the importance of including instruction in mathematics content, mathematics pedagogy, and their integration in methods courses. Reid and Reid (2017) note the importance of methods course instructors who demonstrate enthusiasm for mathematics and model reform-based strategies through activities, which can reduce MA and improve EPSTs' self-efficacy in teaching mathematics. The use of manipulatives, technology, and cooperative learning strategies have all been found to decrease MA in EPSTs and have a positive impact on their attitudes towards mathematics (Barrett, 2013; Gresham, 2007; Lake & Kelly, 2014; Quinn, 1997). Methods courses that highlight mathematical terminology (Reid & Reid, 2017) and emphasize a conceptual over procedural understanding can also alleviate MA within this population (Lake & Kelly,

2014). Finally, methods courses can support math-anxious EPSTs by providing a safe environment and encouraging reflection on their anxieties and experiences with mathematics (Reid & Reid, 2017). Hollingsworth and Knight-McKenna (2018) describe the benefits of supporting EPSTs through reading about MA and its impact on teaching, while Wilson (2018) found that written reflections can have a profound influence on helping EPSTs understand their anxieties. Furthermore, providing EPSTs with an online platform to discuss mathematics teaching anxieties with their peers during a methods course can also lead to a reduction in various factors of their mathematical concerns (Liu, 2008).

Methods courses have also been found to increase EPSTs' confidence in their abilities to teach mathematics through exposure to pedagogical practices and styles. Bandura (1977) describes the benefits of having a safe environment to practice subjectively threatening scenarios in developing greater feelings of self-efficacy. For math-anxious EPSTs, a mathematics methods course can provide this opportunity to practice an anxiety-provoking scenario through peer-teaching opportunities (Gresham & Burleigh, 2019). Methods courses also provide EPSTs with specific teaching strategies and lesson ideas, giving students greater confidence in their abilities to teach mathematics (Looney et al., 2017). As teachers' instructional decisions are partially based on the theories they were taught in their teacher education programs (Beilock & Willingham, 2014), methods courses can also impact EPSTs' anticipated pedagogical approach, which may in turn lead to a decrease in anxiety. Teacher candidates often opt to utilize traditional teaching methods similar to the way in which they were taught as students, in part due to a lack of familiarity with more innovative strategies (Doruk, 2014). Methods courses play an influential role in exposing pre-service teachers to reform-based teaching

strategies and challenging prior conceptions about mathematics education, which can decrease their mathematics teaching anxieties (Brown et al., 2011; Gresham & Burleigh, 2019; Levine, 1993; Reid & Reid, 2017). In particular, Levine's (1993) study of the relationship between EPSTs' own mathematics education experiences, anticipated teaching style, and anxieties towards teaching mathematics found that after a group of EPSTs had completed a mathematics methods course, the largest decrease in anxiety was experienced by EPSTs who changed their anticipated teaching style from teacher-oriented to student-oriented, in line with the theoretical background of the methods course.

Teacher education programs for EPSTs are generally comprised of both mathematics methods courses and student teaching placements; however, in the literature on MA in EPSTs, greater focus is placed on the impact of methods courses, while field experiences are less well-studied. Since 2015, Ontario pre-service teachers are mandated to complete a minimum of 80 days in practicum teaching placements, twice the minimum length of the previous requirement (Ontario Ministry of Education, 2013). It has been demonstrated that pre-service teachers consider field placements to be influential in their teacher education (Smith & Lev-Ari, 2005) and extended field placements contribute to greater personal teacher efficacy overall (Cole, 1995), but there is limited research regarding their impact on *mathematics* teacher efficacy. Reid and Reid (2017) describe how field experiences teaching mathematics can help EPSTs' mathematical knowledge for teaching and provide EPSTs with the opportunity to try new methods in real classrooms. However, to achieve such benefits, it is important that EPSTs are paired with mentor teachers with strong mathematics teaching knowledge (İmre & Akkoç, 2012). Brown et al.'s (2012) study aimed to uncover common themes of EPSTs' anxieties

during mathematics teaching placements. Being able to observe other teachers or practice and reflect on their own teaching led to decreased anxiety, while EPSTs felt heightened anxiety when concerned with making mistakes or using unknown resources, and other themes, such as prior experiences with mathematics, had mixed results. The impact of coordinated developmental field placements, where the grade level increased during each successive placement, on EPSTs' MA was studied in an American program (Swars et al., 2009). In this study, EPSTs completed field placements of 2 days per week over an average period of 7 weeks in each grade level. Swars et al. (2009) found that EPSTs felt higher MA and decreased efficacy in the upper grades due to the increased difficulty of the math content, suggesting that the grade level an EPST is assigned for their field placement may have significant impacts on their level of MA. Perkins (2016) notes that the high-stakes nature of field experiences may cause EPSTs to avoid taking risks. Similarly, Olson and Stoehr (2019) found that EPSTs experience the highest MA while being evaluated during placements. The previous studies suggest some ways in which field experiences may impact EPSTs' MA, but further research on this topic is required.

Methods courses and field experiences, as two major components of teacher education programs, are often studied as separate entities, however, some studies have aimed to uncover how these elements connect into a broader understanding of the educational experiences of pre-service teachers. Enhanced engagement between methods course instructors, faculty supervisors, and mentor teachers was specifically highlighted by Kajander et al. (2013) as a recommendation for the extended Ontario teacher education program (Ontario Ministry of Education, 2013). According to Novelli and Ross (2017), pre-service teachers often complain of a divide between theory and practice

during their teacher education programs. Swars et al.'s (2009) study of a mathematics teacher preparation program, discussed above, examined the experiences of EPSTs throughout two methods courses and several developmental placement experiences. They found that while mathematics methods courses give EPSTs great optimism regarding their roles as teachers, student teaching experiences then expose them to a more realistic view of the profession. Other studies have demonstrated a similar result, indicating that belief in one's teaching efficacy generally increases during mathematics methods courses, but decreases slightly after student teaching placements (Utley et al., 2005), especially when these two components are highly disconnected (Capraro et al., 2010; McDonnough & Matkins, 2010). While exposed to liberal theories during teacher education, many pre-service teachers fail to adopt these philosophies and employ more conservative practices as they begin their careers (Ebby, 2000; Korthagen, 2010b; Tait, 2006), though there is debate over why this phenomenon occurs (Zeichner & Tabachnik, 1981). Without the support of their course instructors, Swars et al. (2009) found that EPSTs adopt the practices of their mentor teachers, which may not align with the theories and strategies from their mathematics methods courses. Dillon (2017) also discusses the influential role of the mentor teacher in general and the frequency with which student teaching practice may not resemble the ideas presented in teacher education courses. Reid and Reid (2017) note the importance of having mentor teachers encourage EPSTs to take risks and try new mathematics teaching strategies, but that EPSTs often face pressure to teach in a traditional, direct manner during their field experiences, and in general, many mentor teachers receive no professional development for their role as a mentor (Hudson & Hudson, 2010). As mentor teachers illustrate instructional practices in a classroom

setting and provide teacher candidates with advice and support, teacher candidates tend to adopt their mentor teachers' pedagogical styles in lieu of the methods presented in B.Ed. courses. Further research pertaining specifically to the preparation of EPSTs with MA could allow for an understanding of how the connection (or lack thereof) between these entities may impact their mathematical anxieties, which is addressed in the results of the present study.

In the past decade, several researchers have studied innovative programs that closely integrate elements of methods courses and field experiences. İmre and Akkoç (2012) describe a methods course which allowed EPSTs to observe a real class of elementary students. These observations allowed EPSTs to gain an understanding of students' learning processes and learn from the teachers' pedagogical style, while providing EPSTs with the opportunity to discuss and reflect on the experience within the methods course (İmre & Akkoç, 2012). Tait (2006) also highlights EPSTs' desire to observe experienced mathematics teachers during their teacher education programs. Other studies highlight programs where small teaching opportunities with real students are integrated within mathematics methods courses. Gresham and Burleigh (2019) found that a tutoring experience helped reduce EPSTs' MA and increased their confidence, while Novelli and Ross (2017) detail how a methods course that had EPSTs lead small groups of Grade 5 students in mathematical tasks allowed them the opportunity to apply course theory into practice. Unlike high-stakes field experiences (Perkins, 2016), such integrated opportunities allow EPSTs to practice teaching real students in scenarios that are less threatening and provide a clear math focus (Hollingsworth & Knight-McKenna, 2018). Working with elementary teachers outside of a formal practicum experience has

also been found to be beneficial for math-anxious EPSTs. Perkins (2016) studied a program where EPSTs with MA worked with a mentor teacher over the course of eight weekly mathematics lessons. These mentor teachers were selected based on six criteria: experience, professional responsibility, mathematical confidence, teaching expertise, appropriate personal attributes, and time (Perkins, 2016). Perkins (2016) found that the opportunity to work with a mentor teacher with such positive attributes in a less intimidating context helped EPSTs gain confidence in and feel less anxious about teaching mathematics.

Impact on Student Achievement and Attitudes

MA can impact a teacher's pedagogical practices, with implications for students' mathematical learning and attitudes towards the subject. Firstly, elementary teachers with MA may protect themselves from situations that create anxiety (Stoehr, 2017b), thus, they tend to spend less time on mathematics lessons than their non-math anxious peers (Brady & Bowd, 2005). This is reflected in the fact that elementary teachers with high MA are generally more comfortable teaching lower grades (Gresham, 2018; Stoehr, 2017a) where they are more comfortable with the content, or other subjects than mathematics (Stoehr, 2017a, 2017b). In addition, there is a significant negative relation between EPSTs' MA and teacher efficacy (Gresham, 2008), and personal teaching efficacy has been found to relate to a teacher's choice of instructional strategies (Wertheim & Leyser, 2002). While teachers with high efficacy devote more time to planning and choose from a wide variety of activities (Chang, 2015), math-anxious teachers spend much more time learning and practising mathematical concepts (Beilock et al., 2010) and are concerned about their students' ability to learn when they have

trouble understanding the content themselves (Olson & Stoehr, 2019). Because teachers with low self-efficacy tend to use lecture-based teaching and avoid problem solving activities during their math lessons (Gresham, 2008), teachers with MA are also more likely to use these approaches in their teaching practice thereby limiting students' opportunities to develop higher-order / critical thinking skills in the subject area. Furthermore, the anticipated teaching style of EPSTs often mimics the style they experienced as elementary students, which was often this same teacher-oriented approach (Doruk, 2014; Levine, 1993; Reid & Reid, 2017). Even for teachers who adopt reform-based practices, they tend to return to a more traditional style early in their careers (Ebby, 2000; Tait, 2006). Moreover, beyond the mathematics content, other teaching challenges such as classroom management and lesson planning can play a role in increasing in-service teachers' MA (Gresham, 2018).

Many anxieties towards teaching mathematics felt by EPSTs stem from a feeling of lacking teaching methods and instructional strategies (Bates et al., 2013; Stoehr & Olson, 2017), which may also result in their use of lectures instead of more creative, reform-based practices. Passive learning has been identified as a problem in mathematics education in North America (Orpwood & Sandford Brown, 2015), and a reliance on rote learning and memorization can have negative impact on student understanding and ability to solve problems at high levels of difficulty (Organisation for Economic Co-operation and Development [OECD], 2016). Beyond the impact on student learning, certain teaching styles can also put students at risk of developing MA themselves. Teachers with high MA tend to employ traditional techniques (Gresham, 2008) which focus on rudimentary skills, direct instruction, and rely on tests as the primary means of

assessment (Finlayson, 2014). The “skill and drill” approach in particular, often utilized in teacher-oriented pedagogies, can lead to frustration for many students (Brady & Bowd, 2005), and common assessment practices such as high-stakes, timed testing can create high-anxiety situations for students of all skills levels (Geist, 2010). Teaching that promotes conceptual understanding generally creates less anxiety in students (Fiore, 1999); however, this can require a significant paradigmatic shift for EPSTs (Swars et al., 2006; Tait, 2006), especially those who do not feel comfortable with math. It is thus important to help math-anxious EPSTs adopt reform-based pedagogical strategies in teacher education due to the potential impacts of their teaching practices.

Beyond choice of pedagogical approach, there are a variety of ways that the sentiments and actions of teachers, particularly those with MA, can impact students’ mathematical attitudes. MA can negatively affect teachers’ expectations about students’ capabilities (Mizala et al., 2015), and these assumptions can have significant negative effects on students’ attitudes and anxieties towards mathematics (Geist, 2010; Gunderson et al., 2012). These expectancies are often gender-biased, thus placing female students at greater risk for developing such negative attitudes (Mizala et al., 2015). This effect is particularly strong for female students when their teacher is female (as is frequently the case in elementary grades), as female teacher MA has been found to make their female, but not male, students more likely to believe stereotypes that women are less capable than men in mathematics (Beilock et al., 2010). Teacher actions can also have negative impacts on students’ mathematical attitudes. Bandura (1993) has highlighted how teachers with low self-efficacy (which often results from MA) tend to be more critical than helpful when providing feedback. Unfortunately, this criticism can be a form of

math abuse (Fiore, 1999), which, particularly at the hands of teachers, can lead to student development of MA. Even supportive feedback, however, can have negative consequences. Teachers who are uncomfortable with math often attempt to reassure struggling students with messages that mathematics is difficult, however, this can lead students to perceive math as challenging, thus becoming anxious as they doubt their abilities to be successful (Boaler, 2016). Both critical and helpful messages from teachers, in particular from teachers with MA, can thus put students at risk of developing MA themselves. Some researchers, however, have discussed potential benefits of teachers with MA in terms of their relationships with weaker mathematics students. Teachers with MA are in a unique position to relate to students who are struggling due to their own K–12 experiences (Gresham, 2018; Wilson, 2018), and some of these anxious teachers actively work to hide their negative mathematical attitudes from their students through positivity and enthusiasm (Brown et al., 2011; Gresham, 2018).

Various studies have also examined the relationship between teacher MA and student achievement. Classes that present students with appropriately challenging mathematics problems have been found to achieve at higher levels (Chang & Beilock, 2016), however, because teachers with high MA tend to avoid challenging problem-solving activities (Gresham, 2008), their students generally do not receive this necessary challenge and thus may achieve at lower levels. Additionally, math-anxious EPSTs' expectations for students are generally lower than their non-math anxious peers, which not only can influence student attitudes but may also have a negative impact on their achievement (Chang & Beilock, 2016). Students with MA tend to perform at lower levels, where, regardless of actual ability, their anxiety often negatively impacts achievement (Beilock et al., 2010), and teacher MA is an environmental factor in this

anxiety-performance relationship (Chang & Beilock, 2016). Because teacher MA can lead their students to develop MA through various means, as discussed above, teacher MA can have a negative impact on student achievement by increasing their anxieties towards mathematics. MA is often associated with poor performance (Brady & Bowd, 2005; Ramirez et al., 2013), a relationship that was already found in Dreger and Aiken's 1957 study, with recent PISA results demonstrating a 34-point difference, which is roughly equivalent to 1 year of schooling, between students with and without MA (OECD, 2013). In particular, MA has been found to reduce students' working memory capacity and thus compromise their ability to perform, which is especially true in high-stakes, timed testing scenarios (Ashcraft, 2002). One key to improving student achievement may therefore be to help teachers deal with their MA during their pre-service education programs for the benefit of their future math students.

Summary

The concepts presented in this paper provide an exploration of the literature regarding MA in EPSTs. MA is found at disproportionately high levels in EPSTs when compared with other postsecondary students (Gresham, 2007; Hembree, 1990), which can have a significant negative impact on their self-efficacy as teachers (Gresham, 2008). This MA often stems from their own negative mathematical experiences as students (Brady & Bowd, 2005) and lack of content knowledge (Bates et al., 2013). Mathematics methods courses have been found to reduce EPSTs' MA (Beilock & Maloney, 2015) and increase their confidence in teaching mathematics (Looney et al., 2017). While studies have aimed to explore themes of EPSTs' anxieties during mathematics teaching placements (Brown et al., 2012) and the collective impact of both methods courses and field experiences on their MA (Utley at al., 2005), these topics would benefit from further

research. EPSTs' MA can have implications for their choice of pedagogical strategies (Gresham, 2008), and, as future teachers, their MA can have negative effects on both student attitudes towards the subject (Gunderson et al., 2012) and their achievement levels (Chang & Beilock, 2016). These studies demonstrate the continued need for teacher education programs to address EPSTs' past and current anxieties towards mathematics to alleviate their negative impacts on both EPSTs and their future students.

CHAPTER THREE: METHODOLOGY AND RESEARCH DESIGN

In this study, I utilized an explanatory sequential mixed methods approach with emphasis on qualitative methods to explore MA in a sample of EPSTs. Data were collected primarily through individual, semi-structured interviews, guided by pre-interview questionnaires, in order to achieve this study's aim of gaining a better understanding of the impact of a teacher education program on EPSTs' MA. Quantitative questionnaires were used to gain an understanding of participants' background characteristics in mathematics. Interviews then addressed participants' experiences in their teacher education program, both in mathematics methods courses and student teaching placements, in relation to their past experiences with mathematics and their self-efficaciousness towards their teaching practice. This chapter will outline the design, site and participant selection, data collection methods, and data analysis employed in this research, as well as measures used to establish credibility, methodological assumptions, and ethical considerations.

Research Methodology and Design

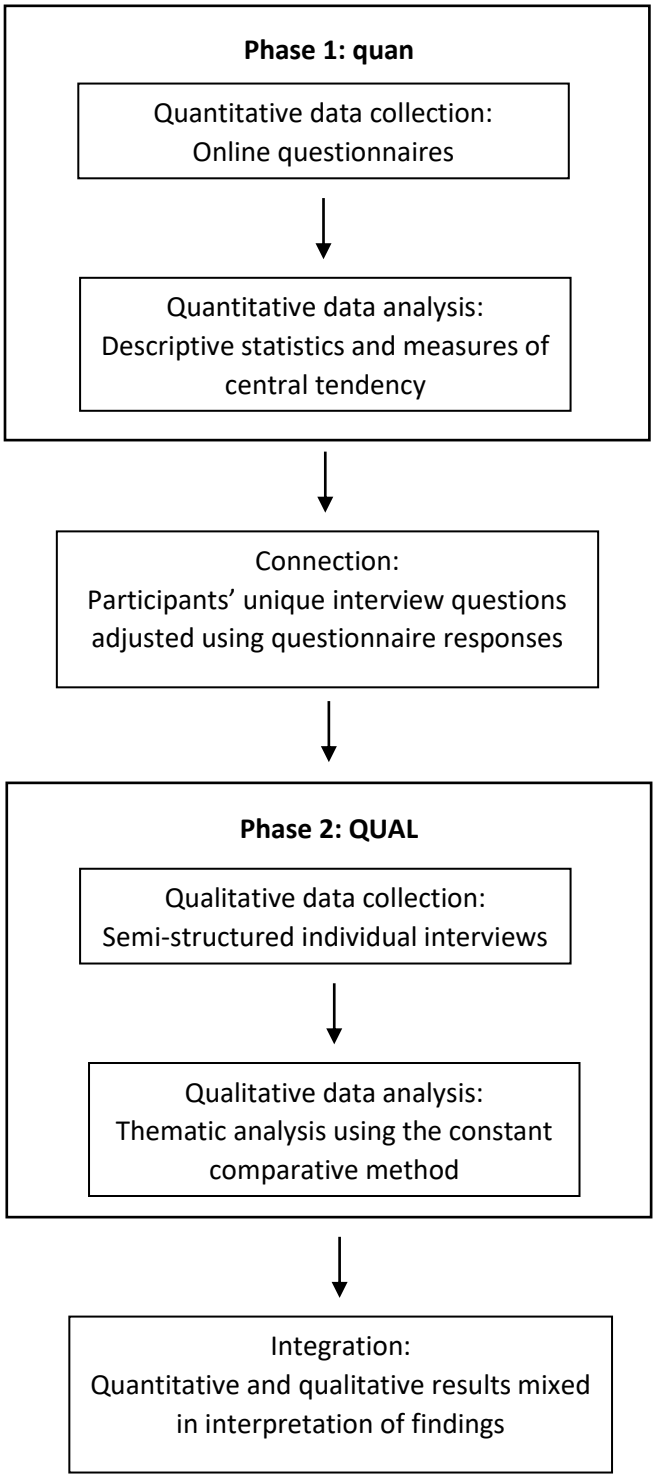
An explanatory sequential mixed methods approach was employed as the research methodology of this thesis project, with greater emphasis on qualitative than quantitative methods (i.e., quan → QUAL). The explanatory sequential approach is described by Ivankova et al.'s (2006) as "collecting and analyzing first quantitative then qualitative data in two consecutive phases within one study" (p. 4). In this research study, priority was given to qualitative methods that explored participants' unique perspectives and experiences in depth to address this study's purpose of gaining a better understanding of the impact of a teacher education program on EPSTs' mathematical anxieties. The

quantitative component played a supplemental role, which Morse (2016) describes as only partially complete on its own, but meaningful in enhancing the validity of mixed methods studies by enriching and verifying findings from the core method. Quantitative and qualitative components were mixed through connection, as quantitative results were used to adjust the qualitative data collection in participant interviews (Ivankova et al., 2006). Furthermore, results from both quantitative and qualitative analyses were be integrated in the interpretation of findings (Morse, 2016; Plano Clark & Creswell, 2015).

This research was based in a constructivist epistemology, which aimed to examine the impact of a teacher education program on EPSTs' mathematical anxieties. In total, nine EPSTs were recruited from the first and second-year classes of the 2-year consecutive primary/junior and junior/intermediate teacher education programs at an Ontario university, detailed in the following section. Because of the study's basis in constructivism, significance was placed on participants' varied perspectives as related to the unique context of this study. In order to uncover these perspectives, an individual, semi-structured interview, conducted in-person or via telephone, was employed as the primary method of data collection (QUAL), guided by pre-interview questionnaires (quan) as illustrated in Figure 1. Questionnaires were quantitative in nature, featuring multiple choice and Likert rating scale questions concerning participants' background characteristics (e.g., experiences as K–12 math students, level of postsecondary mathematics education) and analyzed using descriptive statistics. Interview questions for all participants were based in this project's conceptual framework and the associated literature as described in Chapters 1 and 2, relating to participants' histories as mathematics students, experiences in their teacher education program's methods courses

Figure 1

Explanatory Sequential Mixed Methods Approach Research Design



Note. This design flow was adapted from Del Gobbo (2016).

and field experiences, and their particular anxieties related to mathematics. Due to the sequential approach of this study, however, interview questions for individual participants were adjusted based on their unique questionnaire responses, as well as the results of the analysis of all questionnaire data. Interview data were analyzed using the constant comparative method (Bogdan & Knopp Biklen, 2003). These findings were integrated with the quantitative findings and presented thematically in Chapter 4.

Selection of Site and Participants

This research was conducted with teacher education students enrolled in the Faculty of Education at a mid-sized Ontario university. This university has two campuses, one main campus hosting all academic programs and one exclusively utilized by the Faculty of Education, and participants were recruited from both locations. Both concurrent (direct entry) and consecutive (post-undergraduate) teacher education programs are offered by this Faculty of Education in all divisions: primary (Grades K–3), junior (Grades 4–6), intermediate (Grades 7–10), and senior (Grades 11 and 12). As a recent graduate of an intermediate/senior consecutive teacher education program at an Ontario university, I selected this site as I have some familiarity with the new four-semester teacher education programs. Due to the importance of contextual knowledge in qualitative research (Tilley, 2016), this familiarity was beneficial in my data collection and interpretation and qualifies me as an appropriate researcher for this study (Tracy, 2010).

A purposeful convenience sampling technique was employed to recruit participants for this research. Purposeful sampling allows for the intentional selection of the most appropriate participants (Plano Clark & Creswell, 2015) as based on the specific

needs of the study. This study only recruited participants enrolled in the university's consecutive teacher education program, due in part to their greater diversity of prior postsecondary education experiences. Unlike students in the concurrent teacher education program who enter directly from secondary school, the consecutive program requires that students have already completed an undergraduate program at a recognized university. As consecutive program students will have completed these degrees at many different universities and in a variety of programs, recruiting participants from this program allowed for a greater diversity of postsecondary background characteristics to be studied. A convenience sampling method was also employed as recruitment of participants who meet the eligibility criteria relied on their voluntary participation for this research.

Teacher education programs in Ontario offer certification in two adjacent divisions (i.e., primary/junior (P/J), junior/intermediate (J/I), or intermediate/senior (I/S)). Due to the high prevalence of MA in EPSTs (Brady & Bowd, 2005; Gresham, 2007) and the low percentage of students meeting provincial expectations for the Grade 3 and 6 EQAO assessments (Casey, 2017a; EQAO, 2018), this study recruited participants in the P/J (Grades K to 6) and J/I (Grades 4 to 10) programs, which place emphasis on the elementary grades. In order to explore a variety of perspectives, I aimed to recruit a balance of participants from both P/J and J/I divisions. Of teachers certified in the elementary divisions, J/I teachers specialize in one teachable area while P/J teachers do not declare a specialist. By recruiting participants in both programs, this study could explore any differences in MA in EPSTs with different teachable subjects in the J/I divisions as highlighted by Malinksy et al. (2006). Though attempts were made to recruit participants whose teachable subject is math, which, at this university, has a prerequisite

of three full undergraduate mathematics credits, none volunteered to participate. This study recruited participants enrolled in both the second and final semesters of the four-semester teacher education program. Participants in their second semester had completed one mathematics methods course, as well as one internship and one full teaching placement, while participants in the final semester had completed both an additional methods course and teaching placement. This allowed for an exploration of the impact of both methods courses and field experiences on participants' mathematical anxieties.

I recruited participants both in-person, by distributing letters of invitation at several consecutive teacher education courses at both campuses, and by sending email invitations to all consecutive P/J and J/I students via the faculty of education's administration. The letter of invitation detailed the study's purpose and the participation process and provided potential participants with a link to the online consent form and questionnaire. In total, 12 teacher education students provided consent to participate in the study and completed the online questionnaire. Of these 12 participants, one opted out of participating in the individual interview and two did not reply to email requests to schedule the interview. As the purpose of the questionnaire data was to supplement individual interviews, responses from these three individuals were irrelevant without connection to interview data, thus they were excluded from the study's results. As a result, this study involved nine participants in total, all of whom have been given pseudonyms. The demographic characteristics of these nine participants are outlined in Chapter 4.

Data Collection

This explanatory sequential mixed methods study used questionnaire data (quan) to guide the primary methods of semi-structured, individual interviews (QUAL). The first

step in the data collection process was to administer quantitative questionnaires to all participants. This was achieved using an online survey tool, Google Forms, which participants accessed via the link included in the letter of invitation, due to the advantages inherent in using internet surveys (Sue & Ritter, 2007). The questionnaire (Appendix A) featured multiple choice and Likert rating scale questions addressing participants' background characteristics, including factors such as gender, experiences as K–12 math students, level of postsecondary mathematics education, and teachable subject area. Prior to starting data collection, I asked a convenience sample of two colleagues, one who had recently completed the consecutive P/J teacher education program and another enrolled in a professional degree program, to complete the questionnaire as a pretest test of timing and clarity (Ruel et al., 2015). Questionnaire data were analyzed using descriptive statistics, calculated using Microsoft Excel, in order to uncover trends in participants' background characteristics, however, no inferential statistics were calculated due to the study's small sample size (n = 9) and emphasis on qualitative methods (Plano Clark & Creswell, 2015). These data were then connected to the qualitative component of the study, as each participant's interview questions (Appendix B) were uniquely adjusted to address their questionnaire responses. In this way, information obtained from these quantitative questionnaires played a supporting role (Morse, 2016) by helping to inform the interview process and support the qualitative methods utilized in this research.

The qualitative phase of this study then involved conducting individual semi-structured interviews, either in-person or by telephone. This study was guided by a constructivist epistemology frequently employed in primarily qualitative research (Yilmaz, 2013), aiming to understand the meanings participants attribute to their

experiences with MA. Interviewing allows for the achievement of this purpose by encouraging participants to share and reflect on their personal stories of MA, providing the opportunity to explore their perspectives and construct a broader understanding of EPSTs' MA (Kahlke, 2014). I opted for individual instead of focus group interviews as participants, who are all students of the same teacher education program, would have likely been familiar with one another and may have been hesitant to share their personal anxieties with their peers. The semi-structured nature of the interview allowed me, as the interviewer, to ask specific questions based in the study's conceptual framework and related literature, while providing me with flexibility to tailor questions to participants' unique background characteristics and pursue new directions that emerged in situ (Tilley, 2016). In this way, the interview structure allowed for an in-depth exploration of participants' diverse perspectives to enhance multivocality (Tracy, 2010). Interview questions addressed participants' prior mathematics education experiences at both the K–12 and postsecondary level, their mathematical anxieties and attitudes and how these have been affected by their methods course and practicum experience, their anticipated mathematics teaching style, and their self-efficacy towards teaching upper elementary mathematics. As with the questionnaires, I asked my two colleagues to review the interview questions for clarity, and I also received my thesis supervisor's approval of the protocol before beginning data collection.

As in-person interviews can be both time-consuming and more costly to participants due to transportation expenses (Ward et al., 2015), I provided participants with the option of completing the interview in-person or by telephone. Ward et al. (2015) describe how, despite the commonly assumed superiority of face-to-face interviews,

phone-based interviews are beneficial in helping participants feel more at ease by being in their own environment, and overall less intimidated and reserved during the interview. John and Oliver were the only participants whose interviews were conducted face-to-face. Each interview was 30 to 45 minutes in duration and was recorded on an electronic device. Telephone interviews were audiotaped using speakerphone in a quiet setting, as suggested by Burke and Miller (2001).

Upon completion of this step in the data collection process, I personally transcribed the interviews in order to prepare them for analysis. I did this using the transcription program Transcribe (transcribe.wreally.com) and saved each transcript as a password-protected Microsoft Word document. Due to the inherent subjectivity and difficulty of recording the complexities of spoken language in written form, I used Tilley and Powick's (2002) list of transcription conventions to guide this process and minimize complications, making alterations as necessary to suit my unique data. Furthermore, I opted to use a denaturalized transcription approach as outlined by Oliver et al. (2005), correcting the grammar of participants' speech and emphasizing the meanings of interview data. My position as researcher, interviewer, and transcriptionist motivated me to take great care throughout this process and allowed me to remain close to the data (Creswell, 2013; Mero-Jaffe, 2011), thus enhancing its credibility. Once all transcripts were complete, I provided each participant with the opportunity to conduct a member check, both in order to respect their contributions to my research and ensure the transcript accurately represented their intended meanings (Mero-Jaffe, 2011; Tracy, 2010).

Data Analysis

Due to its sequential (quan → QUAL) mixed methods approach, this study employed two forms of analysis, conducted non-simultaneously, in order to uncover findings from both quantitative and qualitative data. First, quantitative data from online questionnaires (multiple choice and rating scale questions) were analyzed using descriptive statistics to uncover trends in data from all participants (Plano Clark & Creswell, 2015). This analysis included common descriptive statistics such as frequency and measures of central tendency, specifically mean and standard deviation (Plano Clark & Creswell, 2015), calculated using Microsoft Excel. Due to the supporting role of the quantitative data (Morse, 2016) and the small sample size of nine participants, inferential statistics were not calculated to find significance between variables. Findings from this analysis were then connected to the qualitative phase of this study, as each participant's data were compared with these overall trends and their unique interview questions Q1–5 and Q7 were adjusted based on their questionnaire responses.

In the second phase of data analysis (QUAL), this study employed thematic analysis based on the constant comparative method (Bogdan & Knopp Biklen, 2003; Creswell, 2013) in order to capture emergent meanings from the data and construct an understanding of EPSTs' experiences with MA (Yilmaz, 2013). Due to the non-linear nature of qualitative research and analysis (Cho & Lee, 2011) and the aims of the constant comparative method (Bogdan & Knopp Biklen, 2003), data analysis began early in the research process as codes and categories were developed based on the study's conceptual framework and basis in the literature, and as more began to emerge as key themes were repeated across participant interviews. As the interviewer and

transcriptionist, I was able to record these developing codes and categories during the transcription process, a key step in qualitative data analysis (Tilley, 2016), taking note of all related incidents in the data (Bogdan & Knopp Biklen, 2003). Once the transcription and member checking steps were complete, I revisited the data to search for new incidents and emergent codes, revising my analysis as necessary to eliminate ambiguous codes or categories (Li & Seale, 2007). These findings were also integrated with results of the quantitative analysis, which played a supporting role (Morse, 2016) in connecting qualitative data to participants' background characteristics. Finally, I constructed thematic models, presented in Chapter 4, to fit the final categories from this qualitative analysis and communicate key results.

Establishing Credibility

Credibility is an important aspect of quality in any primarily qualitative research project, referring to the "trustworthiness, verisimilitude, and plausibility of the research findings" (Tracy, 2010, p. 842). As primarily qualitative research differs from primarily quantitative research in assumptions, purposes, and approach (Yilmaz, 2013), so too are measures of qualitative and quantitative credibility distinct. Tracy (2010) outlines four criteria for qualitative credibility: thick description, triangulation or crystallization, multivocality, and member reflections. Thick description, which allows readers to understand the inherent cultural meanings of the data (Tracy, 2010) was achieved in this primarily qualitative study by including a detailed description of the study's unique setting, enhanced by my contextual knowledge as a recent graduate of a four-semester consecutive teacher education program. Triangulation and crystallization, which requires the analysis of multiple forms of data (Tracy, 2010), was accomplished via an integrated

interpretation of interview transcripts and questionnaire responses. Multivocality asserts that multiple voices are represented in a study's data analysis (Tracy, 2010), and this aim was realized by recruiting several participants in various program divisions and emphasizing the diversity their perspectives in the final report. Finally, member reflections emphasize the input of participants beyond a study's initial data collection process (Tracy, 2010), which was achieved by providing participants with the opportunity to conduct a member check of their interview data. These measures of triangulation and member checking, in addition to the efforts to recognize my biases described below, served to strengthen the validity of this study (Leung, 2015; Zohrabi, 2013). Furthermore, this study's reliability was enhanced by including a clear audit trail of all data collection and analysis procedures and the internal consistency between participants' questionnaire and interview responses (Creswell, 2012; Leung, 2015; Zohrabi, 2013).

Due to my position as a recent Bachelor of Education graduate and aspiring mathematics teacher, improving mathematics teacher education holds personal meaning for me, thus I am an appropriate researcher for this topic (Tracy, 2010). It is imperative, however, that I understand the inevitable impact of my position in how I conduct this research (Watt, 2007), especially as I have a strong mathematics background, outlined in Chapter 1, and likely experience less MA than my participants. While I attempted to remain neutral throughout the research process and reporting of findings, I needed to be self-reflective about my subjectivities and how they affect my interpretations of the data (Tracy, 2010) in order to conduct a quality study. This reflexivity is especially critical due to my position as the primary researcher, interviewer, and transcriptionist for this work, as I have significant influence over all aspects of the study. Having these various

roles played by the same person, however, does allow for greater proximity to the data, thereby enhancing its credibility (Mero-Jaffe, 2011). As described above, credibility of the data was also achieved through the use of a standard set of transcription conventions (Tilley & Powick, 2002) for all interview data, and providing participants with the opportunity to review these transcripts through a member check (Tracy, 2010).

Due to the mixed design of this thesis project, it is also imperative to consider measures of quality for the study's quantitative component. The quantitative element of this study was based in a survey design, a nonexperimental procedure used to describe trends amongst participants' characteristics (Plano Clark & Creswell, 2015), which was analyzed using descriptive statistics. The reliability and validity of the questionnaire were enhanced by using low-interference descriptors to collect factual information (Q1–12 and Q18–20) and questions utilized in or modified from a prior study (Q15–16; Ashcraft, 2002), as well as conducting a pretest test (Ruel et al., 2015) and ensuring the clarity of all questions (Appendix A; Creswell, 2012; Leung, 2015; Zohrabi, 2013). If surveying is utilized as the sole method in a purely quantitative study, researchers must recruit a large participant sample representative of their population and be able to determine significance and generalize trends to the larger population (Plano Clark & Creswell, 2015). As this study, however, employed a mixed methods approach with priority on qualitative data, it was not necessary to have a large sample, calculate inferential statistics, or to be able to generalize its findings. Morse (2016) describes how in a mixed methods study, the supplemental method is not rigorous enough to produce a complete research study alone, instead, this component enhances the study's credibility by enriching findings from the core method. Credibility with respect to this study's quantitative component was thus achieved through its connection and integration with the

study's qualitative elements, producing an enriched understanding of the data's themes and implications.

Methodological Assumptions

Primarily qualitative research is based in unique methodological assumptions regarding the nature of reality. Based in a constructivist approach, qualitative research assumes that knowledge is subjective and socially constructed, inseparable from the unique social contexts and value systems of the "knower" (Yilmaz, 2013). As a result, this primarily qualitative study was designed to draw from participants' unique perspectives and uncover the diversity of their experiences with MA through the use of interviewing as the primary method of data collection. It was assumed that participants provided responses that honestly portrayed their interpretations of their experiences in teacher education and their past histories as mathematics students. As interview questions, however, asked participants to reflect on memories from as early as elementary school, the distance between these past experiences and the time of interviewing may influence participants' abilities to recall specific information. Finally, this methodology assumed that participants were comfortable discussing their personal anxieties towards mathematics in both the questionnaires and interview setting.

Ethical Considerations

Approval for this research project was granted from the Social Science Research Ethics Board (SREB) at Brock University (REB #18–115). This study presented minimal risk to participants due to the limited potential for harm as compared to participants' everyday lives as teacher education students (Canadian Institutes of Health Research, Natural Sciences and Engineering Research Council of Canada, and Social Sciences and

Humanities Research Council of Canada, 2014). During the recruitment process, participants were provided with detailed information about the study, the actions requested of them as participants, benefits or risks of participation, and the option for withdrawal in both a letter of invitation and consent form. Participants were incentivized to participate in this study by being entered into a draw to win a $75 gift certificate to a major online retailer, which was given out after the collection of interview data but that the participant could have kept if they later chose to withdraw. Of the nine participants, I had a prior relationship with one, Abby, whom I have known for 10 years prior to this study as we attended the same secondary school. Written confirmation of consent, appropriate for this population of adult university students (Tilley & Gormley, 2007), was then obtained from all participants via the online consent form before beginning the data collection process.

While complete anonymity was not possible as I, the primary researcher and interviewer, knew the participants' identities (Tilley, 2016), I ensured confidentiality was maintained in a variety of ways. I first assigned pseudonyms to all participants, creating a master list matching participant names to their pseudonyms that only I was able to access. I recorded all forms of data using pseudonyms to disguise participants' identities from all committee members. Only I was able to access the raw online questionnaire data (containing participant names) through Google Forms using my unique password-protected account. All electronic data were password protected and hard copies were kept in a locked space, ensuring the data were not accessible to anyone other than me and my committee members. Finally, pseudonyms are utilized for all participants and any other individuals mentioned in this report and will be utilized in all future papers or

presentations resulting from this study. These measures to maintain confidentiality were made clear to participants before obtaining consent to confirm that they are comfortable participating in this study and to establish a strong relational ethic (Tracy, 2010).

Summary

This study used an explanatory sequential mixed methods approach to examine the mathematical anxieties of EPSTs. Participants were recruited from all first and second-year students in Brock University's consecutive primary/junior and junior/intermediate teacher education programs. Individual, semi-structured interviews were the primary method of data collection, guided by pre-interview questionnaires. Data were analyzed using descriptive statistics and the constant comparative method and presented thematically in the final project report. Credibility of the data was established using Tracy's (2010) criteria and self-reflexivity regarding my position as the researcher. The study's methodology made several assumptions rooted in the primarily qualitative nature of this research. Finally, ethical factors, particularly the maintenance of participant confidentiality, were carefully considered throughout the duration of this study.

CHAPTER FOUR: PRESENTATION OF RESULTS

The purpose of this study was to examine the impact of a teacher education program on EPSTs' mathematical anxieties. This study utilized an explanatory sequential mixed methods approach with emphasis on qualitative methods (quan → QUAL). Data collection occurred in two phases. In Phase 1, quantitative data were collected using online questionnaires and analyzed using descriptive statistics and measures of central tendency. In Phase 2, qualitative data were collected using individual semi-structured interviews. The two phases were connected by using quantitative data to adjust qualitative collection methods, and results are integrated in the discussion of findings in Chapter 5. The current chapter presents the results of each phase consecutively. All data analyses were guided by this study's conceptual framework and research questions as well as findings from the literature review.

Phase 1

This section presents the quantitative results from the first phase of this explanatory sequential mixed-methods study. These results comprise both the demographic data of the nine participants, as well as the quantitative results regarding their educational backgrounds, mathematical anxieties, and experiences in their teacher education program obtained through analysis of their online questionnaire responses (Appendix A). Descriptive statistics are presented as frequencies, while mean and standard deviation are included for Likert scale data. Mode and median calculations are presented where relevant to the analysis.

Participant Demographics

As described in Chapter 3, nine EPSTs participated in both phases of data collection. Table 1 summarizes their program (Q5) and year (Q6) of study and indicates

Table 1

Program and Year of Study

Program	Year 1	Year 2
Primary/Junior	Courtney Leah Nicole	Abby Emma
Junior/Intermediate (teachable)	Isabelle (French) Karen (French)	John (History) Oliver (Science)

teachable subjects for those in the Junior/Intermediate program (Q7). All participants' identities have been protected using pseudonyms. Of the nine participants, only two (John and Oliver) were male (Q4), reflective of the predominance of women in elementary teaching in both Ontario and Canada (Little, 2017; Statistics Canada, 2018).

In contrast to concurrent teacher education programs in Ontario, which admit students directly from secondary school, consecutive teacher education programs require that students have already completed an undergraduate university degree. As a result, this study's nine participants have varying postsecondary experiences. Table 2 illustrates each participant's faculty of study for their undergraduate degrees (Q8) and the number of undergraduate mathematics and statistics courses they completed during their undergraduate program (Q9 and Q10). All participants who completed mathematics and statistics courses reported during their individual interviews that these courses were not elective but were mandatory components of their programs of study.

Questionnaire Results

The results from the quantitative analysis of questionnaire responses are separated into three distinct categories: participants' experiences as mathematics students at the K–12 level (Q11–Q14), participants' ratings of their anxieties towards mathematics (Q15–Q16), and participants' experiences in their teacher education program (Q17–Q20). As outlined in Chapter 3, these quantitative results are not complete on their own; rather, they are supplemental to the qualitative data in this explanatory sequential mixed-methods (quan → QUAL) study (Morse, 2016). These results are presented using descriptive statistics and measures of central tendency, specifically mean and standard deviation.

Table 2

Undergraduate Faculties of Study and Number of Mathematics or Statistics Courses Completed

Participant	Undergraduate faculty	Number of math courses
Abby	Arts	1
Courtney	Humanities	0
Emma	Humanities	0
Isabelle	Health Sciences, Humanities[a]	3
John	Arts	0
Karen	Arts	0
Leah	Arts	0
Nicole	Arts	0
Oliver	Physical Sciences	2

[a]Isabelle completed a double major program in two different faculties.

Participants' Experiences as Students in Elementary and Secondary Mathematics

Questions 11 through 14 of the questionnaire (Appendix A) were designed to gather information about participants' experiences as students in grades K–12 mathematics. Questions 11 and 12 are ordinal variables which highlight the participants' highest level of mathematics education in secondary school. In Ontario, secondary school students are required to complete mathematics courses in Grades 9, 10, and 11. Grade 12 mathematics is elective, but certain mathematics courses may be mandatory as prerequisites for postsecondary programs. It was assumed that participants completed secondary school in Ontario, but Q12 provided the option of answering "Other" where participants could specify a course offered elsewhere. The combined results of Q11 and Q12 indicate that two-thirds of participants completed mathematics as an elective beyond Grade 11. Four participants (Abby, Isabelle, Leah, and Oliver) completed the highest level of mathematics offered in Ontario secondary schools, Grade 12 University. Two participants (Karen and Nicole), completed secondary school nearly two decades prior, meaning they were students in the former Ontario school system (before 2003) when courses were offered up to Grade 13. Karen completed a mathematics credit equivalent to Grade 12 University in the current system, while Nicole indicated she also completed Grade 13 OAC mathematics designed for university preparation. Thus, six participants in total completed Grade 12 or higher mathematics at the equivalent of the University level. Of the remaining three participants, Emma completed Grade 11 University/College mathematics, John completed an equivalent to Grade 11 University/College mathematics in another province, and Courtney completed Grade 11 College mathematics.

Question 13 provided interval data highlighting how participants felt about their experiences as early elementary (Grades K–3), late elementary (Grades 4–8), and

secondary (Grades 9–12) mathematics students. Participants were asked to rate their experiences during each of these levels of schooling using a Likert scale from mostly negative (1) to mostly positive (5). Table 3 highlights each participants' responses to Q13 and indicates the mean and standard deviation for each level, while Figure 2 illustrates the changes in each participants' ratings between these different levels.

The mean of participants' ratings of their experience in early elementary was 4.44 (*SD* = 0.73), indicating that participants' experiences during these grades was overwhelmingly positive. In fact, only one participant rated these grades as neutral (3), and no participants rated them as somewhat negative (2) or mostly negative (1). This mean decreases to 3.89 (*SD* = 1.17) for late elementary, demonstrating that some participants began to have more negative experiences in mathematics during these grades. While the most common rating of participants' experiences during these grades was somewhat positive (4) and still no participants rated them as mostly negative (1), four of the nine participants' ratings decreased from their ratings for early elementary as evidenced in Table 3 and Figure 2. Furthermore, the larger standard deviation between these levels highlights that participants' positive or negative feelings towards their experiences varied more widely in late elementary than in earlier grades. Finally, participants' mean rating of their experiences in secondary school was neutral at 3.00 (*SD* = 1.56). This mean again demonstrates that participants had more neutral or negative feelings towards their experiences in Grades 9–12 than in the elementary grades. In fact, only one-third of participants rated their experiences as positive (4 or 5), while these grades received the most ratings that were negative (1 or 2) of all levels. Additionally, the standard deviation again increased from the previous grade levels, highlighting the widerrange in participants' sentiments towards their secondary mathematics experiences.

Table 3

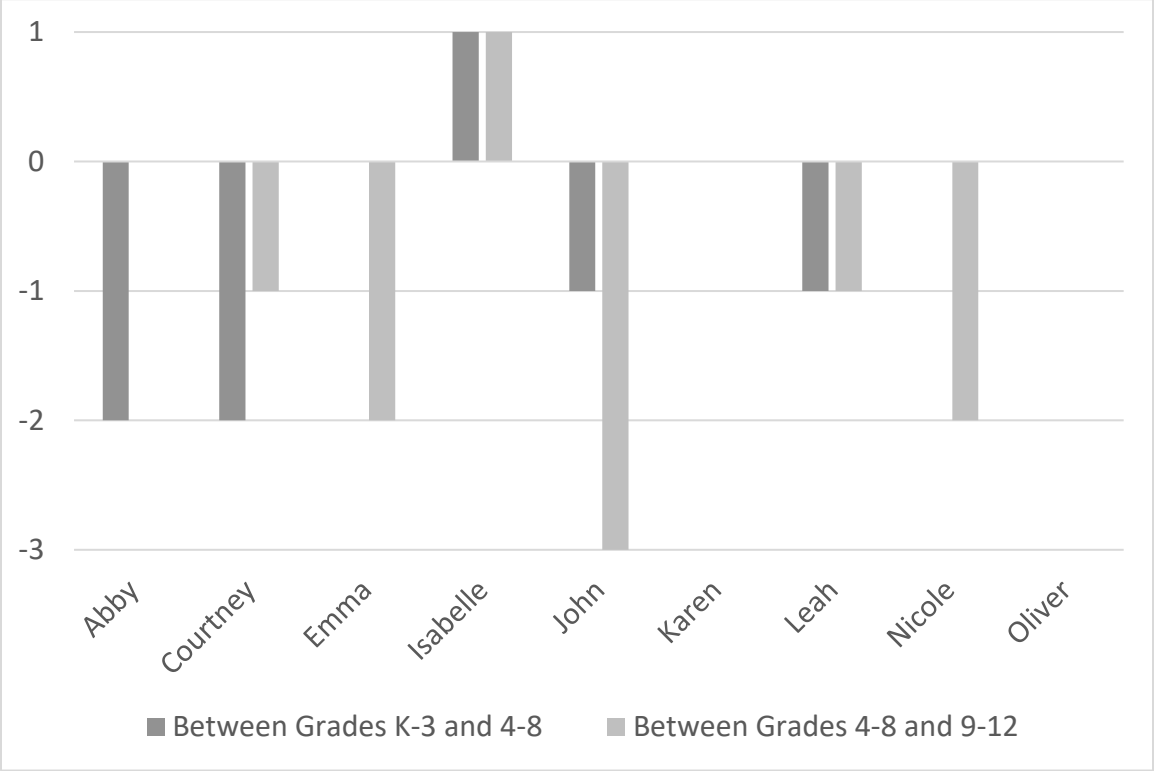
K–12 Mathematics Experience Ratings by Grade Levels

Participant	Grades K–3	Grades 4–8	Grades 9–12
Abby	4	2	2
Courtney	4	2	1
Emma	4	4	2
Isabelle	3	4	5
John	5	4	1
Karen	5	5	5
Leah	5	4	3
Nicole	5	5	3
Oliver	5	5	5
Mean (SD)	4.44 (0.73)	3.89 (1.17)	3.00 (1.56)

Note. 1 = mostly negative, 2 = somewhat negative, 3 = neutral, 4 = somewhat positive, 5 = mostly positive.

Figure 2

Changes in K–12 Mathematics Experience Ratings by Grade Levels



Note. A positive value indicates an increase in rating, while a negative value indicates a decrease. Karen's and Oliver's ratings were consistent for all grade levels; thus, they do not display a positive or negative change value.

The changes in participants' experiences as mathematics students is illustrated most clearly in Figure 2. Six of the nine participants demonstrated increasingly negative sentiments towards mathematics as they progressed through Grades K–12, with ratings decreasing by at least two points overall, while only Isabelle showed an increase in rating. Analysis of the responses to Q13 thus indicate that participants had quite positive initial experiences as mathematics students in early elementary school which became more diverse and increasingly negative as they progressed through late elementary and secondary school.

Question 14 also gathered interval data about participants' experiences as elementary and secondary mathematics students. This question targeted participants' achievement levels in early elementary, late elementary, and secondary school. Participants were asked to state their overall level of performance during each category on a scale from mostly F's (less than 50%) to mostly A's (80–100%), in line with the Ontario Ministry of Education's achievement categories and performance ratings in mathematics. Table 4 provides participants' responses to Q14 along with the mean and standard deviation for each category, while Figure 3 illustrates the changes in participants' performance between these levels of schooling.

The mean of participants' overall performance was the same in both early and late elementary at 3.44 (SD = 0.73). This demonstrates an average grade of B (70–79%), which is categorized as meeting the provincial standard in Ontario. Only two participants changed their performance level between these grades as reflected in both Table 4 and Figure 3, as Isabelle's performance increased from mostly B's (3) to mostly A's (4) while Oliver's decreased from mostly A's (4) to mostly B's (3).

Table 4

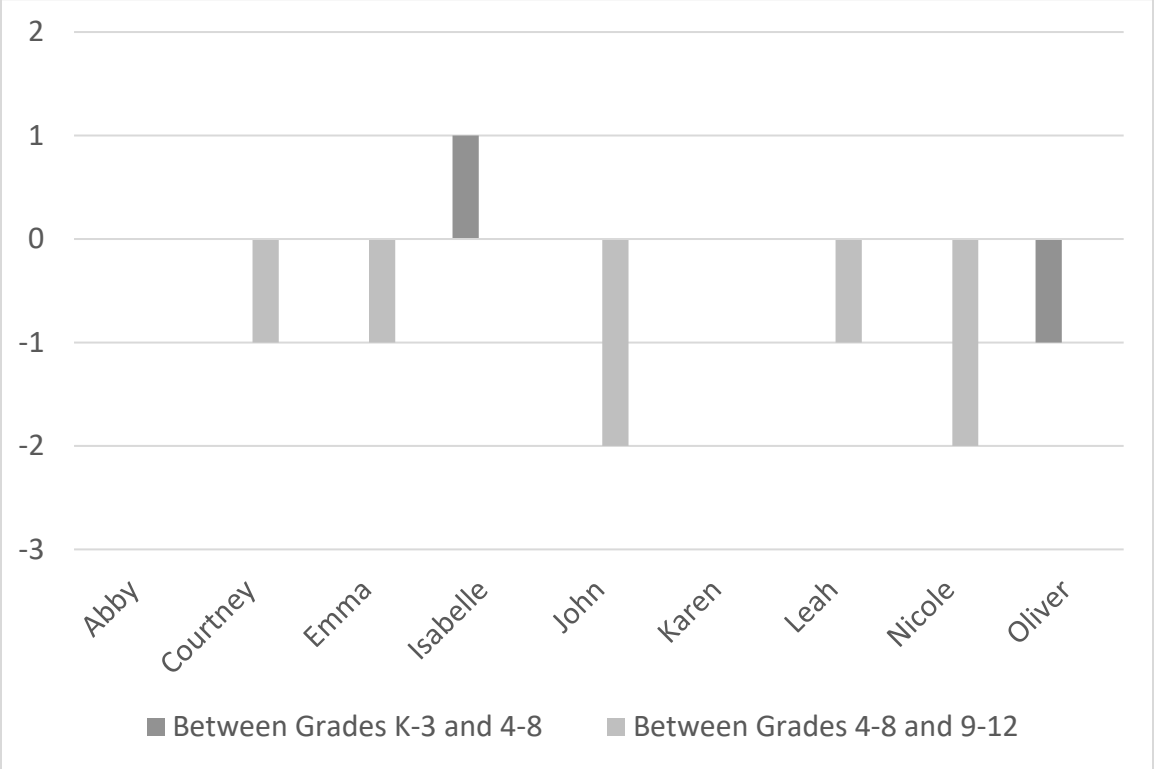
K–12 Mathematics Achievement by Grade Levels

Participant	Grades K–3	Grades 4–8	Grades 9–12
Abby	3	3	3
Courtney	2	2	1
Emma	3	3	2
Isabelle	3	4	4
John	4	4	2
Karen	4	4	4
Leah	4	4	3
Nicole	4	4	2
Oliver	4	3	3
Mean (SD)	3.44 (0.73)	3.44 (0.73)	2.67 (1.00)

Note. 1 = mostly D's (50–59%), 2 = mostly C's (60–69%), 3 = mostly B's (70–79%), 4 = mostly A's (80–100%).

Figure 3

Changes in K–12 Mathematics Achievement by Grade Levels



Note. A positive value indicates an improvement in performance, while a negative value indicates a decline. Abby's and Karen's achievement was consistent for all grade levels, thus they do not display a positive or negative change value.

During both levels of elementary school, the most common response to Q14 was mostly A's (80–100%), indicating that a majority of participants performed above the provincial standard from Grades K–8. However, in the secondary grades, the mean of participants' overall performance decreased to 2.67, and showed a wider range of responses with an increased standard deviation of 1.00. This mean of 2.67 indicates a grade of C (60–69%) which is below the provincial standard, indicating that overall, this study's participants did not achieve at high levels in secondary mathematics. In fact, only Isabelle and Karen performed above the provincial standard, rating their overall performance as mostly A's (4), while Courtney indicated she was much below the standard at mostly D's (50–59%). This decline in achievement is evident in Figure 3, which illustrates that over half of the participants' performance levels decreased in secondary school. This analysis demonstrates that in general, this study's participants performed at or above the provincial standard in elementary school, but this achievement level was not sustained in secondary school.

Participants' Levels of Mathematical Anxieties

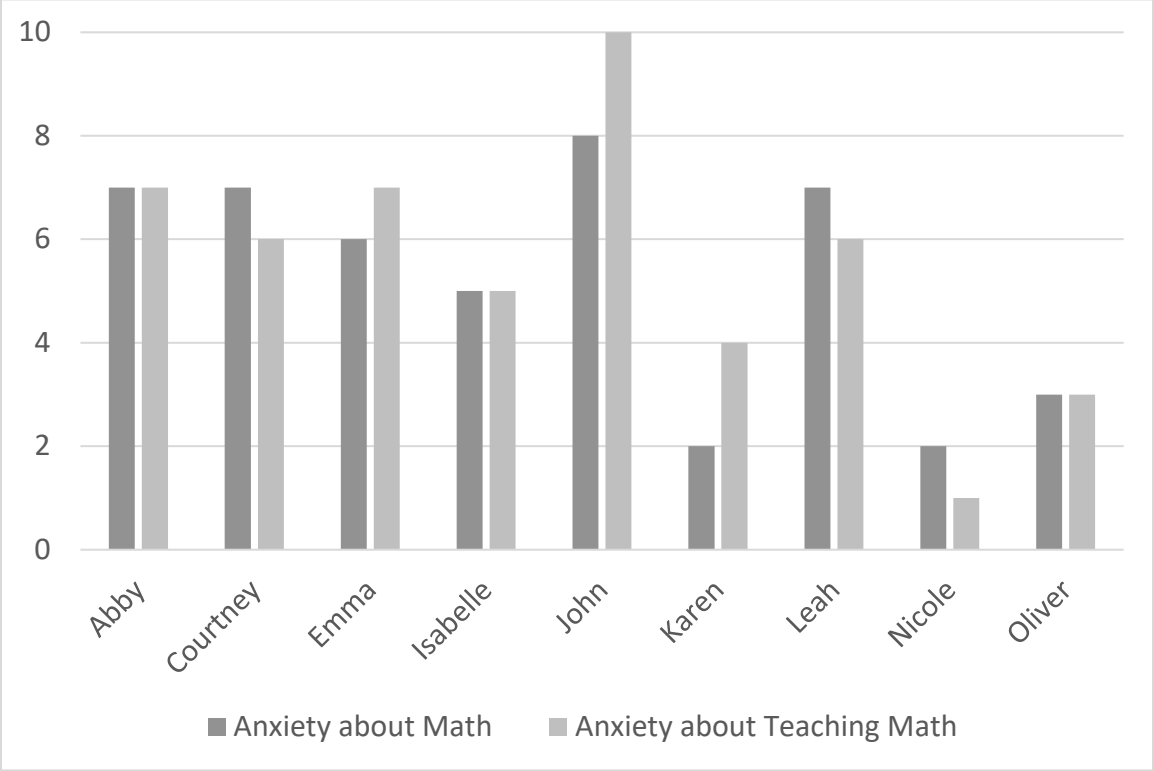
Questions 15 and 16 of the questionnaire (Appendix A) were included as a brief measure of participants' MA and MTA as outlined in Chapter 2. Brown et al. (2011) note that individuals experiencing anxiety can discriminate between these two concepts, and they are commonly, but not always, related. While there exist several multi-item questionnaires designed to measure MA, such as the 98-item Mathematics Anxiety Rating Scale (MARS; Richardson & Suinn, 1972), Ashcraft (2002) claims that it is possible to obtain an accurate rating of one's level of MA by asking individuals to rate their math anxiousness on a scale from 1 (not anxious) to 10 (very anxious). As the

purpose of Q15 was to get a quick rating of participants' MA which would then be elaborated during the individual interviews, and in order to minimize participants' time commitment to the study, I opted to use Ashcraft's (2002) brief question in lieu of a more lengthy instrument such as the MARS. Furthermore, due to this study's focus on a wide range of experiences of MA, no instrument was included to specifically identify MA at a level where it would be considered an anxiety disorder or merit clinical intervention. Question 16 then measured participants' MTA by following the same format as Q15, asking participants to rate how anxious they are about teaching mathematics on the same 1 to 10 scale. In this study, I categorized ratings of 1–3 as low anxiety, 4–6 as moderate anxiety, and 7–10 as high anxiety.

The interval data obtained from Q15 and Q16 is presented in Figure 4. The mean of participants' ratings of their anxiety about math (Q15) was 5.22 (SD = 2.33), indicating that, on average, this study's participants were moderately anxious about mathematics. The standard deviation of 2.33 indicates a wide variety in participants' ratings, with a six-point difference between the lowest and highest ratings of 2 out of 10 and 8 out of 10 respectively. Participants' MA was not necessarily linked to their undergraduate experience in mathematics (Q8–Q9): both Karen and Nicole rated their MA as 2 out of 10 but did not take mathematics in university, while Isabelle and Abby, who both completed university mathematics courses, rated their MA as 5 and 7 out of 10 respectively. The three participants who rated their secondary school experiences as mostly positive (5) on Q13 (Isabelle, Karen, and Oliver), however, had three of the four lowest MA ratings of all participants. In contrast, John, who rated his experience in Grade 9–12 as mostly negative (1), had the highest MA rating at 8 out of 10. The most

Figure 4

Ratings of Mathematical Anxieties



common response to Q15 was an MA rating of 7 out of 10 (Abby, Courtney, and Leah), who all had varying responses to Q11–Q14 regarding their experiences and achievement levels as Grade K–12 mathematics students.

The mean of participants' ratings of their anxiety towards teaching mathematics (Q16) was 5.44 (SD = 2.60), also indicating that the participants were moderately anxious on average about teaching mathematics. This mean of 5.44 is only slightly higher than their mean MA rating of 5.22, and also slightly more widespread with a higher standard deviation of 2.60 than their MA ratings' standard deviation of 2.33. Indeed, participants' MTA had a range of nine points between the lowest rating of 1 out of 10 and the highest rating of 10 out of 10, indicating a larger spread than the range of six points for participants' MA, however, all participants' individual ratings of their MA and MTA had a difference of no greater than two points. Similar to the MA ratings, Nicole had the lowest MTA at 1 out of 10 despite having no undergraduate math experience (Q8–Q9), while Isabelle and Abby, who did complete undergraduate math courses, again rated their MTA as 5 and 7 out of 10 respectively. The analysis also revealed similarities to Q15 regarding the participants who rated their secondary school experiences as mostly positive (5) on Q13 (Isabelle, Karen, and Oliver) again having three of the four lowest MTA ratings, and John, who had mostly negative (1) experiences in secondary school, had the highest MTA at 10 out of 10. The most common responses to Q16 were an MTA rating of 6 out of 10 (Courtney and Leah) and 7 out of 10 (Abby and Emma). Analysis of Q15 and Q16 suggests that overall, this study's participants were moderately anxious about mathematics itself and about

teaching mathematics, and individually, participant MA ratings were close but not always equal to their ratings of MTA.

Participants' Experiences in their Teacher Education Program

The final items in the questionnaire (Q17–Q20) asked participants about their experiences in their teacher education program. Questions 18 to 20 gathered data regarding whether participants had taught math during their field experiences and in which grade levels. The results of these data are presented in Table 5, organized by the basic qualifications for which elementary teachers can be certified in Ontario (i.e., primary, junior, and/or intermediate). No participants have taught Grade 9 or 10 as part of their practicum placement as the junior/intermediate program at this university assigns students exclusively to field experiences in Grades 4–8; instead, the school's intermediate/senior program is designed for future secondary school teachers. Results of Q18–Q20 indicate that of the study's five primary/junior EPSTs, all have taught varying grades at the primary level, but only Abby has taught at the junior level (Grade 6). Of the junior/intermediate EPSTs, John and Oliver have taught math at both the junior and intermediate levels while Isabelle has only taught at the junior level. Out of all the study's participants, only Karen had not yet taught any mathematics at the time of data collection.

Finally, Q17 provided interval data regarding how participants perceived changes in their mathematical anxieties (MA or MTA) during their mathematics methods courses, field experiences, and their overall teacher education program. Participants were asked to rate changes in their mathematical anxieties during each of these components of their teacher education using a Likert scale from significantly decreased (1) to significantly

Table 5

Experience Teaching Mathematics in Practicums

Participant	Practicums completed	Primary (Grades K–3)	Junior (Grades 4–6)	Intermediate (Grades 7–10)[a]
Abby	2	Yes	Yes	—
Courtney	1	Yes	No	—
Emma	2	Yes	No	—
Isabelle	1	—	Yes	No
John	2	—	Yes	Yes
Karen	1	—	No	No
Leah	1	Yes	No	—
Nicole	1	Yes	No	—
Oliver	2	—	Yes	Yes

Note: — = not applicable.

[a]No participants have taught secondary mathematics (Grade 9 or 10).

increased (5). Table 6 presents each participant's responses and provides the mean and standard deviation for each category.

At the time of data collection, only the four participants in Year 2 had completed both mathematics methods courses required as part of their teacher education program. Participants' mean rating of the change in their mathematical anxieties during their mathematics methods courses was 2.89 (SD = 1.17). As evident in Table 6, participants had mixed responses to this section of Q17. Only Oliver responded that the mathematics methods courses significantly increased (5) his anxieties, while all other participants gave ratings between somewhat decreased (2) to somewhat increased (4). Furthermore, both the median and mode for this section of Q17 were that participants' anxieties were somewhat decreased (2), with five of the nine participants selecting this rating.

The second component of Q17 examined participants' field experiences, with all Year 1 participants having completed a brief internship and one full practicum, while Year 2 participants had completed and additional full practicum at the time of data collection. The mean rating participants gave to their change in anxieties during their field experiences was 2.78 (SD = 1.09). This mean is only slightly lower than that of the mathematics methods courses, with a slightly smaller standard deviation. Only one participant, Leah, responded that her practicum experience had significantly decreased (1) her anxieties. Otherwise, similarly to the methods courses, all participants gave ratings between somewhat decreased (2) to somewhat increased (4), and again, the median and mode for this question were that participants' anxieties had somewhat decreased (2).

Table 6

Changes in Mathematical Anxieties During Teacher Education

Participant	Mathematics methods courses	Practicum experiences	Overall teacher education program
Abby	2	2	2
Courtney	2	4	4
Emma	2	2	2
Isabelle	4	4	3
John	4	2	4
Karen	2	4	2
Leah	2	1	2
Nicole	3	3	3
Oliver	5	3	4
Mean (SD)	2.89 (1.17)	2.78 (1.09)	2.89 (0.93)

Note. 1 = significantly decreased, 2 = somewhat decreased, 3 = no change, 4 = somewhat increased, 5 = significantly increased.

Finally, the last component of Q17 concerned participants' overall teacher education program. This question was intentionally broad in order to include all elements of the program, such as any other courses, professional development opportunities, or the program culture. The mean of participants' ratings of how their overall teacher education program affected their mathematical anxieties was 2.89 (SD = 0.93). As with the other components of Q17, this mean indicates only a slight decrease in anxiety, with somewhat mixed responses. All participants gave responses to this component of Q17 between slightly decreased (2) and slightly increased (4), suggesting that the overall teacher education program had no drastic effect on participants' anxieties. The mode for this question was again slightly decreased (2), though the median response was that there was no effect (3) on participants' anxieties. Question 17 was designed to give only a brief insight into participants' experiences during their teacher education program and its effect on their mathematical anxieties, and the qualitative results in the following section elaborate on these responses.

Results from Phase 1 of this study suggested that participants had minimal experiences in university level mathematics prior to their teacher education program. Participants' experiences as students in elementary and secondary mathematics were overall increasingly negative and demonstrated a decline in achievement during Grades 9–12. Participants also had overall moderate levels of both MA and MTA. During their teacher education program, most participants had some experience teaching mathematics in practicum experiences at the time of data collection, with a range of sentiments on how each component of their program affected their mathematical anxieties. As illustrated in Figure 1, this quantitative data was analyzed using descriptive statistics and measures of

central tendency in Phase 1 of the study. It was then connected to qualitative data collection through adjustments to each participant's unique interview protocol (Appendix B) in this explanatory sequential mixed methods study (quan → QUAL). The following section presents the results from Phase 2 of the study, which utilized individual interviews to explore participants' mathematical anxieties.

Phase 2

This section presents results from the qualitative data obtained through semi-structured individual interviews. As outlined in Chapter 3, this study placed emphasis on the qualitative methods in Phase 2 which were supported by the quantitative data from Phase 1 presented in the previous section. After completion of their questionnaires, each of the nine participants' unique interview protocols were adjusted by incorporating their questionnaire responses in Q1–5 and Q7 of the interview (Appendix B). All participants, presented with pseudonyms, were interviewed in-person or via telephone and recorded with an electronic device. I transcribed all interviews using a denaturalized process (Oliver et al., 2005), then participants were given the opportunity to conduct a member check. Analysis of interview data was conducted using the constant comparative method (Bogdan & Knopp Biklen, 2003) and guided by this study's research questions. Analysis of the data led to six major themes: (a) prior experiences with mathematics, (b) anxieties towards mathematics, (c) the influence of mathematics methods courses on mathematical anxieties, (d) the influence of field experiences on mathematical anxieties, (e) the synthesis of mathematics methods courses and field experiences, and (f) anticipated future mathematics teaching style. Themes (c) through (e) were directly informed by this study's research question examining the ways in which teacher education programs impact the mathematical anxieties of EPSTs, while themes (a), (b), and (f) emerged from

the analysis as other key elements of EPSTs' MA and development as elementary teachers.

Prior Experiences With Mathematics

This theme examines participants' experiences with mathematics prior to commencing their teacher education program, primarily concerning their histories as students in elementary and secondary school. Four related subthemes emerged from the data analysis as critical elements of participants' mathematical past: (a) culture in mathematics education, (b) class activities, (c) level of content difficulty, and (d) experiences beyond K–12 education.

Culture in Mathematics Education

When discussing their experiences as elementary and secondary students, a majority of participants highlighted the culture, or the environment, attitudes, and behaviours, of their mathematics classes. Analysis of the data revealed that this culture was often connected to the characteristics of participants' mathematics teachers. For Isabelle, the only participant who rated her experiences in Grades 9–12 more positively than in earlier grades, her teachers' mathematical content knowledge was an influential factor. She noted:

> In the elementary levels I felt like the teachers gave me more of a textbook answer. … In the junior grades I had good math teachers. … The teachers taught the concepts in a way that was age-appropriate and then I was able to put the pieces together. … In high school as the concepts were getting more and more complex, I could tell that the teachers were better able to answer some of the

> tough questions. I'm guessing that was probably because their teachable was math and they had a strong background in it.

In contrast, John did not feel the same positive impacts of his teachers' mathematical background:

> When I got to high school, the teacher knew her stuff, but she wasn't very exciting, so I spent a lot of time falling asleep of not paying attention. … She was very formulaic, she spoke very slowly … she wasn't the most engaging teacher.

Other participants highlighted the impact of their teachers' relationship building with their students. John spoke highly of his middle school teacher's efforts to connect with his students:

> He was very good at the interpersonal, making sure everybody knew what was going on. If you had trouble, he would set aside time at lunch and you could go and see him, he would stay after school and say, "If anyone wants to come and do math homework you can," so he was very available. He was more engaged on a personal level and made sure we knew what was happening.

Emma also reflected on her teachers' encouragement when she was struggling in her Grade 11 course, noting:

> I remember the teacher being great with us. There were a couple of us [students] who were in the same boat as me, and he tried to get us to come and show up because we were debating, "If we can't drop the course, why don't we just not go to it?" He was great, saying, "Come in and sit down, you don't necessarily have to do anything, but I'll try to work with you."

On the contrary, Nicole found that she was not offered the individual support she needed during secondary school:

> I wish somebody had recognized that I had a comprehension issue. I was understanding the content, but I couldn't extend it or apply it outside of that context. … I wish somebody had recognized that, because I probably would have gotten more out of my high school experience and it would have changed the trajectory of my learning as an adult. … To recognize it and say, "Stop working at the pace you are, let's go back and look at this in a different way."

In some cases, this culture was also influenced by peer interactions and pressures. Courtney described how she avoided situations that provoked anxiety through the support of her classmates:

> I feel like peer work was definitely a lot easier to understand because I didn't feel so pressured to ask the teacher and think, "If I didn't get that concept, now I have to ask her. What if she gets mad, what is she thinks I don't listen?"

For Abby, a lack of competition in her primary level classes helped her avoid negative feelings towards mathematics. She described:

> Probably because in K–3 … I don't think I realized at that age that I wasn't keeping up with everyone else. I think it was more enjoyable because I didn't realize that I may not have been as smart as everyone else.

However, these attitudes shifted as Abby reached the older grades. She reflected, "I think later in school you start to compare yourself to others, you start to compare everyone's marks." Courtney felt similar heighted pressures from her teachers and peers during secondary school, as she outlined, "With 9–12 it was a completely different ballgame. I had more pressure with the students and then more pressure with the teachers

too." Finally, Courtney highlighted stresses of secondary school in terms of its impact on her future. She described:

> There was the whole aspect of "What happens next? Are you going to college or university?" For those, you need to meet requirements and it's stressful. I think it's also the pressure of "What if I don't pass; where is this going?" And thinking, "If I'm not successful, will I absolutely shoot myself in the foot for the rest of my future?" The added pressure … it puts you into a downwards spiral.

For these participants, the culture of their mathematics classes had a meaningful impact on their mathematical anxieties. Their stresses were largely related to their mathematics teachers, peers, and worries about the impacts of their performance on their future.

Class Activities

Several participants noted specific activities that had effects on their attitudes towards mathematics. Nicole had positive memories from her time as an early elementary student, as she highlighted:

> I remember in elementary school math was fun. My Grade 1 teacher had a magic math carpet. The kids would sit around the math carpet and that's where we would do our lessons. … I don't remember exactly what we were learning, but I just remember enjoying it.

Oliver and Isabelle, who both rated their experiences in mathematics education quite positively, also commented on two learning tasks they enjoyed. For Oliver, this was the opportunity to solve problems collaboratively as a class. He outlined, "I remember in Grade 10 we had difficult questions, and a lot of times we'd be given 10 minutes to work

on it individually, and then as a class we'd try to solve it." Likewise, Isabelle's memorable task was solving interdisciplinary problems in her secondary classes:

> If we were talking about graphing, for example, they may have used an example with a science experiment, and I was better able to view it from different perspectives as opposed to just through the lens of the math textbook.

On the contrary, other participants noted much more negative experiences when asked to describe memories of their K–12 math education. Leah recalled the lack of variety in her mathematics education, claiming, "When I was in elementary school, I only learned one method. They didn't teach multiple ways of learning the same concept." She later described a speed-based activity that had adverse effects on her mathematical confidence:

> I remember doing something called the math minute in Grade 6, which was where you complete this chart of 60 multiplication questions in one minute. I could never finish it because I didn't have my multiplication tables fully memorized. It would crush my confidence and I did not like that timed test.

Two of the other participants who shared poor experiences, Abby and Courtney, both rated their experiences beyond the primary grades as negative overall. Courtney did not enjoy the monotony of her teachers' instructional approaches, explaining:

> When I was growing up, there weren't a lot of ways to learn in terms of differentiated instruction. For example, these days in math they do math talks and number strings, those weren't used when I was younger. The teacher would basically say, "Here's the worksheet."

She later described an activity that substantially diminished her mathematical confidence:

> [The teacher] would essentially say, “If you didn’t do well at this around the world math game where you’re put in front of your friends to do multiplication and embarrassed if you don’t get the right answer, you aren’t good at math.” It was like a flash card, they’d say, “two times two” and whoever got it first moved on.

Lastly, Abby highlighted the damaging effects of an approach her teacher employed when returning evaluations. As she detailed:

> The teacher would say, “The A students are on tip, and then there’s the B students,” and then they’d write it on the board, “This many people got A, and this many people got B.” I would sit there sweating, thinking, “What category do I fall under? Why do these letters mean anything?” … Now being in teachers’ college, they’re straying away from that whole process. I thought, “If I had that back in the day I wouldn’t have been fixated on ‘13 people got an A and three people got a C, am I one of those three people?’” It was almost like a game, and the students were trying to figure out who got what. I think the way it was delivered was not healthy for anyone’s confidence.

These varied responses demonstrate the mixed impacts of different class activities and instructional techniques on participants’ mathematical confidence and anxieties.

Level of Content Difficulty

Analysis of the data revealed that many participants’ mathematical experiences in Grade K–12 were influenced by the level of content difficulty. As evidenced in Phase 1, two-thirds of participants had increasingly negative experiences and declining performance as they progressed through elementary and secondary school. In their

individual interviews, many participants elaborated on these sentiments, beginning with their positive experiences as primary students. As Courtney noted, “Grades K–3 had simpler math. We were doing patterning and geometry with identifying shapes which is more straightforward, and it’s a little more basic.” John also found the content easier in these early grades, as he reflected, “I think when I was in Grades K–6, the math was more addition, subtraction, multiplication, division, and [my interest in] sports played into that.” Likewise, Leah found these earlier grades to be simpler due to the nature of the concepts, stating, “In K–3 there wasn’t a lot of memorization involved for math, so it was easier for me to grasp the concepts in school when that was the time to work on them.”

In contrast to these early experiences, many participants began experiencing greater difficulty during the upper elementary grades. For Leah, this decline in achievement began with the introduction of multiplication tables and rote learning:

> In Grades 4–8, I remember the multiplication tables that started being introduced. That’s when I really started developing anxiety towards math because memorization was involved. … When it came to the multiplication tables, which were pure memorization, you needed to practice them outside of school to master them and I never did. That really added to my anxiety about math.

Similarly, Courtney had trouble with these newly introduced operations. She explained, “A lot of times multiplication and division would be difficult.” John also felt some struggles during the junior grades. He recalled, “I remember in Grade 4 when we did long division, everybody struggled with that one, for some reason. It was 3 weeks of, ‘We’re doing to do long division again.’” However, for John, his significant difficulties began during his middle school years, noting, “Grade 8 was fractions … that’s where things

started to go off course." Algebraic representations including variables are also introduced during the intermediate years. This concept was mentioned by both Courtney and Karen as a source of stress as mathematics students. Courtney detailed:

> When you get into the older grades it gets more difficult and more challenging. You start adding in algebra which includes letters as variables. It causes more stress because you're having to work a little harder on the answer, which I found difficult.

She further highlighted how her troubles with multiplication and division made algebra even more difficult:

> When we got into algebra and started doing formulas that involved multiplication or division, that was a huge issue for me. I knew that I wasn't very good at multiplication or division, so now incorporating letters on top of that was more difficult because I thought, "If I know I can't do this, what makes you think I can now start adding the alphabet into it?"

Unlike Courtney, Karen consistently rated K–12 experiences positively and achieved at high levels, but she too experienced struggle with algebra:

> I remember in Grade 8 it was difficult, but then when I had the a-ha moment I never stopped progressing from there. … I think it was about "What is this x doing in the equation? It's a letter, I don't understand how I can solve for x." I was sitting at the dining table with my dad who was trying to explain it and I wasn't getting it.

For a majority of participants, their most negative experiences in mathematics were during secondary school, as reflected in the data analysis in Phase 1. This period

was damaging to participants' mathematical attitudes largely due to the increased content difficulty. Nicole explained:

> There was a pivotal point starting in high school where, for some reason, it got away from me. … I think I had the knowledge and understanding part, but I didn't know how to apply what I was doing in different contexts, and then when that hit, I got frustrated and I didn't care anymore.

Likewise, Emma outlined the increased difficulty in secondary school compared to the earlier grades:

> In elementary school, [math] was almost natural for me, and then when I got to high school, I dropped out of Grade 11 math because it was too difficult. That's where I had the negative experience because it was over my head in high school. … I had a much better experience in math in elementary school versus in high school when I felt like there was no hope.

Later in the interview, she expanded on these feelings, reflecting:

> When I hit Grade 11 Functions [University level], I just couldn't do it anymore. … I think that was just the end of the road for math for me.

Similarly, John mentioned the difficulty he experienced with senior level mathematics, noting, "My math ended in Grade 11 and even that was a struggle for me to get over the line."

For these participants, their troublesome experiences with secondary level math had a damaging effect on their mathematical attitudes. Courtney noted how she lacked any desire to pursue further math education, declaring, "As soon as I could stop taking math, I did." Emma's struggles with senior level math, as outlined above, left her feeling

pessimistic about mathematics. She stated, “My impression of math is my last impression, which was Grade 11.” Finally, John explained his negative sentiments during and after secondary school, as he described:

> When I was young, I liked math, and then when I was about 14, I fell off the math wagon. Since then it’s been a horrifying subject for me. … The last time I was going math I just thought, “How can I do enough to get by?” It was never with the intention of “I’m going to remember how to do this because someday I’ll be teaching it.” … There was the relief of passing at the end of Grade 11 … at the end of that semester knowing, “I never have to do math again, I know I passed the exam, it’s over.”

These struggles in secondary school left these participants with moderate or high anxiety and negative opinions of mathematics.

Experiences Beyond K–12 Education

While much of the data regarding participants’ prior experiences was about their time as K–12 students, several participants also mentioned mathematics-related experiences they had after graduating secondary school. Most of these unique experiences were positive and helped students feel more comfortable with mathematics and/or teaching. Of all nine participants, Isabelle had the most undergraduate level experience with mathematics and statistics, having taken three courses. She discussed how her academic training has influenced her content knowledge, declaring:

> In my academic background I’ve been exposed to more data management, especially at the postsecondary level, as opposed to calculus. That’s why I feel

> like I know the content better and I can better teach it because I have a stronger background in it.

Unlike Isabelle, Emma did not have any undergraduate math experience, but she mentioned how her prior postsecondary experience exposed her to some elementary teaching methods, stating "I did early childhood education at [a local college]. We talked about math a little because we were teaching kindergarten, discussing the play basis while still teaching." Abby had also gained exposure to elementary mathematics education before beginning her teacher education program. She describes this prior work experience as follows:

> An experience that I'm lucky to have is that I was an educational assistant for 2 years, so I had long-term positions and I was in classrooms day in and day out. I was lucky enough to see SO many—even hundreds—of ways that teachers teach math, things I liked and things I didn't like, and things I thought the students understood and things they didn't. It was interesting to see teachers teach math in so many different ways. I was able to see it from a role that wasn't an intimidating role … where maybe I didn't even realize I was paying attention to it. I was lucky in the fact that I've been able to see so many different classrooms and so many ways math has been implemented.

For each of these participants, their prior educational and work experiences have increased either their mathematical or pedagogical content knowledge, enhancing their understanding of mathematics education.

Two of the participants, Karen and Nicole, had graduated high school nearly two decades before pursuing teacher education, and they both described the positive impacts

of being mature students. Nicole mentioned how her age had alleviated her trait anxious feelings, claiming “I’m almost 20 years out of high school, and I think as an adult you have an opportunity to not sweat the small things quite as much.” Similarly, Karen had an alternate career prior to enrolling in the teacher education program which changed her perspectives on mathematics. She explained, “I used math where I was working some years ago. It was nice to be able to use it and to realize that there are uses for math out in the world.” Finally, Nicole described how her experiences as a parent have shaped her engagement with mathematics:

> Partially because I’m responsible for three tiny people, I have to model better habits (laughing) … being a parent and seeing how my child is being taught math and knowing where she’s headed with her mathematical learning, I think that’s definitely changed things because I want her to do well and I don’t want her to have a negative experience with math. I encourage her to be a mathematical thinker. I make a lot of effort to draw attention to the fact that we’re doing math, for example, I might stack your pancakes and there might be four, but if you really wanted six, how many more do you need to have? Real life applications.

Due to the greater amount of time passed since they completed secondary school, both Nicole and Karen have been afforded opportunities that gave them more positive experiences with mathematics.

The only participant who detailed a negative postsecondary experience with mathematics was Emma. Though her academic background in early childhood education helped expose her to pedagogical techniques, she also highlighted the discouraging experience she had in a past work position:

> I was a scribe for EQAO last year. I worked with two Grade 6 students. … I had one student who could not move on from one question until he finished, and he was just so frustrated. Every time he couldn't figure it out, he said "I need to figure it out." It's hard to watch kids like that who have anxiety. … It was really upsetting to see him struggle so much and not be able to move on. He's in Grade 6, he's 10 years old; he doesn't need that.

Observing a student's struggle with mathematics in her position as a standardized test scribe thus stood out to Emma as a negative past experience with mathematics education.

This theme portrayed the variations in participants' experiences with mathematics prior to commencing their teacher education program. Firstly, participants' mathematical attitudes were impacted by interactions with their teachers and peers and the wider culture of their Grade K–12 mathematics classes. Participants also highlighted both enjoyable and distressing activities or instructional techniques that were noteworthy in their memories of their mathematics classes. Furthermore, data analysis found that participants' mathematical anxieties were negatively impacted by the increasing level of content difficulty in the upper elementary and secondary grades. Lastly, participants noted a variety of encounters they have had with mathematics since secondary school, including further academic training, work experiences, and occurrences in daily life, that had mostly beneficial impacts on their anxieties towards mathematics.

Anxieties Towards Mathematics

This theme outlines participants' anxieties for doing and teaching mathematics (both MA and MTA). The two subthemes are divided accordingly into (a) mathematics anxieties and (b) mathematics teaching anxieties.

Mathematics Anxieties

Participants' responses to Q15 in the questionnaire showed a variety of levels of MA as outlined in Phase 1, and this variation was reflected in their interview data. Analysis of the data suggested that many participants developed MA during Grade K–12 and have retained these anxieties ever since. Courtney stated these feelings directly, noting, "I grew up not liking math at all … to be honest I've hated math for essentially my whole life." Abby echoed Courtney's sentiments, proclaiming, "I'm not a numbers person, it was just never a strong point in my life." Leah also mentioned how her lack of confidence in math stemmed from her experiences in secondary school, stating, "I stopped trying because I put myself in a category [of being bad at math]." Likewise, when I asked John to explain his anxieties towards math, he noted, "I'm just set in my ways of being scared of it." Courtney outlined how she experienced these anxieties as a mathematics student, describing, "I would get frustrated very easily, which obviously caused some anxiety. I felt that if I didn't get the answer the first time I shut down, I wouldn't get the answer at all, so that was frustrating." She also experienced substantial anxiety related to being evaluated, as she noted, "I was mainly thinking 'If I didn't pass this test, will I pass the next test?' and the anxiety stemmed from that, the idea of failure."

Some participants felt mathematical anxieties directly relating to their present understanding of mathematics as EPSTs. John, whose MA rating was the highest at 8 out of 10, described how he feels high anxiety towards mathematics in comparison to other subjects:

> When I look at other subjects that I'm more comfortable with, I see the depth. … I don't have that same comfort in math, or that same sense in math. I think that was

> where most of the anxiety comes from, it's that you see the standard that you're expected to know as a teacher, and with math I don't know if I'm at that standard.

Other participants had lower levels of MA but were concerned about their ability to recall mathematical concepts. Emma felt these concerns due to the amount of time that had passed since she was learning the same concepts, explaining, "I grew up liking anything algebra related, but I don't remember much of it because it's been a while. I don't mind math, it's just a matter of remembering all the steps." Leah echoed these sentiments, claiming, "I'd have to do a lot more research to refresh my memory on the concepts and main math units in Grade 6." Even Karen, whose level of MA was only a 2 out of 10, felt concern about her ability to recall mathematical processes. As she explained, "I'm not a mathematician, I don't have to use math every day, so if I had to use a specific concept to do lots of operations then I'd be a bit nervous."

On the contrary, some of the participants who gave themselves low or moderate ratings of MA explained why they did not feel these same anxieties. Though Karen felt uneasy at the prospect of using specific concepts, she did not feel nervous about mathematics in her everyday life:

> My personal feeling towards math is that I always felt capable and it's something that I've never shied away from. … In day-to-day life, thinking about bills and payments and savings for retirement, I feel competent that I can figure it out.

Oliver, who completed two mathematics and statistics courses in his undergraduate degree, felt that his academic background gave him confidence in doing math:

> I have no anxiety approaching math. Sometimes problems will take me longer to solve but I'll solve it, and due to the way that I was trained I can use a lot of

> heuristics. Practice makes perfect, so I did a lot of practice and it's not a problem for me.

Finally, though Isabelle did not experience high MA overall, she noted how recent efforts in promoting mental health awareness allow her to feel comfortable disclosing any anxieties she does feel. She explained:

> When I hear the word anxiety, I think a lot about mental health, which is a prevalent issue now in our society. I feel like our social and cultural influences have definitely impacted my awareness and my confidence to admit that yes, there are certain concepts where I don't feel as comfortable and that draw some anxiety.

Overall, for participants who experience considerable MA, these anxieties stemmed from their experiences as K–12 students or their lacking specific content knowledge. Participants with lower MA, in contrast, felt comfortable with the subject due to their academic training or experiences in everyday life.

Mathematics Teaching Anxieties

As with participants' MA, responses to Q16 in Phase 1's questionnaire also demonstrated a wide range in participants' anxious sentiments towards teaching mathematics. Some participants' anxieties stemmed from their past MA and lack of content knowledge. As John described it, "The anxiety comes in from thinking 'I have 30 people looking at me that want me to teach this thing that I've been scared of for my whole adult life.'" He noted that his anxieties were highest when thinking about teaching intermediate students:

> My strong grounding in math stops at Grade 6 or Grade 7, which when you're doing Junior/Intermediate you go beyond that … Grade 8 or 9, that would be scary. There would be a lot of panic, which obviously is not the best feeling, because realistically that is probably a step up from where I am in math. … That fear of Grade 8 or 9, we're getting into MATH now.

Several other participants reflected these anxieties about working with students in the junior and intermediate grades due to the more difficult content. Courtney noted, "With students that are older, I make a mistake, I'm going to have one kid in the back call out, 'No miss, you're wrong'" Similarly, Emma disclosed, "I'm almost worried that I'll get into a Grade 6 class and think, 'I don't remember how to do this.' That's where I'm a little bit hesitant." Even Isabelle, who had the most undergraduate math experience of all participants, felt these anxieties based on the content difficulty in various grades:

> It depends on the level of math. If I had to do high school math, I would definitely need help. I think even some middle school math I would need a refresher, but I think elementary I would be okay.

Also emergent from the data analysis were participants' concerns about their ability to convey information to students. In John's case, this was based in his lack of strong mathematical understanding. He explained:

> I'm anxious about not knowing enough or having enough of a grounding to help students who aren't getting the material. When I get an idea the way I get it, that way might work for me but not for other students. It's not having that comfort of being able to say "If you can't see it the way I can see it, here's another way."

He further elaborated on his worries about teaching math in comparison to other subjects:

> When you know something well you can approach it from different ways and KNOW with confidence that you're going to get to the right spot, that they're going to understand it. Science, history, anything else in Grade 6/7 like I can approach it in different ways, where in math I think, "I don't know how you got that answer, I hope that's okay."

In contrast to John, Karen and Oliver were confident about their mathematical abilities, but revealed similar concerns about their ability to communicate mathematical ideas. As Karen described:

> It's one thing to know a concept for yourself, but to be able to teach it to another person in language that they will understand, it's quite a bit different. I understand it one way, but to teach it to a student who's just not getting it, I don't know if I will be able to get it across in various ways other than the way that I understand it.

Oliver also outlined the pressures he felt about ensuring students understand the course material, revealing, "There's a huge burden of responsibility … me understanding the concept is one thing, but transferring that idea, that conceptual understanding, to the next generation of students is a lot more responsibility." Furthermore, in comparison to the participants who felt anxious about teaching older grades as discussed above, both Karen and Oliver believed it would be more difficult to teach primary classes. Karen explained, "The basic content, I feel like I get it so well that I don't know how I would be able to break it down. … It's so natural to me." Oliver felt similarly about teaching junior classes too, stating:

> I think there's a misconception that when you teach junior and primary grades that it's easier. It's harder, because for them to understand a concept you have to

> have more visual representation and things like that, so there's more work on the teacher's end.

He also noted how explaining more basic content could still be an issue when teaching intermediate classes:

> Teaching Grade 8, I'm supposed to teach multiplication and division of fractions, but a lot of students don't even know how to add and subtract fractions, or they lack the ability to see a visual representation of a fraction. I have to go back to the basics and teach them beforehand.

Another frequently mentioned topic was a concern about causing students to develop MA or have poor mathematical experiences. Leah hoped her future students would not acquire the same negative attitudes she had in her past education:

> When I was in elementary school, I feel like I did not have a growth mindset, I had a fixed … I placed myself in a category of "I'm not good at math, I'm never going to be good at math," so I don't want that to happen to any of my future students.

John also demonstrated concerns based on his own negative mathematical experiences:

> I've seen the downsides of not being good at math. … I've seen the impacts, so knowing that you've got these little people and you don't want to send them off the wrong way when they're 12 like what happened to me.

As with both Leah and John, Abby was concerned about the effects of her mathematics teaching for her students, explaining:

> I'll always be worried that I'm not giving them what they need because I know what it's like to be that student that doesn't get it. … It's the anxiety of wanting to

> be good enough because I care. You care about your job and your role and how you're influencing others—that my anxiety comes from wanting to make sure I give them the information they need.

However, Abby also noted that her past experiences may provide an advantage for teaching mathematics due to her unique perspectives. She clarified:

> I feel like I can relate to the kids who don't get it. … I know what it's like to be in those shoes. … I think my struggles in math, I don't want to say they make me a better teacher, but they give me a different perspective for certain students in my room because I get the frustration. I get how frustrating it can be to be a kid who doesn't get math when everyone else seems to say "Yes, yes, I get it."

The final cause of mathematical anxiety emerged from analysis of Abby's interview. She outlined how new educational policies and societal pressures were an added burden to her as a future educator:

> I don't get what is going so wrong in society that we are SO pressured as teachers to be these phenomenal math teachers. We need to know what we're teaching, but I don't get why it's "Now you need to do a math test if you want to be a teacher, now you've got to do this."

Analysis of the data also revealed some areas where a minority of participants felt confident about their mathematics teaching abilities. As described above, Karen and Oliver both felt anxious at the prospect of teaching primary and/or junior mathematics. In contrast, they were more secure about their ability to be successful teaching older grades. Oliver mentioned how the higher grades aligned with his mathematical preferences, explaining, "The higher the grade, the more developed the students are. They can

understand abstract concepts a lot more easily, which means I can teach algebraic representations instead of more visually." Likewise, for Karen, she felt she would enjoy teaching older students as the content would be easier to explain:

> I would enjoy teaching math to older grades. … I still re-learn it all the time, so I would be able to teach it because I'd be re-learning at the same time as them. Teaching Grade 5 and Grade 6 content, I could do a critical review for myself and remember how I understood it and try to formulate my lessons around that. I think it would be easier at a junior level.

In contrast, Isabelle felt that she would prefer teaching certain topics instead of certain grades, in part due to her academic background in statistics. She explained:

> I think it depends on the stream. I'm more comfortable teaching data management as opposed to algebra. I have that confidence in some strands, while in others I think there could be some growth and improvement, but I think that's with any subject, not just with math. There are going to be some areas where you're going to feel stronger or even have a personal interest in some topics, and others are not going to be your first choice to teach.

Generally, most participants felt some degree of anxiety for teaching mathematics. Data analysis found that these anxieties were most commonly based in their content knowledge or by grade level, the ability to convey information, or concerns about their impacts on future students.

This theme examined two subcategories of participants' mathematical anxieties: their anxiety for doing mathematics (MA) and their anxiety for teaching mathematics (MTA). Though some participants felt relatively competent in mathematics, many others

described an established aversion to the subject. These negative sentiments included feelings of frustration and concern about their lack of content knowledge or having forgotten mathematical procedures. In terms of their anxieties towards mathematics instruction, participants outlined concerns over the responsibilities of teaching, lacking the depth of understanding required to explain content flexibly, and causing their students to have struggles similar to those participants experienced as students. Moreover, while most participants outlined concerns over working with junior and intermediate level classes, those who claimed they had low MA tended to feel more at ease about teaching these higher grade levels.

Influence of Mathematics Methods Courses on Mathematical Anxieties

The development of this theme was guided by this study's first research question examining in what ways mathematics methods courses impact the mathematical anxieties of EPSTs, and how these anxieties are influenced by the relationships between methods courses and pre-service teachers' background characteristics. Four main subthemes emerged from the data analysis: (a) methods course culture, divided into (i) instructor characteristics and (ii) peer interactions; (b) content knowledge; (c) pedagogical techniques; and (d) course resources, with connections to participants' background characteristics outlined where applicable within each theme.

Methods Course Culture

One theme that clearly emerged from the analysis of the data was how the culture of participants' mathematics methods courses impacted their anxieties. Two subthemes regarding this culture were apparent: (a) the course instructors' characteristics, and (b) participants' interactions with their peers.

Instructor Characteristics. When discussing their experiences in the mathematics methods courses, many participants noted the influence of their various course instructors. The majority of participants felt their course instructor's actions and messages about the subject had a positive impact on their mathematical attitudes. Nicole commended her instructor when she affirmed, "The professor was amazing. She set the tone for the class and did an amazing job of teaching the content that we were learning. … It did create a sort of excitement and positive outlook." Abby also offered significant praise for her course instructor, whose identity has been protected using the pseudonym Susan. Abby enjoyed Susan's entertaining teaching style and declared:

> Susan was just so good, especially the activities she had. On the last day she had a "math around the world" activity, so even though you were doing things that you probably didn't want to do, it was fun. She had music playing, we had these little passports and these cool stickers that you got at every station and it was awesome. … She was amazing. She was so fun, and she made something that can be SO negative and boring fun.

For other participants, it was their instructor's encouraging nature that helped put their mathematical anxieties at ease. Isabelle commented on the welcoming environment that her instructor nurtured, regardless of students' prior experiences, when she reflected:

> I think we created a culture in our class where no matter what your background is, this is a place for learning; it's a safe space. I think that's something the instructor created in our classroom, and I was appreciative of that.

Some of the highly math-anxious participants were grateful for their instructors' promotion of a growth mindset, especially in relation to the fixed ideas they had

previously held towards mathematics. To this end, Abby again described her admiration of Susan, explaining:

> The fact that Susan wanted you to make mistakes, and she said, "Mistakes are good, and mistakes show your learning," it resonated with me. I thought, "I wish I could have told my 10-year-old self that too!" I wish I'd had someone to say, "It's okay that you're learning, it's okay that you're making mistakes," instead of "Why are you making mistakes, what do we need to fix?"

She later repeated herself by proclaiming, "Susan makes math fun, but then she makes you believe in yourself too. … It's crazy to think that even at this age, you need that encouragement from someone, but she's amazing." Similarly, John rated his MA quite highly due to his struggles in intermediate and senior mathematics, but noted how the instructor's positive messaging influenced his attitudes:

> [The instructor] gave us the growth mindset of "Everyone can learn math, you can still learn math," while I think often, if you're not good at something by the time you're 20 or 21, people say, "If you can't ride a bike well, you can't ride a bike, you're just not going to be able to do that." That was probably the big positive takeaway for me.

Nicole also felt the positive impacts of her instructors' remarks, noting:

> We were all feeling some stress and anxiety about starting [the course], but right from the beginning, she put everything into perspective, saying, "We're not here to be the best mathematicians, we're here to understand how students learn so we can teach them what they need to know."

In these cases, participants' worries about mathematics were alleviated when offered encouragement from their methods course instructors.

Lastly, two participants mentioned their methods course instructors' influence as a role model. When discussing the positive impact Susan had on her, Abby stated, "Susan's the kind of teacher I wanted, and that's the kind of teacher I want to be." Furthermore, Nicole mentioned how she could see her own characteristics reflected in her instructor, commenting:

> It was nice to have a math instructor who was female. It was also nice to have a math instructor who was part of what would be considered an underrepresented group in math, and as a person of colour I appreciated that.

The only participant who mentioned her course instructor having an adverse impact on her anxieties was again Abby. Though she offered considerable praise for Susan, her first-year instructor, she did not have the same luck in her second-year class. Abby's mathematical anxieties from her own K–12 experiences returned during this course, as she divulged:

> Second year was the most dreadful math class and I think it brought back those negative feelings of "I hate this, I hate math." The teacher was so negative and SO boring. … She had no way of getting it across in an interesting, entertaining way, which made me think "Math sucks, math is boring, and no one wants to teach math."

She further explained the negative implications for her mindset towards mathematics, revealing:

> I think [the instructor] made me not enjoy math again, which takes away the belief that you like math and you can do it. It switches your mindset when you're in this environment and you think "Wow, this sucked." It turns your mindset negative too.

This discouraging scenario had a lasting effect on Abby's mathematical mindset, causing her to lose some of the confidence she gained in her first-year class. However, in general, participants experienced considerable reductions in their mathematical anxieties as a result of their instructor's enthusiasm and encouragement.

Peer Interactions. The data analysis revealed that participants' mathematics methods course classmates made a substantial impact on reducing their mathematical anxieties. For primary/junior students Abby and Leah, who both had high MA and moderate or high MTA, it was valuable to realize that they were not the only EPSTs who were not confident about mathematics. Abby explained how many students began the program feeling nervous:

> I think it's shocking how many people weren't confident in math. I'm one of them, but I thought I was maybe one of five when the majority of the class was terrified to teach Grade 6 math. … That decreased my nerves too because everyone was on the same playing field.

Leah echoed Abby's sentiments, revealing:

> It helped to realize that a lot of people were in the same boat as me. During our very first class, we went around the room and talked about how we were feeling about the course. Almost everyone, with the exception of a few people, said that they never liked math and had the same feeling as I did going into the course.

> Knowing that a lot of other people were in the same boat as me made me feel better.

For Isabelle and John in the Junior/Intermediate program, the methods courses helped them understand the differences in her peers' comfort levels in mathematics. Isabelle noted:

> Coming from a pretty small undergraduate program, everyone was exposed to the same mathematical concepts and had the same math background. In this math course I saw that everyone had a different background and different preferences towards math. I thought it was enlightening because I didn't think about that before.

Likewise, John explained the differences he observed and how he realized he was not alone in having high levels of mathematical anxieties:

> There were still a lot of people that were nervous about math, it seems like you either like and/or get and/or feel comfortable about doing math, or you don't, and you aren't comfortable doing math. You see that in Junior/Intermediate … and the divide seems to be pretty big. There were other people in my classes that were at the same level of me in math. … I just accepted that there were going to be five or six people in the course that could teach math 15 million times better than I will EVER be able to do it [laughing].

For these participants, these peer interactions helped them realize that many of their classmates had different educational backgrounds and shared their anxieties towards mathematics.

Other participants enjoyed the interaction with their peers in their methods courses, which allowed them to learn from one another. Leah described these interactions when she detailed a weekly class activity:

> We had a problem of the day where each week, a group of students would have a problem and they would teach it to our class as if they were teaching it to a class [of elementary students]. Everyone at my table group would work together to solve the problem. That wasn't a discussion about math anxiety per say, but it was helpful to hear them work through the problem together and realize "Okay, that's not coming back to them immediately either." It was helpful to build off each other's strengths and realize that others are not remembering everything right away.

Isabelle also commented on the positive classroom culture amongst the EPSTs:

> There were some students that had a strong background in math. They didn't take over the class, and they were helping others to learn concepts that they may have found simple, so I really liked how we were helping each other.

In addition, both Courtney and Karen felt that they were able to expand their pedagogical knowledge through interactions with their classmates. Courtney learned new strategies from her peers, stating, "Working in a group, I think it's great that you get to bounce ideas off each other and see how different teachers teach. … I think it's great that we get to grow off each other." Similarly, Karen was able to gather resources from her classmates. She noted, "Everyone presented a ten-minute activity to the class. There were a few activities where I thought, 'Those were really useful!' and I kept a copy of their resource for myself." These interactions helped participants feel comfortable in the

methods course and increase their knowledge of mathematics and pedagogy. Altogether, this subtheme demonstrates the positive impact participants felt from peer interactions within their methods courses.

Content Knowledge

As outlined in Phase 1 and the above themes, a majority of participants did not have strong training in mathematics before enrolling in their teacher education program. Prior to commencing their first-year methods course, primary/junior and junior/intermediate students are emailed instructions to complete a course through the platform Elevate My Math (elevatemymath.com). This mandatory course is designed to help students recall concepts from the elementary mathematics curriculum, and comprises a diagnostic assessment, learning modules, and a final assessment to measure improvements in their performance. For many participants, this assessment and review (which many referred to as the "refresher course") was a significant source of anxiety, in part due to an initial lack of information about its implications for the course. Upon learning about the course, Emma, who had no mathematics experience since Grade 11, instantly felt worried, exclaiming, "I remember getting an email [about the refresher course] and thinking 'Oh no, I don't know anything!' … I thought 'This must mean we're learning so much math that I'm behind already.'" Courtney, who had frequently experienced test anxiety in mathematics as a K–12 student, was concerned about what the assessment implied for her future in the program, as she explained:

> That was stressful, because I thought "If I don't pass this, does that automatically mean I get kicked out of the program?" … It didn't seem like a refresher course to me, it was more, "Let's hope you understand all this math, because if you don't,

> you're going to have a difficult time in teacher's college." … It had me doubting myself and thinking "Am I going to be successful in this program?"

Even Oliver, who had low MA and felt confident in his content knowledge, experienced some anxiety, stating, "I think anyone would have anxiety if you say there's a quiz component."

Beyond this initial concern, several participants felt heightened anxiety related to the course's content difficulty. As Abby exclaimed, "When I did it, I thought 'Is this what math is going to be like when we get to teachers' college? Because this is so hard!' … I don't know if it was just me, but it was the hardest thing ever." Courtney, who had explained how she had always struggled with mathematics in her interview, also found the content challenging as she explained:

> The refresher did more than just K–6 math, and even though I'm P/J, I feel like it should have been stemmed towards the grades that you're going to teach. I know I had some Grade 8 and Grade 9 questions on there, so that was a little difficult for me.

She further described how she needed to seek out extra help with the course, stating, "I did have a hard time with that course. … I did have to get some help, some tutoring from friends and family to help me out." Finally, as discussed above, John began to experience significant difficulty in mathematics during his years in middle school. For him, the refresher course triggered these difficult memories, as he noted, "It increased the anxiety because there were a lot of friends from Grade 8 that came back." The difficulty of the Elevate My Math course was thus a source of concern for some participants who lacked strong mathematical content knowledge.

A couple participants also felt a disconnect between the diagnostic assessment and the rest of the methods course. Emma noted how the content from the assessment and learning modules was never reviewed during the methods course, as she outlined, “We didn’t apply what we learned, it was more remembering how to do all these steps … but we didn’t go through the steps on how to do it.” Oliver also mentioned this divide in his interview, offering what he thought would have been a better approach:

> If the instructor were able to take the data that she received from Elevate My Math, the assessment, and bring it into our course, saying, “By looking at Elevate My Math, I noticed that a majority of the students in our class need a little bit more work to understand multiplication and division of fractions. Let’s spend an hour on that, so when you’re actually teaching this unit in Grade 8 math, you will have a better understanding.” She never did that.

These comments suggest that students may have benefitted from greater review of mathematical content not only prior to, but also during their methods course.

While the above excerpts illustrate the anxieties participants felt as a result of the diagnostic assessment and review, many also felt this component of the methods course was beneficial for their content knowledge. For Isabelle, the refresher course acted as a reminder of the material included in the elementary mathematics curriculum, as she reflected:

> I thought it was helpful. It got me back into the mindset of what is expected of a J/I math teacher and [helped me recall] some of the strands and concepts because I haven’t been exposed to them for a number of years.

Nicole felt similarly about the assessment and learning modules, as she stated, “I see the value in it because it did remind me about the topics and concepts that I might be working on with students.” Leah also found this effect, noting, “I remembered the concepts, I picked up on them faster than I thought they would, and they were coming back to me. … It was elementary math, it wasn’t as challenging as I thought it would be.” For John, who experienced some anxiety from working with intermediate level mathematics content again, he found that Elevate My Math helped improve his content knowledge. He explained:

> I was glad that we did it because there were concepts where I actively went back and made sure that I was refreshed on them throughout the course. … If there had been more of the refresher it would have helped me, because sometimes that was it for the actual MATH math.

He even noted that he would have preferred to use the platform throughout the course:

> For me, it would have helped if it were integrated throughout the course. For example, “Okay, this week you’re going to look at the Grade 8 material and let’s make sure you have a refresher on the Grade 8 material.”

Likewise, Karen described how she would benefit from using Elevate My Math on an annual basis:

> I liked the modules for the course and the videos. I felt like they were insightful and helpful, and basic enough but also thorough enough. … I still have some areas where I could do better. I feel like though I learned it in Elevate My Math, I could probably do Elevate My Math once a year, just to have a refresher.

The diagnostic review also had a positive impact on several participants' confidence and attitudes towards mathematics. Considering the amount of time since she had attended secondary school, Karen found surprise at her achievement on the assessment, declaring, "I was quite surprised that I did so well on the initial test because I haven't been in high school for 18 years. I thought 'Oh, I've still got it!'" Likewise, John was also surprised at his successes, claiming, "It boosted my confidence in some areas because there were concepts where I thought, 'I know how to do that. I didn't realize I knew how to do that so well, but I did.'" Emma, who initially experienced anxiety about this course component, felt it enhanced her confidence as she detailed, "I almost felt better after going through [the refresher course] because I thought 'Oh, this is not that bad,' and learning it again made me feel like I was more prepared." Lastly, for Nicole, who had enjoyed mathematics until secondary school, the assessment helped her recall these positive feelings. She reflected, "When we did the Elevate My Math course prior to starting, it reminded me that I do like math and I do enjoy math."

Beyond the diagnostic assessment and review, two participants commented on the changes in their mathematical content knowledge during the in-class component of the methods course. Courtney found the course helped her overcome some of her past mathematical struggles through the use of manipulatives. She revealed:

> I find it's a lot easier for me to grasp ideas when the instructor says "If you didn't understand it this way, what if we use manipulatives? Do manipulatives help?" That's something that worked for me that I feel wasn't offered when I was growing up.

On the contrary, Abby struggled with the updated mathematical terminology and techniques compared to how she learned mathematics as a child, as she disclosed:

> It's interesting to see what the students are doing … and not being able to use words like borrow or move over. It's interesting for people to be teaching math that has nothing to do with what we learned when we were kids. It's almost like we're reteaching ourselves, we're teaching math in a totally different way than how we learned it.

Participants thus felt varying impacts of the methods course content on their mathematical anxieties. For most, these effects were a result of the diagnostic assessment and review completed before the course. Some felt substantial anxiety at the content difficulty and worried they would not be successful in the teacher education program, while others appreciated the content review and felt more confident with the course material as a result. Finally, the differences between the mathematics content in their methods courses and how they learned mathematics as K–12 students led to positive and negative effects on a few participants' anxieties.

Pedagogical Techniques

Analysis of the data suggested that some participants appreciated the reform-based methods introduced in their courses and the contrast with the traditional techniques utilized in their K–12 education. Emma explained how she valued the differentiation emphasized in her methods course:

> The ways that we're learning now aren't the ways I would have been taught. It was about finding ways to teach everybody in the room, not only the general

> mass. I think my first-year math course was great at helping us figure out ways to teach instead of just saying, "This is how you would teach this specific concept."

Karen also appreciated learning about differentiated instruction, and noted how her instructor helped bridge the differences between familiar traditional and the new reform-based techniques:

> Every time that a new topic came up in class, our instructor would explain how we would have been taught it, and then they explained it in the new ways that they're currently using to teach it. There were a lot of concepts where I thought "Oh, I would never have done it like that." She gave us strategies to differentiate for different styles of learning.

Likewise, these pedagogical reforms allowed Courtney to better recognize her past aversions to mathematics. She explained:

> I think understanding that now there's not one way to get an answer has been helpful. I didn't have that growing up, and I think that's where a lot of my negative connotations come from. Knowing that teachers now appreciate the process rather than just the answer is so helpful.

Courtney reiterated these views when she explained how the methods course has impacted her attitudes towards mathematics:

> I've learned to like math a little bit more because I've learned different ways of teaching it. … I think providing more opportunities to learn and different ways of learning has helped. How we can teach in different ways, and what happens if this student doesn't get it right, how we can encourage them, that's helped me with my own math as well.

For these three participants, the exposure to reform-based instructional strategies during their methods course made a positive impact on their attitudes towards mathematics.

Conversely, other participants felt that these reform-based techniques added to their anxieties about teaching mathematics. Isabelle entered the program feeling confident about her abilities to do and teach math but learning about the various elements of mathematical instruction gave her cause for concern. She disclosed:

> After taking that course, I felt like there were so many different elements that I wasn't taking into consideration. I'm now so much more aware of all the elements you have to put into tailoring a math lesson, like differentiation and other things. That's caused my anxiety to go up a bit.

She later detailed these different elements:

> I think the resources can play a major factor to how you go about teaching a lesson, your prior knowledge, how comfortable you feel teaching math, the classroom environment that you've created, and your students and their comfort level. You might have a group of students where half the class is strong in math and the other half of the class doesn't feel too great about it. You have to think about how you're going to incorporate that into your lesson plan so you can reach everybody in the class, not just students that really enjoy it or those that prefer doing other things.

Like Isabelle, Oliver also felt confident in his mathematical abilities before starting the program, but he felt increased anxiety at the prospect of using newer pedagogical techniques. He outlined, "I learned math one way and now I've got to teach it a completely different way, and I have to wrap my head around it." Despite their fairly

high content knowledge, these instructional challenges had considerable consequences for both Isabelle's and Oliver's anxieties towards teaching mathematics.

Finally, for some participants, the challenges of connecting mathematical content and pedagogy was a main source of concern. John described how information was presented in the methods course, explaining, "They were teaching HOW you would teach math or approaches to math, which is good, which is what I have anxiety about, but it was also in a way that wasn't specific to any grade level or area." Lacking much prior experience with mathematics, this was worrying for John, as he had trouble connecting these instructional techniques to the mathematical content:

> John: The disconnect was that I could understand, "I see how you would use this, I see how this relates to math," but then I'm not comfortable enough in the area of math that I'm teaching to apply it. I don't have a deep enough knowledge of the math itself to say, "I can see how I might apply this thinking or how I might incorporate manipulatives into [a specific lesson]." I think that was the issue, it was like they were teaching math as if you're well-grounded enough in math to be able to understand what they're teaching.
>
> Sarah (researcher): So, it might have been more helpful for you if they said, "In Grade 5 math you learn angles and here's a way that you can teach that specific angle content"?
>
> John: Yes, that would have been good for me.

Likewise, Courtney believed it would have been beneficial to have greater connection between content and pedagogy in the course, especially considering how much time had passed since she was in elementary school. She reflected:

> I think it's just how do you teach math? What happens when you are teaching a Grade 6 course, how would you teach Grade 6 math? I feel like we should get a refresher within the first few weeks. I know it's difficult, but a lot of us haven't been in Grade 6 for a long time. What is it, how do you teach it, what are some tips and tricks? … That's an ideal situation.

It was not only participants with low content knowledge who shared this concern. Oliver too expressed his desire for the course to explicitly discuss the curriculum for each grade, commenting, "In the course we never analyzed different grades … we never looked at every grade, we never analyzed the curriculum, we never analyzed the textbooks, and we never looked at some of the resources out there." He again noted his concerns when he stated, "I don't know which particular mathematical concepts to use, which particular activity to use for which particular idea or lesson."

In summary, participants shared contrasting opinions regarding the pedagogical approaches presented in their mathematics methods courses. Some appreciated the reform-based techniques and found they helped them overcome negative sentiments towards mathematics, but for others, the pressures of teaching and lack of connection to specific content heightened their concerns for teaching mathematics.

Course Resources

Mathematics methods courses not only present EPSTs with instructional strategies, but also expose them to a range of materials used in mathematics education. Participants felt these resources were advantageous in helping them feel more comfortable teaching mathematics. Firstly, a majority of the participants mentioned how valuable they found the course textbook, Marian Small's (2015) *Making Math*

Meaningful to Canadian Students, K–8. Leah stated, "I found the textbook helpful because it had a lot of strategies, and it broke down each unit and how to teach it in different ways," while Isabelle claimed, "I like how they had little activities in the textbook that you can use alongside your lessons." Abby reflected these opinions when she mentioned, "That was a good book. It had a lot of good resources and a lot of good examples on how to teach math, and you could refer to it for ideas." Furthermore, Courtney liked how the textbook aligned with elementary mathematics content, explaining, "The Marian Small book has been helpful because it gives you different ways to learn. … I think Marian Small does try her best to incorporate and follow the curriculum when possible." Finally, both Emma and Isabelle found it beneficial that the textbook outlined students' common errors and misunderstandings. Emma detailed the benefits of having this information:

> We used the Marian Small book, *Making Math Meaningful,* and that was helpful. It has boxes that outline broad misconceptions about a topic, and that helped me to see that, were I to teach the subject, what could students be hearing instead of what I want them to hear.

Isabelle too liked how this element of the textbook broadened her understanding of teaching mathematics, noting, "The textbook was helpful because it provided a lot of misconceptions that students might have when I'm teaching a lesson that I would never have considered." In general, many of the participants found the course textbook to be an indispensable tool for their understanding of teaching mathematics.

The other useful resources that participants mentioned from their methods courses were various manipulatives and online platforms. Abby enjoyed the exposure to

manipulatives, declaring, “Susan was amazing at showing us many options of things we could use, like manipulatives. … She would pull them out and let you play with them, and she’d show you how to use them in interesting ways.” Emma instead discussed how she liked the simplicity of the online resources included in the course, as she stated:

> For a lot of the online resources I thought, “That could definitely be used in a classroom, that doesn’t seem too out of the box like I’d have to learn it before I can take it into a classroom.” They seemed straightforward for use and easy and engaging for students.

Likewise, Isabelle commented on how she saved these resources for her future practice:

> I liked how we had to do game forums every week where we had to search online for a different play-based game to target a specific grade and we had to analyze it based on different roles. I thought that was helpful. I bookmarked a lot of them as curation for my future classroom, so I thought that was helpful and a way to build up some resources.

Finally, Karen found the online resources useful as a basis for planning lessons. She noted, “We saw Ministry and EduGAINS [a Ministry-developed website] resources. … If you’re struggling with a particular unit, you can at least kickstart it by using the EduGAINS website with the different plans and resources that are available there.” As demonstrated by these excerpts, the variety of physical and virtual resources included in their mathematics methods courses allowed participants to collect resources for their future practice and improved their overall confidence for teaching mathematics.

This theme examined the influence of mathematical methods courses, as one of the two major components of mathematics teacher education, on participants’

mathematical anxieties, and how these may be influenced by participants' background characteristics. Their course culture, examined in terms of their course instructor and their peers, was a noteworthy factor impacting these anxieties. For most participants, their instructors alleviated stresses by displaying enthusiasm, giving encouragement, and acting as role models, though one instructor's poor attitudes made a substantial negative impact. In terms of their peers, sharing anxieties with classmates, understanding their varied mathematical backgrounds, and collaborating within the course all reduced participants' anxieties. On the contrary, participants experienced many concerns related to their content knowledge during the course, primarily caused by the diagnostic assessment and review component. Several participants described their concerns about the quiz element, the content difficulty, and the lack of connection between this assessment and the course. However, some participants found that the diagnostic helped them recall mathematical processes and improved their confidence overall. Participants had mixed sentiments towards the reform-based strategies introduced in the course: many noted the positive impact of approaches like differentiated instruction, while others were overwhelmed by the range of factors involved in lesson planning and the departure from the traditional methods to which they were accustomed. Finally, participants largely found that course resources were beneficial to reducing their anxieties, including the textbook, manipulatives, and any online programs.

Influence of Field Experiences on Mathematical Anxieties

This theme relates to this study's second research question examining in what ways field experiences (practicums) impact the mathematical anxieties of EPSTs, and how these anxieties are influenced by the relationships between field experiences and

pre-service teachers' background characteristics. Analysis led to the development of six main subthemes: (a) mentor teacher characteristics, (b) instructional approaches, (c) grade level, (d) practicum resources, (e) being evaluated, and (f) working in authentic settings. As with the previous theme, connections to participants' background characteristics are outlined where applicable within each subtheme.

Mentor Teacher Characteristics

When discussing their field experiences, many participants commented on the influential role of their mentor teacher. In many cases, these mentor teachers, whom participants referred to as associate teachers, displayed positive attributes that helped to ease participants' mathematical anxieties. Leah listed several such qualities, noting, "Because I had a good relationship with my associate teacher—she was very approachable, very helpful, very friendly—I didn't have any anxiety towards working with her, so that helped. … I got along well with my associate teacher." While Abby and Courtney had both suffered from considerable MA prior to their teacher education program, their mentor teachers alleviated some of their anxieties by showing sympathy and encouragement. Abby reflected on this positive influence as she explained, "I think the support of my first associate teacher helped. … Having him say 'You know this, they're 12 and you're 25,' made me push myself by realizing 'I can do this, I can teach it.'" Likewise, Courtney mentioned how she disclosed her mathematical anxieties to her mentor teacher, remarking, "I initially told [my associate teacher], 'Well, I'm not really great at math." … It did help me that she was understanding." For these participants, their mentor teachers' approachability and compassion helped to ease their anxieties during their field experiences.

Other participants commented on the value of the teaching supports they received

from their mentor teachers. Emma, who had high of MTA, portrayed how her mentor teacher helped with lesson planning:

> My first year I had a great [associate teacher] and she would go over all my lesson plans before I taught them. She was great at helping me feel comfortable before I taught anything. That was good for my first year because I wasn't sure what I was doing or if I was doing something correctly, and when she had suggestions, I was open for everything.

Leah also detailed the specific ways in which her mentor teacher helped her adapt to the classroom environment:

> When I first got to my placement, they were working on subitizing and [my mentor teacher] showed me how she tries to connect it to their morning lesson. She talked me through what [the students] have done so far and what their strengths were and the areas that they were still working on.

On the contrary, participants who did not receive such supports felt frustrated and increasingly anxious. When describing his second field experience, Oliver remarked, "I think I had four observation days and then [my associate teacher] just threw me a textbook and said, 'There you go, go plan' and I barely had anything." He was also irritated when he felt his mentor teacher expected him to work harder than she did, noting, "She wanted me to do math Jeopardy and all those activities. I thought 'Why am I doing this? You didn't do it yourself.'" Emma illustrated the differences in the support she received from her mentor teachers when managing her class, claiming:

> It was not my classroom so I feel like it was harder for me to discipline in someone else's room while they're looking at me. I felt like my first associate teacher was helpful with that, I think because it was my first year, but my second

> one did that a bit less so that was a bit of my anxiety.

Participants who received supportive coaching from their mentor teachers felt more confident preparing lessons, while those who lacked such supports felt annoyance and increased anxiety towards teaching.

Two participants mentioned their mentor teachers' education in mathematics and other areas of teaching. For Courtney, her mentor teacher's strong mathematics background was intimidating. She disclosed:

> My associate teacher was the math lead. … I guess that anxiety stemmed from me thinking, "Wow, this is someone who really knows math, who loved it, who is the math lead at my school. Now she has me as a student teacher, who hates math and gets so nervous about math.

However, Isabelle described how her mentor teachers' extensive training in special education was beneficial when planning lessons, noting, "My associate teacher had a strong background in special education, so she was able to remind me about those different pieces and to consider students misconceptions." She elaborated on this aspect of her mentors' experience as follows:

> My associate teacher took a unique approach with her special education background … she had recently gotten a master's in special education and was a special education resource teacher for a number of years. The students definitely benefitted from her experience and her background.

Mentor teachers' teaching experience thus had mixed impacts on participant anxiety, as participants found it either daunting or beneficial to lesson planning.

Overall, mentor teachers who were compassionate and provided strong coaching helped ease participants' concerns, those with extensive training had varying effects on

participants' anxieties, and those who were unhelpful made participants feel frustrated and nervous.

Instructional Approaches

Participants both witnessed and utilized a range of pedagogical styles during their field experiences. For some, being paired with a mentor teacher with effective pedagogical strategies helped to alleviate some of their mathematical anxieties. John found these benefits from observing the reform-based instructional approaches used by his mentor teacher:

> My associate teacher liked using three act math. She was often introducing, usually an image, and saying to the class "What do we think? How are we going to use our math thinking?" She changed the way I thought of how to teach math. She liked to use a lot more word problems to try and get them thinking outside of just numbers. That was great because that was what I was more comfortable with. She was a great resource.

Like John, Courtney's mentor teacher exposed her to newer instructional strategies. Though she was intimidated by her mentor teachers' experience in mathematics, this knowledge was beneficial for her pedagogical development. She stated, "Working with my associate teacher helped because she taught me that new way to teach those primary grades, especially to teach math." Courtney later elaborated on how she employed her mentor's strategies for differentiating content, recalling:

> I did a task with tic tac toe, and I knew if I got two partners who were on a lower level in math, I would adjust my own questions so it met their needs rather than just giving out a worksheet that's the same for everyone.

Isabelle also found her mentor's teaching experience to be valuable, explaining:

> My associate teacher taught intermediate, so she knew the curriculum moving

> forward and what was expected of the students. She was able to tailor the Grade 5 curriculum and differentiate to help the students be as successful as they could be.

While the above participants were all paired with mentors who used reform-based strategies, others had practicum experiences in more traditional classrooms. For Nicole, she felt pressure to adopt these methods and found this experience to be very frustrating. She disclosed:

> My associate teacher would say, "It's easier to do it the way it's always been done," and push me to do it her way because why make it more complicated? It wasn't a very risk encouraging environment. … There were times with lesson planning where I would write the lesson plan how I wanted to do it but do it my associate teacher's way.

She later expanded on the disappointment she felt on being unable to teach how she wanted, revealing, "I wanted more from my placement. I wish my associate teacher would have been open to mentoring with newer concepts, but I don't think that she fully understood what those newer concepts were." In comparison, Abby enjoyed her mentor teachers' traditional style in her Grade 6 practicum. She explained:

> My associate teacher was super traditional. He still uses those [student workbooks designed to accompany math textbooks]. I found the way he taught it interesting because he did the three-part lesson plan, but he did it based on the textbook, and my students were getting it, it worked so well for them.

Even when given the opportunity to use newer techniques, Abby chose to adopt her mentor teacher's approach, stating, "He was open to me doing whatever I wanted to do, but what he did worked so well that it was hard to stray from it."

Analysis of the data thus suggests that participants felt at ease when assigned to

field experiences where innovative pedagogical styles were employed. In contrast, participants whose mentor teachers used traditional methods had mixed opinions: some felt frustrated from the pressure to utilize such strategies, while others liked using these same techniques.

Grade Level

During their field experiences, EPSTs can be assigned to teach any grade level within their program's limits (i.e., Grades K–6 for Primary/Junior, and Grades 4–10 for Junior/Intermediate). Data analysis revealed that participants' mathematical anxieties during their practicum varied largely based on the grade level they were teaching. For Abby and John, both math-anxious EPSTs, teaching late elementary induced major worry. Abby stated this concern directly, revealing, "I remember when I taught my first placement, Grade 6, I was SO anxious. I still think 'I don't want another Grade 6 placement because what if I can't explain something properly?'" She noted that this concern was mostly due to the higher-level mathematics content, expressing, "I had to refresh myself on everything that they were learning." Despite familiarizing herself with the course material she taught, she retained these anxieties, noting "I think I'm still nervous that I could go back in to Grade 6 and it could be a different unit that I'm teaching, because for each placement we don't teach that much material."

John, who also taught Grade 6 mathematics, had a variety of concerns about working with these older students. He disclosed:

> I was very anxious because there were students that were better at math than I was, and that's not an issue but it made me anxious trying to keep up with them. Or the students that weren't getting it, I was anxious about not knowing enough or having enough of a grounding in math to help them properly.

For both Abby and John, a lack of confidence with the upper elementary mathematics content substantially increased their practicum anxieties.

It is also noteworthy that Abby was the only participant to have completed field experiences at both the primary and junior levels, having taught Grade 6 and then kindergarten. She found drastic differences between the content difficulty in these grades as she remarked, “The math [in kindergarten] is not hard because it’s so basic that as a teacher, to switch your brain [from Grade 6 to kindergarten], it’s interesting. I’m glad I had the experience because they’re so different.” Surprisingly, despite her anxieties for teaching Grade 6, she claimed that teaching kindergarten was more demanding due to the difference in teaching styles:

> I found for kindergarten that the way you introduce numbers is so simple that it’s hard. I didn’t think kindergarten math was hard, but to think about how [the students are] going to grasp the concept and how to introduce it in a way that’s play-based, personally I found it to be more challenging than Grade 6.

This remark demonstrates that, though Abby had challenges with the mathematics content in Grade 6, she saw that the pedagogical demands of younger grades can be even more difficult.

Contrary to the participants who taught upper elementary, those in the Primary/Junior program who taught younger grades during their field experiences largely enjoyed their practicums and experienced a decrease in anxiety. Emma taught both Grades 1 and 2, and she felt the lower level content to be fairly simple as she remarked, “I think because I’ve been teaching primary, it’s the quote-on-quote easier math that I’ve been teaching right now so that’s decreased my anxiety about [teaching math] a little bit.”

Leah also noted that she did not experience anxiety while teaching younger grades, explaining, “My first placement was in kindergarten, so I didn’t have much anxiety teaching math for kindergarten because it was simple, I was doing patterning with them and subitizing.” Moreover, Nicole echoed both Emma and Leah’s sentiments towards the content level and added how much she enjoyed teaching the younger students, noting, “In Grade 2 the concepts are fairly simple, and when you use manipulatives the students have a chance to see how everything works together. That was really fun and interesting.”

Lastly, analysis of the data revealed two participants who mentioned how their field experiences have enhanced their confidence for future practicums. Emma reflected on this change when she stated:

> I went from Grade 2 to Grade 1, and I loved Grade 2, but I didn’t love Grade 1. I think that’s given me the push I needed to be able to teach junior. I was anxious about teaching junior, and then I taught Grade 1 and I thought “I’m ready to teach the older kids.” I think the experience has decreased my anxiety about teaching math and teaching older kids.

Abby also made mention of the positive impact of her field experience. She found the challenges she experienced in Grade 6 were beneficial to her learning, declaring, “I think it was good for me to hit the ground running. This is as hard as it’s going to get to teach, so start here.” Overall, participants’ anxiety increased when teaching late elementary grades due to the difficulty of the content. Though they did not face this same concern in the primary grades, some faced pedagogical challenges with these younger students, or felt more confident to teach higher grades after completing their field experiences.

Practicum Resources

EPSTs are appointed to a wide range of schools during their field experiences, thus their school and classroom environments can differ greatly in terms resource availability. Emma, who had completed two field experiences, found a noteworthy difference between her two classes as she remarked, “In my first placement I found myself on Pinterest or Google a lot, searching interesting ways to teach, whereas my second associate had them in the classroom already.” Likewise, John had also completed two practicums, the first teaching English and the second teaching mathematics. He noted his relief that the school where he taught mathematics had a great variety of resources, comparing this to his first placement when he revealed:

> In resources, they were just more limited at [the first practicum school]. It was okay because I was going English and I was more comfortable with it, so I wasn’t as worried, but it could have been a different story in math.

Finally, Oliver was frustrated with his mentor teachers for providing him with few resources, disclosing “I’ve had associate teachers who just threw me a math textbook and said, ‘Go plan, go teach.’ I thought ‘What am I supposed to do?’ I did the best I could, I tried to find things online.” Participants whose field experiences lacked resources spent significant time searching for resources online, and for John, it would have caused him additional anxiety in teaching mathematics when compared to other subjects.

Conversely, a majority of participants had field experiences with a great variety of resources available. Nicole mentioned how her mentor teacher shared these materials, claiming “My associate teacher gave me resources from past years.” Emma went into greater detail about the resources at her disposal during her second practicum, stating:

> My last placement, she's been teaching primary forever, so she only has K–3 materials. She had little bins behind her desk—a math bin, a language bin, a science bin—all these worksheets that she's used. … She would go through them periodically and she was good with saying "Photocopy whatever you want, just bring it back and you can have it."

By allowing Emma to photocopy her materials, Emma was able to access these resources for lesson planning during her field experience but could also develop a catalog of resources for her future practice. John also found his second placement to have a much wider range of resources than his first:

> She had a lot of resources for math … she had an entire set of math books that included lesson about teaching math through the lens of social justice and things like that. She had a fair amount of manipulatives next door, and the school was very good about sharing ... pretty much anything that you needed, you could find it.

Like Emma and John, Leah's classroom had a great variety of resources that she consulted when planning her lessons:

> [My associate teacher] had a ton of resources in her classroom, like she had these little math activities and games, a ring of all these different kinds of math activities. There were tons of ideas that I could use that were fun, and the kids loved them. She had a big room full of books and resources that I could explore and get ideas from, so that was helpful. … I wasn't pulling things out of thin air, there was tons that I had to work with, lots of ideas that I could either use directly or build upon, so it was helpful.

Though Courtney mentioned the intimidation she felt from her mentor teacher being her school's math lead as discussed above, she described the benefits of her mentor teachers' strong mathematics background in terms of resource availability, noting, "My associate teacher had a lot of manipulatives. Her being the math lead helped because she knew what worked and what didn't, so that was helpful because I was able to access it right off the bat." Unlike the other participants' experiences, Oliver's first mentor teacher provided him not with manipulatives, but with resources on educational theory:

> My associate teacher, he gave me resources by Van de Walle and others. … In those resources and guiding books it taught me some of the different ways to present the information to different learning styles. At the same time, it shows some of the common misconceptions that the students could have at a particular grade level, saying, "When students are learning about fractions, these are some of the common mistakes they make." Then, when I'm designing my lessons or that particular unit, I think "Okay, I understand this."

Lastly, Isabelle outlined how she adopted an online resource that was being used in her practicum class, stating:

> The resource that I liked was Knowledge Hook. It's an online program where the students were able to answer math questions based on the lesson, and they would get rewarded for it through medals or points. I thought that was helpful and it was a good way to bring technology into the classroom.

These excerpts demonstrate how participants who had access to a range of resources felt less anxiety towards lesson planning due to the wide range of materials they were able to adapt in comparison with participants' negative experiences in resource-limited classes.

Being Evaluated

In EPSTs' field experiences, they are generally evaluated by both their mentor teacher and a faculty advisor who conducts an observation of their class. For many of the participants, this experience of being evaluated when teaching mathematics heightened their MTA. In the case of Nicole, this evaluation put her under pressure to teach in a transmissive style, and she disclosed, "I wanted to get a good report for that placement, so I did what I needed to do." Likewise, Oliver received confusing messages from his mentor teacher, who used traditional instructional strategies, on how he should teach the class. He lamented:

> I did it more traditionally at first, and my associate teacher said, "No, you're not supposed to do that." I thought "I see, NOW you want me to use the new way, fine, I'll use the new way." She didn't give me a good review at the end.

For other participants, their concerns with being evaluated were focused on their faculty advisors. Discussing her heightened anxiety, Abby noted, "I was way more stressed for the first evaluation, but I don't think because of what I was teaching, I think just to impress [my advisor]." Emma reaffirmed Abby's statement, explaining, "The only time I was anxious about [being evaluated] was when the principal and my cohort leader came to see me, it was more intimidating." Courtney too described the additional anxieties prompted by her faculty advisor, as she was concerned about his perspectives of her pedagogical techniques. She described, "When my evaluator came in, it was frustrating because I thought 'Well, I've built a relationship with my associate teacher and the way I teach is based off of her, does it align with what he thinks?'" For these five participants,

the experience of being evaluated by their mentor teacher or faculty advisor contributed to their frustrations and anxieties during their mathematics teaching placements.

In contrast to her anxieties about her faculty advisor, Courtney was more relaxed about being evaluated by her mentor teacher. When discussing her first practicum experience, she explained, “I didn’t think of it as being evaluated, I took it as a learning opportunity. I understood the fact that I wasn’t going to be perfect, it was my first ever placement.” Similarly, Isabelle’s anxiety was not affected by the prospect of being evaluated, in part due to her mentor teacher’s approach to assessment and giving criticism:

> My associate teacher was always giving me feedback and telling me how I can better myself as a teacher. When she was evaluating me, I just felt like it was any other day because of the environment that we had created in the classroom and the relationship between the two of us.

Participants thus had varied anxious responses to being evaluated during their placements. Anxiety was increased for participants who disagreed with their mentor teacher about pedagogical style or during their faculty advisor’s evaluation, but others who received strong supports from their mentor teachers felt more relaxed about being assessed.

Working in Authentic Settings

The final subtheme to emerge from the analysis of participants’ field experiences was the effect of working in real classrooms. For a few participants, interactions with students during these settings helped to relieve their anxieties about teaching mathematics. Abby’s practicum in a Grade 6 classroom developed her mathematics

teaching self-efficacy through observations of her students' success. She stated, "When I saw them doing their practice … I thought it was great, my kids were doing so well at math." This experience also helped ease her fears regarding her lack of content knowledge. She recounted:

> I had a strong class, and even though they got concepts quickly, I taught them geometry and my associate teacher told me things I didn't even think about. He said, "Even though these students are good with numbers, when you add shapes, you're going to lose three-quarters of them." I thought, "Really? This is the easiest material!" It was interesting to see that the students who were usually done in ten minutes were struggling with concepts. I think it allowed me to see that they're not going to know everything right away. … It brought my anxiety down because you're afraid of the unknown, and when you're working with your students as they go, it's not like they're experts at math.

John had similar positive experiences with the students in his Grade 6 practicum. He mentioned how he was open about his anxieties with his students, disclosing, "I told the students, 'Math is not my strong suit. You might have the answer, just because I'm doing it one way doesn't mean that it's the right way.' I think that was positive." He was also able to turn an anxiety-provoking scenario with a student into a helpful experience. As he described:

> The first day I taught a math lesson, it was algebra, and one of the students said, "I think that answer you put there is wrong." In theory that's the worst nightmare, but I said, "Is it? What's the answer?" They said, "It's this," and I said, "Can you

> explain why?" It became a positive, it took away a lot of the anxiety about being wrong.

John also detailed how seeing student solutions helped lessen his anxiety about his content knowledge due to his limited prior experience with mathematics:

> I did a lot of diagnostic assessments, so I'd get them to give me their work and see what they were writing and what they were drawing. That helped me because I was seeing how they were approaching it, which helps with me being terrified of "You're finding this answer but you're doing it in a different way than me, I don't know how to help you."

Altogether, John felt more confident as a mathematics teacher after this practicum. As he summarized it, "It was a positive experience because I wasn't as worried about getting things wrong and the students all seemed to get it. Nobody seemed to be horribly scarred [laughing]."

In contrast, other participants' experiences working with students led them to develop new concerns about teaching. While Karen had not yet taught math, her practicum observations caused her to become more anxious about teaching mathematics due to the planning involved. She explained:

> Once I'd been in the classroom, I realized that even if you have a Grade 5 classroom, you might not have all Grade 5 level students. Planning for math in particular … you might be planning a unit for geometry and have to plan it at a Grade 3, Grade 4, Grade 5, Grade 6, Grade 7 level for your whole class. The planning seems like it could be a lot just for a 50-minute lesson.

She also felt anxieties about planning after realizing the special education needs in elementary classes, noting, “I was expecting there to be one or two people that might have an Individual Education Plan in your classroom, but not about half. I thought ‘Wow, that’s a lot to plan for.’” For Emma, her teaching anxieties were enhanced when she realized the classroom management needs of younger students. She described her experience in a Grade 1 class:

> It was a lot. I was there at the beginning of the year, and it was getting them to be able to sit on the carpet for ten minutes and to be able to focus on one thing instead of just running around. There was a lot of getting them used to Grade 1.

Finally, two participants noted how lacking certain opportunities to work with students contributed to their mathematics teaching anxieties. Emma experienced anxiety from only having taught primary level math, explaining:

> I’ve only had primary placements, so I think that’s where the anxiety comes from. … I’m sure Grade 6 math isn’t that difficult, I just haven’t taught it before, so I don’t know exactly what I’d be entering into with a Grade 6 class.

Nicole reiterated the negative impact of missing out on teaching opportunities. While she taught mathematics during her practicum, she had been pressured to use her mentor teacher’s transmissive style instead of the reform-based techniques taught in the methods courses. She clarified, “I would have loved to try different things. In that respect, I’m slightly nervous for being hired and trying strategies out because that will be the first time I have my own classroom.”

Working in authentic classroom settings thus had mixed impacts on participants’ anxieties. For some, it helped to alleviate anxieties about lacking content knowledge and

working with older students, but for others it substantiallycontributed to their teaching anxieties. Furthermore, participants were anxious when they lacked opportunities to work with different levels or test new teaching strategies.

This theme examined how participants' mathematical anxieties were influenced by their field experiences, as the other major component of teacher education, and noted connections to background characteristics. Participants generally found their mentor teachers to be a positive influence as they were approachable, supportive, and knowledgeable, though some participants had negative experiences when they were matched with mentors who lacked these characteristics. Similarly, in terms of instructional techniques, participants generally enjoyed practicums that used reform-based techniques and were frustrated when they felt pressure to teach in a traditional style, though one participant flourished using her mentor's direct teaching approach. In terms of the grade level that participants were assigned, those who taught in younger grades generally did not experience anxiety, but participants who taught junior and intermediate classes tended to be concerned with the content difficulty and meeting their students' needs. Participants' anxieties were overall reduced when they had resources at their disposal in their practicum classrooms or schools, though some participants were forced to search for their own materials online. In terms of being evaluated, participants' stresses were related to the relationship they had fostered with their mentor teachers, but they were often concerned about being assessed by their faculty supervisors. Finally, working in authentic settings allowed some participants to settle their anxieties by observing students experiencing success or calming concerns about students' abilities in

comparison to their own, while for others, this experience heightened their anxieties by observing the many needs present in today's classrooms.

Synthesis of Mathematics Methods Courses and Field Experiences

This theme relates to this study's final research question examining how EPSTs' mathematical anxieties are influenced by the interrelationships between methods courses, field experiences, and background characteristics. The three subthemes that emerged from the data analysis include (a) philosophical alignment, (b) use of resources, and (c) sequencing of the teacher education program.

Philosophical Alignment

Analysis of the data suggested that participants' mathematical anxieties were influenced by the degree of similarity between the philosophies of their methods courses and field placements. Overall, participants tended to experience a decrease in anxiety and enjoy their field experiences when they employed reform-based methods parallel to those used in their methods courses. Isabelle outlined the similarities broadly by stating:

> My associate teacher was teaching from the same textbook that we used in the math course, so I found that there was a lot of similarity between what I was learning in the math course and her style of teaching. I really enjoyed that.

Both Emma and John highlighted the similar philosophies of their methods course and field experiences by mentioning specific instructional strategies that were employed. Emma explained how she applied her course learning to her practicum teaching:

> I remember the instructor talked specifically about problem-based learning. That has resonated with me and I've taken it and applied it into my placements. … I

> really liked it and I've used it in both of my placements, and the students have responded to it well.

Similarly, John noted how the methods taught in his teacher education courses were like those utilized by his mentor teacher, and mentions the positive impact of these methods on student engagement in comparison to the traditional strategies used when he was in school:

> The second placement was very similar about trying to incorporate real-world applications of math and engaging students. My associate teacher was very open about that. … From doing that, I much preferred how we're being taught … and the way my associate teacher was teaching, compared to the traditional way because you could tell the students weren't as engaged.

On the contrary, participants whose field experiences did not resemble the innovative strategies presented in their courses tended to experience frustration and greater anxiety. Nicole directly outlined the disconnect between the teachings of her methods course and what she observed in her field experiences as follows:

> [With reform-based teaching] you're playing with materials, you would have centres set up, you'd do a number talk, your consolidation would be the whole class coming together to connect their learning, as opposed to what we see in our placements is [teachers saying], "Today we're learning about addition strategies and here's a strategy, here's a worksheet, go practice."

Oliver noted how his first mentor teacher discouraged him from applying authentic tasks promoted in his methods course. He highlighted when one of his ideas was rejected during his practicum, explaining, "I wanted the students to create math board games. My

teacher didn't like that … he said, 'Just do a test.' The consensus seems to be that at the end of a unit, it's better to have a test." Courtney also commented on the pedagogical differences and described a time when her mentor teacher rebuffed the notions presented in her methods course:

> The difference would be teaching styles … for example, my associate teacher never learned that you don't use red pen. She said, "That's dumb, that doesn't really matter," whereas we learned [in the course] that you do not use red pen because it gives a negative connotation to the red or induces anxiety when students see so many markings.

These varied experiences indicate that participants felt more at ease and enjoyed their field experiences more when they employed more engaging reform-based strategies in lieu of traditional styles, in contrast to the frustration experienced participants whose practicums did not align with the teachings of their methods courses.

Use of Resources

Akin to the effects of philosophical congruence, analysis of interview data demonstrated that participants' anxieties for teaching mathematics were reduced when they could make use of the resources from their methods courses as student teachers. John explained how he used the course textbook (Small, 2015) during his practicum, stating, "The textbook we had to buy for first year, *Making Math Meaningful,* was good. That was a great resource, it's one I've looked back at for ways to approach a lesson." Despite the demanding nature of her field experience, Emma also utilized this resource, explaining, "I used the Marian Small textbook during my placement as well … I liked it during school, but I'm surprised I opened a textbook in my placement because who has

time for that?" Nicole drew more broadly on the resources presented in her course, claiming that when looking for materials to use in her practicum lessons, "Between my math kit [from a colleague] and the notes from the math course, I was able to plan out my unit."

While no participants mentioned that they were unable to utilize course materials in their field experiences, Courtney, who had high MA and moderate MTA, described some wishes for the course to provide more resources. She claimed, "It would help if we were given more resources … like a key ring of different math games that we could use in the classroom or have on hand when we attend placements." She also expressed a desire for the course to have instructed the teacher candidates on using modern educational technologies, and how this would have made a positive impact in her field experience:

> I wish we had also learned how to use a Smartboard, especially because our focus is on the 21st century learner. … When I went to my placement, they had a Smartboard and the teacher had all these cool tips and tricks about how to do math on the Smartboard. I feel like that wasn't taught to me before, it was more having to learn [during practicum], which is fine, that's what placement is for, but I feel like if it was taught to use before we could impress rather than saying, "Oh, that's interesting."

These comments illustrate the benefits to participants of being able to make use of their course resources in their field experiences and the desire for greater exposure to teaching resources.

Sequencing of the Teacher Education Program

Finally, analysis of the qualitative data highlighted the importance of how methods courses and field experiences are scheduled during teacher education programs. In this program, mathematics methods courses are held in the first term of each year. The internship (a shorter, unevaluated practicum) and first field experience immediately follow the Year 1 methods course, the second field experience immediately follows the Year 2 methods course, with the last practicum starting halfway through their final semester. When participants taught mathematics during a practicum experience immediately after their first-year methods course, they generally experienced a decrease in their mathematical anxieties. Emma described how she enjoyed both learning different pedagogical strategies in the course and then using them as a student teacher:

> I think my first-year teaching math course was great at helping us figure out ways to teach instead of just saying "This is how you would teach this specific concept." It was nice that we could go into our placements right after that and then apply it to whichever grade we were teaching.

Likewise, Leah outlined how reviewing forgotten mathematics concepts and the new teachings of her methods course were beneficial to her subsequent field experience. She stated, "[The content] started coming back to me faster than I thought, and my placement was after my math course where I had already learned different strategies and different ways to show the same concepts."

In contrast, Karen had not yet been afforded the opportunity to teach mathematics in a practicum at the time of her interview, which affected her mathematical teaching anxiety. She explained, "I get slightly anxious because I haven't taught [math]. I didn't go into my structured experiences and do math at all, so the anxiety is not having been

able to practice it right away when I was learning it." In addition, John, who had high MA due to his low content knowledge and limited prior education, detailed the trouble he experienced as a result of not teaching math in his first year of the teacher education program. He claims it would likely have been beneficial for his mathematical understanding to teach math between his methods courses as follows:

> John: I think in second year we had better discussion about applications of math. I found those helpful sometimes, but again, a lot of the time it was so theoretical, and so it was hard thinking about approaches to math where I struggled to see the application in a classroom. If I were to do it again now that I've taught math in a classroom, I think I would be able to say "Okay, I understand where we're going with this."
>
> Sarah (researcher): Would it have been helpful to do your practicum in math first?
>
> John: Yes … if last year's placement, which was a rotary English placement, had been general Grade 6 I would have already done the math. I guess it was bad luck on my part.

The above excerpts highlight the benefits felt by participants of teaching mathematics soon after their methods courses and the importance of providing EPSTs with an opportunity to practice and observe their course learning in classroom settings.

This theme illustrated the interrelationships between methods courses, field experiences, and background characteristics as uncovered through analysis of this study's qualitative data. Overall, participants experienced decreased mathematical anxiety when their methods courses and field experiences utilized similar pedagogical techniques that were more engaging then traditional styles, when they could employ course resources in practicum teaching, and when their practicum in mathematics was scheduled following

their first-year methods course. In contrast, participants were frustrated, and their anxiety increased in situations when mentor teachers disagreed with methods course teachings, they did not receive enough resources, or their program scheduling did not allow for them to practice math teaching.

Anticipated Future Mathematics Teaching Style

This final theme emerged largely from participants' responses to Q9 of the interview protocol (Appendix B) and discusses how participants envision themselves teaching mathematics in the future. Two subthemes were apparent within this theme: (a) retaining elements of the traditional style, or (b) embracing reform-based techniques, both of which were in part influenced by their background characteristics.

Retaining Elements of the Traditional Style

When asked to envision their future teaching style in mathematics, one-third of the participants responded that they would maintain components of the traditional styles they were exposed to as K–12 students. Abby described how her perspectives on this matter aligned with those of her mentor teacher:

> I don't think there's anything wrong with the ways we learned [as K–12 students]. That's what Richard said to me, he said, "What's wrong with using a textbook? What's wrong with using a workbook? There's nothing wrong with it, you've just got to be able to incorporate other things." I want to be able to do both.

Both Isabelle and Oliver echoed Abby's sentiments, mentioning how they would balance traditional and innovative techniques. In response to Q9, Isabelle stated, "I think I'll have a mixed approach, traditional but also having that modern element." Oliver elaborated on this combined approach, providing his reasoning for this perspective:

> I would do probably half-half. … When you're introducing a new mathematical concept or term, you can't have a brainstorm session and have your students come up with all these terms themselves. You still have to directly teach it, and then you engage them in a hands-on activity, or you have a math congress or gallery walk. The bulk of the work I think is direct teaching, and then you start to slowly apply it.

Interestingly, the three participants who envisioned themselves using a combination of traditional and reform-based strategies were the only participants with any undergraduate mathematics experience.

One participant, John, responded that he would utilize reform-based techniques as described in the following section. However, he explained how he found reassurance in seeing teachers at one of his field experiences using traditional teaching methods successfully. He explained:

> To me, it's kind of comforting. At worst you can fall back on it because it seems to be working for them. For me personally that would be fine, I could go back to "Look up on the chalkboard, 2 and 2 is 4," but I could definitely see how students would not like that.

As demonstrated by these excerpts, data analysis highlighted how some participants anticipated using a combination of traditional and reform-based techniques, while others found relief in being able to resort to traditional methods if necessary.

Embracing Reform-Based Techniques.

In contrast to Abby, Isabelle, and Oliver's views of their future pedagogical approaches, the remaining two-thirds of participants wholeheartedly embraced the

reform-based pedagogy introduced in their teacher education program. Courtney, who claimed she never enjoyed math in her past, stated that she wanted to make mathematics fun for her future students as she did in her field experiences:

> I envision myself teaching math in a playful way. I think that's the way I did it in my associate teacher's classroom, I tried to make everything a game. … I try to make it interactive so it's not just blank stares and worksheets.

She elaborated on this approach by highlighting the benefits of using games to reach students of different abilities by saying, "I feel like giving students equal opportunity and using games you can be more interactive and fun because you can also differentiate instruction." Several other participants also noted their desire to use differentiated instruction in their future teaching practice. Emma reflected these notions when she claimed, "Giving students options on how they learn, whether that's the way that I would learn it or not. … I think giving them a million things that they can use to help them along will definitely be implemented." Likewise, Nicole explained her views on using differentiation to help both students who are having difficulties and those who are performing well in mathematics as follows:

> I hope to make math fun, and I hope I have the knowledge that I need to be able to differentiate for my students appropriately. It's easy to work with kids who get it and not to spend time with the ones who don't, or vice-versa where you spend a lot of time with the ones who don't. In that case I'd like to be able to know how to keep the students who do get it moving forward so they don't stagnate while I'm spending time with the ones who require more support.

Finally, Leah outlined her desire to use differentiation as a tool to prevent students from experiencing the same difficulties in mathematics that she did:

> I'd like to show as many different ways as possible to solve one math problem, or depending on what they're learning, give students the freedom to solve it on their own without showing them how. Just differentiating as much as possible so that no student develops anxiety like I did.

When describing how they envision their futures as mathematics teachers, four participants mentioned how they hope to make course learning relevant to their students through real-life applications. John described how he feels applications are beneficial for both student engagement and his own comfort level:

> I think my style is going to be to try and link concepts to the real world through application … partially because that's what I'm comfortable with and partially because I think that's what keeps people interested. I'd really like to make it an open kind of learning as opposed to a fixed style of, "This is what we're doing, this is how we're going to do it" … but instead, "We're going to learn fractions," but try to make how we figure out fractions as open as possible. … In a perfect world, I'd say "Okay, we're doing an hour of math on fractions" and now 20 little people will go off and figure out their own ways of doing fractions and I'd be able to walk around and help everybody.

Similarly, Karen felt that it was important for students to understand the importance of what they were learning. She stated:

> I'd like to make it relevant to the students, so when we're teaching different concepts, to say why it's important to know it and where it would lead to … always being able to connect it to real life situations, why they would need it.

Moreover, she described how she'd like to use a variety of instructional strategies to present course material, as she hopes to "use storytelling and use interesting ways of

teaching it, not only relying on the textbook, because that would be pretty boring." Leah echoed Karen's sentiments on the benefits of connecting material to the real world, declaring, "I'd like to show concepts in as many ways as possible and allow students as much freedom as possible, and making it applicable to real life is something that could benefit them." Likewise, Nicole supported making material relevant to students using cross-curricular approaches as follows:

> My philosophy is that I'd like to see more integration with all subjects, so it's less "Math is done, pack it up, we're moving on to this subject," but a more interdisciplinary approach. … I think that's how kids learn best, you have to make it relevant and applicable. If you stick with the subject-centred approach your learning is very surface.

These comments illustrate how the majority of participants adopted the reform-based strategies for mathematics teaching presented in their teacher education program, expressing the desire to make mathematics engaging, differentiate content, and incorporate real-world applications to make content relevant to their future students.

As emerged from the analysis of participants' responses to Q9 of their individual interviews, this theme illustrates how participants anticipate their pedagogical approaches as future elementary mathematics teachers. One-third of participants embraced some elements of the newer innovative techniques presented in their teacher education program, while retaining core elements of the traditional style utilized when they were K–12 students. In contrast, the other two-thirds of participants expressed a strong desire to base their future practice on newer pedagogical techniques, which included a variety of

ways to make mathematics more exciting, approachable, and relevant for elementary students.

Summary

The analysis of the data highlighted participants' background characteristics, anxieties towards mathematics, and how their teacher education program influenced their mathematical anxieties. First, this chapter presented the quantitative results collected and analyzed from the nine participants' online questionnaire responses in Phase 1. Quantitative data were divided into the following categories based on the individual questionnaire items (Appendix A): (a) participant demographics, (b) experiences in elementary and secondary mathematics, (c) level of mathematical anxieties, and (d) experiences in the teacher education program. These results were then connected to the second phase of the study through adjustments to participants' unique interview protocols (Appendix B). Next, results from Phase 2 of the study were presented which included six major themes. The first two themes highlighted (a) participants' prior experiences with mathematics and (b) their anxieties towards mathematics. The following three themes were guided by this study's research question examining the ways in which teacher education programs impact the mathematical anxieties of EPSTs, connected to participants' background characteristics where evident. These themes included (c) the influence of mathematics methods courses on mathematical anxieties, (d) the influence of field experiences on mathematical anxieties, and (e) the synthesis of mathematics methods courses and field experiences. The final theme discussed participants' anticipated future mathematics teaching styles. The following chapter presents a

discussion of these themes in relation to the existing literature, implications for both practice and theory, and provides suggestions for future research.

CHAPTER FIVE: SUMMARY, DISCUSSION, AND IMPLICATIONS

Improving elementary level mathematics education has been a significant priority for Ontario's Ministry of Education in recent years. Over the past decade, the EQAO's annual assessments of elementary students' mathematical abilities has demonstrated a steady decline in achievement. The most recent 2018/19 EQAO tests show record low results of only 58% of Grade 3 and 48% of Grade 6 students meeting the provincial standard in mathematics (EQAO, 2019). This declining trend in achievement is one of the factors that contributed to the launch of a $60 million renewed mathematics strategy in 2016 and another $200 million strategy in 2019 (Ontario Ministry of Education, 2016, 2019). At the elementary level, these strategies have included changes such as dedicating 60 minutes per day to mathematics instruction and hiring school and board-level lead educators who specialize in this subject. Changes have also been made to support and assess elementary teachers' mathematical abilities, including enhanced professional development opportunities and the introduction of the Mathematics Proficiency Test as a requirement for teacher certification in Ontario (EQAO, 2020).

These measures reflect the significance of elementary teachers' comfort level and expertise in this curricular area. In Ontario, most elementary teachers have educational backgrounds unrelated to mathematics, with only 2% having majored in this subject during their undergraduate program (Casey, 2017b). However, potentially more significant is the lack of confidence and sense of discomfort many elementary teachers feel towards mathematics. A high percentage of elementary teachers experience MA (Brady & Bowd, 2005), which is often harmful towards teachers' sense of self-efficacy in teaching this subject (Gresham, 2008). Elementary teachers' MA has been found to have

many harmful impacts on their pedagogical approaches, including spending less time teaching mathematics and relying on transmissive instructional strategies (Brady & Bowd, 2005; Gresham, 2008). Moreover, teachers' MA can have damaging impacts on their students, as it has been found to contribute to lower levels of achievement (Chang & Beilock, 2016) and the development of negative attitudes towards mathematics (Beilock et al., 2010; Boaler, 2016).

The purpose of this study was to examine the impact of a teacher education program on EPSTs' mathematical anxieties. This study focused on the experiences of pre-service teachers, who experience MA at disproportionately high levels (Gresham, 2007), as they prepare to begin their careers. A review of the literature shows that EPSTs often develop MA from their prior experiences as mathematics students (Brady & Bowd, 2005; Fiore, 1999; Olson & Stoehr, 2019), and that the mathematics methods courses and field experiences in their teacher education programs can have significant impacts on their level of anxiety (Brown et al., 2012; Reid & Reid, 2017; Tooke & Lindstrom, 1998). Furthermore, this research was conducted within the context of the recent changes to teacher education in Ontario, which increased the program length from two to four semesters and doubled the time pre-service teachers spend in field experiences (Ontario Ministry of Education, 2013). Participants in this study were part of the third and fourth cohorts of this new program, providing the opportunity to examine how this new program is impacting EPSTs' MA and MTA. As a result, this study addressed the major research question: In what ways does the examined teacher education program impact the mathematical anxieties of EPSTs? Three subquestions aim to explore the impact of the two major mathematics-related components of teacher education programs, mathematics

methods courses and field experiences, their connections to EPSTs' background experiences, and the interrelationships between these three factors. In this way, this study examined the impact of these distinct elements of teacher education in relation to participants' personal histories and addressed gaps in the literature regarding the impact of field experiences and their synthesis with methods courses. Spielberger's (1966) conception of state and trait anxiety as two distinct facets of one's mathematical anxieties, often employed in studies of MA (Hannula, 2018; Roos et al., 2015), provided the conceptual framework to guide this research. In addressing these questions, this study offers implications for teacher educators, faculty administrators, mentor teachers, and policy makers in the province of Ontario.

Summary of the Study

This study examined the impacts of a teacher education program on EPSTs' mathematical anxieties using an explanatory sequential mixed methods approach. Informed by a constructivist epistemology (Kahlke, 2014), emphasis was placed on qualitative methods (i.e., quan → QUAL) to explore participants' unique perspectives, with quantitative methods playing a supplemental role (Morse, 2006). In total, this study involved nine participants, all EPSTs in the Primary/Junior (Grades K–6) and Junior/Intermediate (Grades 4–10) consecutive teacher education program at a mid-sized Ontario university.

Data collection involved two distinct phases. Phase 1 included the collection of quantitative data using online questionnaires focusing on participants' background characteristics (Appendix A). Participant responses were then analyzed using descriptive statistics such as frequency and measures of central tendency to discover overall trends in

the data (Plano Clark & Creswell, 2015). Next, quantitative and qualitative methods were mixed through connection by using participants' unique questionnaire responses to adjust their individual interview protocols (Appendix B; Ivankova et al., 2006). Phase 2 then focused on qualitative data, as individual semi-structured interviews were conducted with each participant. The development of these interview items was guided by the conceptual framework and the literature and employed a semi-structured format to provide flexibility to explore data emerging *in situ* (Tilley, 2016). Using a denaturalized approach (Oliver et al., 2005), I personally transcribed each interview, which allowed me to remain close to the data (Mero-Jaffe, 2011), and participants were provided with the opportunity to conduct a member check of their transcript to maintain a strong relational ethic (Tracy, 2010). Next, the qualitative interview data were analyzed thematically using the constant comparative method (Bogdan & Knopp Biklen, 2003), continually developing codes and categories to capture emergent meanings and construct an understanding of participants' experiences and perspectives (Yilmaz, 2013). Quantitative and qualitative results are again mixed through integration (Ivankova et al., 2006) in the discussion of the study's results below, allowing for triangulation and crystallization of the data sources (Tracy, 2010).

Analysis of the data uncovered trends and themes related to EPSTs' background characteristics, mathematical anxieties, and the influences of their teacher education program. Firstly, quantitative data analysis highlighted participants' demographic data and revealed trends in their past experiences with mathematics, which were increasingly negative as they progressed through elementary and secondary mathematics classes. Quantitative data analysis also found that participants' unique levels of MA and MTA were similar, and they had a range of opinions regarding how their teacher education

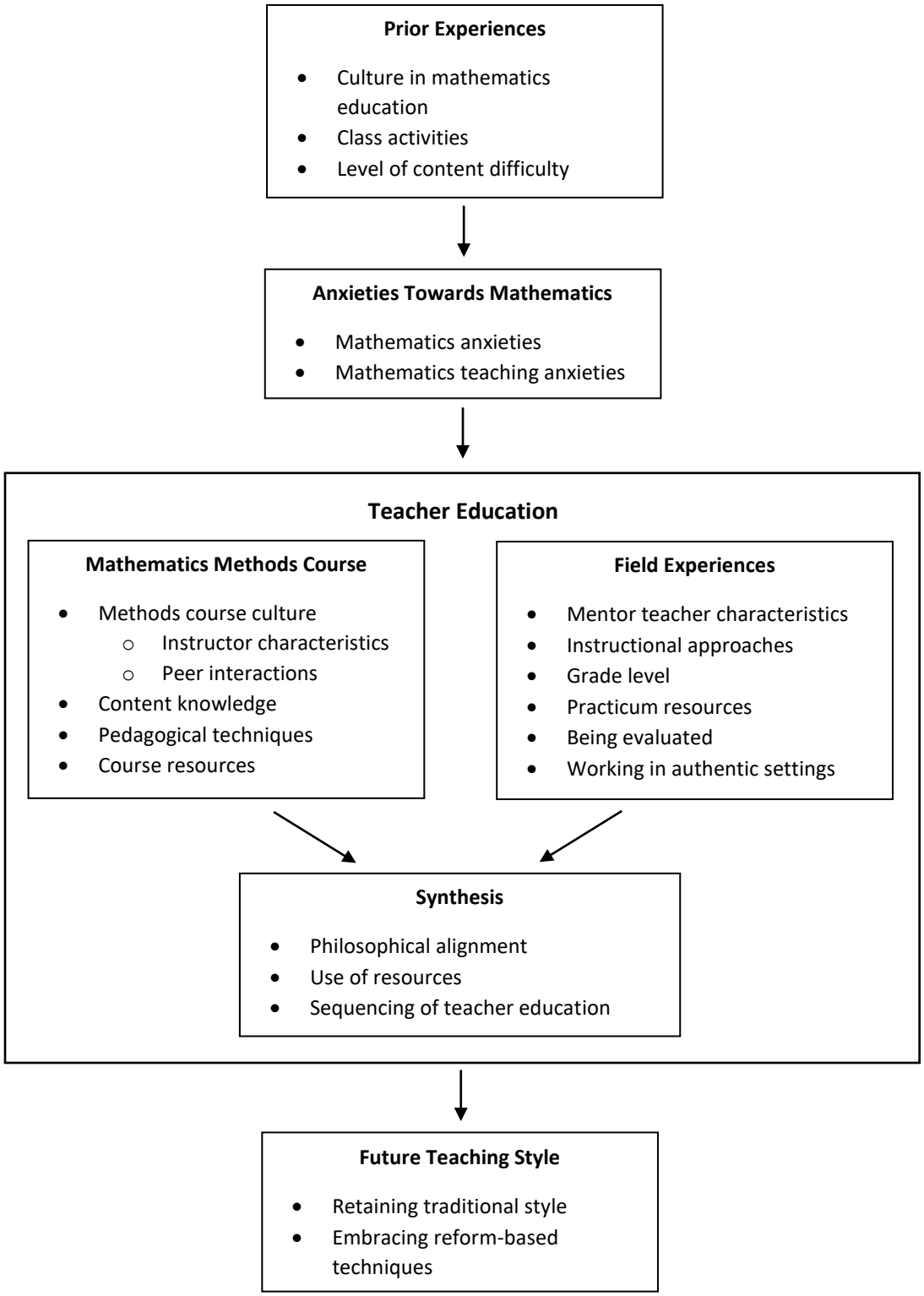
programs impacted these anxieties. Next, qualitative analysis uncovered six major themes pertaining to participants' mathematical anxieties: (a) participants' prior experiences with mathematics, (b) participants' anxieties towards mathematics, (c) the influence of mathematics methods courses on mathematical anxieties, (d) the influence of field experiences on mathematical anxieties, (e) the synthesis of mathematics methods courses and field experiences, and (f) participants' anticipated future mathematics teaching style. These themes highlight a range of ways in which participants' diverse past experiences with mathematics influenced their anxious sentiments (or lack thereof) towards mathematics. Furthermore, results illustrated how the diverse components of pre-service teacher education alleviated or augmented participants' trait levels of anxiety towards doing and teaching mathematics, as well as uncovering stimuli that provoked state anxious reactions in such programs. Accordingly, results demonstrated how these experiences with and changes in levels of MA impacted how participants envision themselves teaching mathematics in the future. As with all primarily qualitative research, this analysis was inevitably influenced by my positioning (Watt, 2007) as a recent graduate a consecutive teacher education program, giving me strong contextual knowledge (Tilley, 2016), with a strong background in mathematics. The following sections integrate quantitative and qualitative results revealing their connections to the existing literature, and highlight implications for practice, theory, and future research.

Discussion

This section provides a discussion of results, integrating the quantitative and qualitative findings from both phases of the study. Figure 5 illustrates the relationships between the study's major themes outlined in Chapter 4. Each of these themes is a critical element of EPSTs' experiences with and attitudes towards mathematics, impacting their

Figure 5

Influence of Mathematical Anxieties on EPSTs' Development as Mathematics Teachers



development as elementary teachers. As outlined in Figure 5, participants' prior mathematical experiences influence their anxieties towards the subject, which are formed before participants commence their teacher education programs. During teacher education, participants' mathematical anxieties are impacted by their experiences in mathematics methods courses, field experiences, and the interrelationships of these two components, while still retaining the influences of their background characteristics. Finally, the combination of these experiences with participants' mathematical histories influence their formation of an anticipated teaching style for their future careers. These connections, as outlined in Figure 5, shape the discussion of the study's results.

Prior Experiences with Mathematics

This section focuses on how participants' prior experiences with mathematics, as both K–12 students and after graduating from secondary school, are largely reflective of the literature. Firstly, participants' demographic characteristics are reflective of statistics of in-service elementary teachers in Ontario. Of the study's nine participants, only two, John and Oliver, were male. Furthermore, both of these participants were in the Junior/Intermediate program aimed at preparing students to teach in the upper elementary grades, while all Primary/Junior participants were female. Provincial and national statistics outline that women comprise a significant majority of elementary teachers, as 80% of those in Ontario (Little, 2017) and 84% of those in Canada (Statistics Canada, 2018) are female. Though this study was primarily qualitative and thus only involved a small sample of participants, the sample's composition by gender is reflective of the wider gender divide in elementary teachers.

Participants' prior undergraduate education also mirror measurements of Ontario's elementary teachers. No participants had a major or minor in mathematics from their undergraduate programs; two of the nine participants had science-based degrees, and the remainder completed programs in the arts or humanities. Only one-third participants had taken undergraduate level mathematics or statistics courses, between one and three classes each, and none of these classes were elective. In addition, one-third of the participants had not taken any mathematics classes since Grade 11, the minimum graduation requirement in Ontario. These statistics are similar to those of in-service elementary teachers in Ontario, as many of Ontario's elementary teachers have not completed mathematics since secondary school (Brown, 2013) with 82% having degrees unrelated to the subject (Casey, 2017b). While Kajander et al. (2013) recommend that EPSTs complete at least one undergraduate mathematics course prior to their teacher education programs, this was only true for one-third of the participants.

Analysis of participants' time as students in Grades K–12 reflects experiences found in the existing research to increase susceptibility to MA. For some, these experiences began in elementary school. A majority of participants rated their experiences in early elementary school, Grades K–3, highly, with an average rating of 4.44 (SD = 0.73) on a scale of 1 (mostly negative) to 5 (mostly positive). However, when asked about any notable memories from these elementary grades, several described activities and instructional techniques that left a harmful impression. These included speed -based activities, where students were required to complete mathematical operations under time pressure and often in front of their peers. Furthermore, these activities involved difficult concepts like multiplication tables, which required significant memorization. Another participant mentioned the worry she felt when her teacher would

return evaluations by achievement level, categorizing students by mark and announcing the results to the class. These experiences reflect participants' histories with math abuse (Finlayson, 2014; Fiore, 1999) and demonstrate the resulting early anxieties they felt towards mathematics, reflecting Maloney and Beilock's (2012) findings that MA can develop as early as Grade 1. Furthermore, participants' worries caused by the public nature of these activities and strategies echo themes in the literature of fears relating to performance (Finlayson, 2014; Stoehr, 2017a, 2017b) and peer interactions (Wilson, 2018), as MA can be heightened with feelings of embarrassment in front of one's peers.

Other participants felt their early elementary experiences were largely enjoyable, but they began to develop negative mathematical attitudes in the intermediate and senior grades. Analysis of participants' questionnaire responses reflects a lower rating of the upper elementary grades, with a 0.55-point decrease in mean rating to 3.89 (*SD* = 1.17) in Grades 4–8. Several participants noted the struggles they experienced with material introduced during these grades, such as algebraic representations and fraction-based concepts. For a few of these participants, their negative mathematical attitudes were heightened as upper elementary students, reflecting Suárez-Pellicioni et al.'s (2016) observation that MA is often present in individuals between the ages of 10–14. A majority of participants' adverse sentiments became even worse during their years in secondary school. Ratings of their Grade 9–12 experiences were the lowest of all levels at a mean of only 3.00 (*SD* = 1.56). Participants' achievement levels also declined during secondary school, as their mean achievement of 3.44 (*SD* = 0.73) in Grades 4–8, which lies between mostly B's (70–79%) and mostly A's (80–100%), fell to only 2.67 (*SD* = 1.00) in Grades 9–12, now between mostly B's and mostly C's (60–69%). Several

participants described the content difficulty during these grades, stating how they felt immense relief at passing these courses and stopped taking math as soon as possible. For many, these negative secondary school experiences left a damaging impression of mathematics that they maintained for many years. Stoehr (2017b) notes how these math-anxious feelings are common in EPSTs, and that many pursue teaching despite these anxieties as is true of this study's participants. Several participants made both positive and negative comments about their teachers during these upper elementary and secondary grades. Some stated their teachers were monotonous or were not observant enough to recognize their struggles and provide individualized coaching. On the contrary, other participants described teachers who were welcoming, encouraging, and dedicated to providing extra support. While Brown et al. (2011) note that EPSTs with MA often recall memories of teachers who were unsympathetic and unhelpful, this study's participants instead had a variety of beneficial and damaging experiences with their own teachers.

Anxieties Towards Mathematics

This section features a discussion of how participants' anxieties towards mathematics, largely shaped by their past experiences with the subject, align with findings in the existing literature. The first of these anxieties is MA, or anxiety about doing mathematics. Participants had a mean MA rating of 5.22 (SD = 2.33) when asked to rate their anxiety on a scale of 1 (not anxious) to 10 (very anxious) as utilized by Ashcraft (2002). This reflects that participants had moderate levels of MA on average, but the range of participants' responses from 2 out of 10 to 8 out of 10 suggests there are substantial differences between individual participants. When divided by program, participants in the Primary/Junior (Grades K–6) program had higher MA than those in the

Junior/Intermediate program (Grades 4–10), with means of 5.80 (*SD* = 2.17) and 4.50 (*SD* = 2.65) respectively. Kalder and Lesik (2011) note that teachers of higher grades have less anxiety towards mathematics, which is true in the case of this study's participants; however, this is usually because these teachers specialize in mathematics instruction. As no participants in this study specialize in mathematics, this difference may instead be reflective of the fact that two of the four Junior/Intermediate teachers completed multiple mathematics courses in their undergraduate programs. Furthermore, while an individual's MA generally increases in secondary school (Brady & Bowd, 2005), all but one of these Junior/Intermediate teachers rated their experience in Grades 9–12 mathematics as mostly positive and thus did not experience this same negative impact.

For participants who rated their MA at or above the median rating of 6 out of 10, some had long-standing adverse opinions of the subject. These included mentions of having never enjoyed or felt positively towards mathematics, again revealing that an individual can start experiencing MA in early elementary school (Maloney & Beilock, 2012). Other participants demonstrated their fixed mindsets towards the subject (Dweck, 2006) as they remarked that they are not a "numbers person" or labelled themselves as someone who, despite their successes in other areas, would always be incompetent in mathematics. Anderson et al.'s (2018) describe how this false notion about mathematical capabilities described by several participants is a common myth, and it can be a significant factor in an individual's anxious sentiments about mathematics (Boaler, 2016). That these moderate and high-MA participants still opted to enroll in their teacher education program is again reflective of Stoehr's (2017b) finding that many teachers

pursue careers in education despite their aversion to mathematics. Participants also felt anxious about their limited mathematical content knowledge, with John specifically noting how he lacks a depth of understanding in mathematics in comparison with other subjects. He and others remarked that they felt nervous about the amount of time that had passed since they were mathematics students, and they held concerns that they had forgotten specific processes and would need to re-learn concepts. These worries align with the literature about EPSTs' MA, as Bates et al. (2013) highlight how a lack of content knowledge is a common fear for EPSTs. Moreover, Brown (2013) discusses how much of this population have not had formal mathematics training since high school, leaving them prone to issues of recalling procedures and conceptual ideas as is true for this study's participants.

The second mathematical anxiety that this study examined is mathematics teaching anxiety (MTA). Participants' mean MTA rating on a scale of 1 (not anxious) to 10 (very anxious) was moderate at 5.44 (SD = 2.60), only slightly higher than the mean MA rating of 5.22 (SD = 2.33). There was a larger range of 9 points, from 1 out of 10 to 10 out of 10, in participants' MTA ratings in comparison with the 6-point range for MA. However, participants' individual MA and MTA scores were generally similar, with no ratings having a difference of greater than 2 points for any one participant. Thus, participants' unique levels of MA were consistently close to their level of MTA as evident in Figure 4. From these results, it is evident that participants were able to discriminate between their level of anxiety about mathematics and their anxiety about teaching mathematics, akin to the results in Brown et al.'s (2011) research. Though this study only uses a small participant sample, its results reproduce findings from existing

literature that one's MA and MTA are often, but not always, related (Brown et al., 2011; Olson & Stoehr, 2019) and that MA has a positive moderate relationship with MTA in EPSTs (Hadley & Dorward, 2011; Peker & Ertekin, 2011).

Analysis of this theme uncovered many similarities between participants' anxieties about teaching mathematics and those described in the literature. Firstly, many participants were again concerned about a lack of mathematical content knowledge, now as related to teaching purposes. Some participants described how their lack of mathematical ability makes them concerned about providing coaching or understanding students' various problem-solving methods. For others, these anxieties were connected to the difficulties of the mathematics curriculum in higher grades. Many participants felt daunted by upper elementary content as they struggled to understand the material and were thus concerned about how they would be able to teach these grades. Again, these results echo Bates et al.'s (2013) findings that lacking content knowledge is a common source of worry for EPSTs. A lack of ability to incorporate content and pedagogy was also mentioned by one participant, John. This concern reflects Thames and Ball's (2010) claim that EPSTs do not only require content knowledge, but a combination of both content and pedagogy in mathematics, known as pedagogical content knowledge (Shulman, 1987). The importance of this connection was also highlighted by Kajander et al. (2013) as a recommendation for the four-semester teacher education program in Ontario (Ontario Ministry of Education, 2013). Another group of participants felt capable in their mathematical understanding but were concerned with their pedagogical skills. These worries included the ability to explain simple concepts and review fundamental skills, meeting the needs of students with diverse abilities, and the

responsibility of conveying information to a new generation of students. These worries are consistent with Brown et al.'s (2011) discovery that EPSTs who feel relatively comfortable with mathematics are sometimes concerned with their ability to provide comprehensible explanations and differentiate instruction.

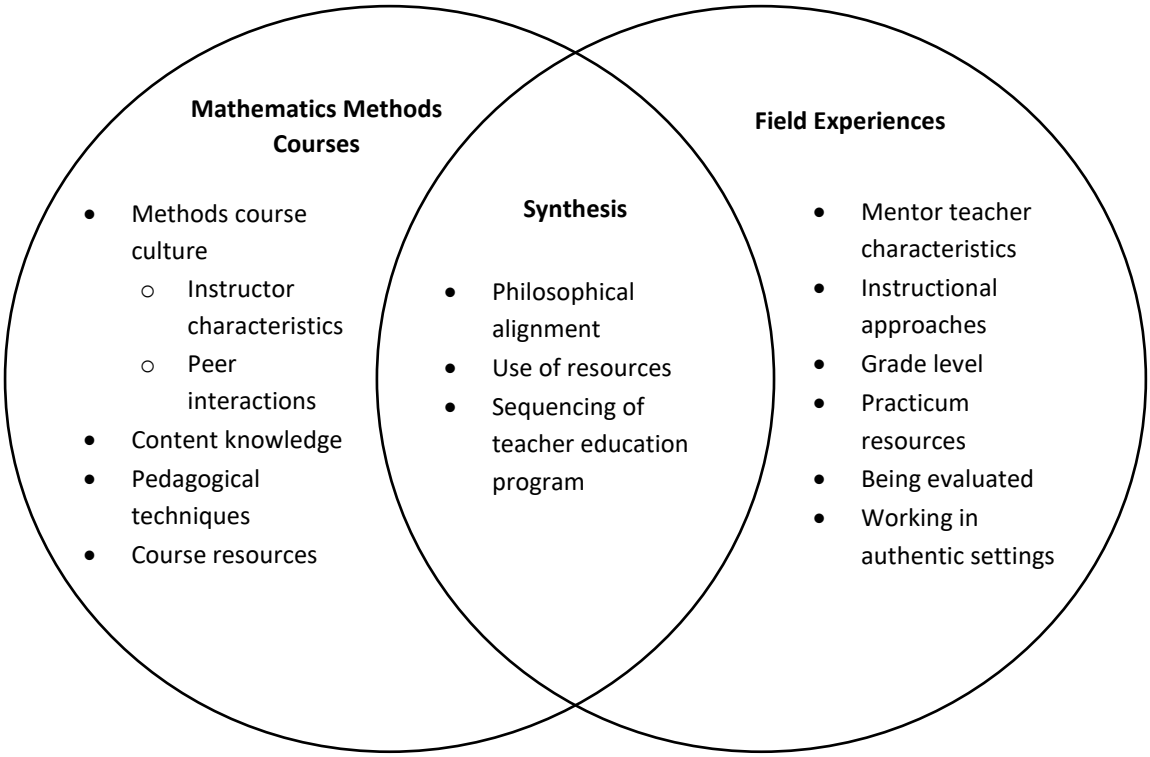
Finally, several participants noted that they were concerned about causing their students to have negative attitudes or difficulties with mathematics like those they experienced in Grades K–12. This notion aligns with Olson and Stoehr's (2019) claim that math-anxious EPSTs often worry about confusing their students, and Gresham's (2018) finding that these EPSTs associate their students with their past selves. This reflection is not always a source of anxiety, however, as Abby felt motivated to use her past experiences to provide her students with a different perspective. This provided her with higher confidence for teaching mathematics than would be expected of an EPST with her level of MA, similar to Brown et al.'s (2011) findings.

Influence of Teacher Education Program on Mathematical Anxieties

The purpose of this study was to examine the impact of a teacher education program on the mathematical anxieties of EPSTs. To achieve this aim, this study examines the impacts of mathematics methods courses and field experiences, as the major components of teacher education programs, and their interrelationships, highlighting connections to participants' background experiences. Figure 6 highlights the major themes that emerge from the data analysis of participants' experiences in their teacher education programs. These findings are detailed below in connection to the literature.

Figure 6

Impacts of Teacher Education on EPSTs' Mathematical Anxieties



Influence of Mathematics Methods Courses on Mathematical Anxieties

The focus of this section is how participants' mathematical anxieties are affected by their mathematics methods courses, and how these impacts align with the literature on EPSTs' MA. Analysis of the data uncovers themes of participants' course culture, as influenced by their instructors and peers, playing a considerable role in their level of anxiety. When discussing their experiences in their mathematics methods courses, many participants praised their instructor's enthusiasm, positivity, and ability to make their mathematics course entertaining, citing these factors as reasons they felt more comfortable with mathematics.

These commendations reflect the indispensable role of methods course instructors who are welcoming and excited about mathematics as described by Reid and Reid (2017). One participant in her second year of the program, Abby, highlighted drastic differences between the instructors of her two courses. While she described her great admiration for her Year 1 course instructor, she notes her second-year instructor displayed negative attitudes and was overall unengaging. Again, this reflection demonstrates how having instructors who display enthusiasm for mathematics is a critical component of methods courses (Reid & Reid, 2017), as lacking this passion caused Abby to experience an increase in MA. In addition, Abby stated how her Year 1 methods course instructor's positivity and use of engaging reform-based methods served as a model for the kind of teacher she aspired to become. This is consistent with Reid and Reid's (2017) discussion of the importance of teachers' positive attitudes and their modelling of reform-based strategies in their methods courses.

Participants also noted their instructor's role in fostering a positive classroom culture. There were many instances when participants commented on their instructors'

ability to create a safe and welcoming atmosphere, provide much-needed encouragement, and support students' mathematical self-efficacy and development of a growth mindset towards mathematics. While many participants had substantial anxiety towards learning math, consistent with the literature on EPSTs (Stoehr & Olson, 2017), these efforts by course instructors helped participants overcome these worries, reflecting the importance of having methods course instructors who provide a safe course atmosphere (Reid & Reid, 2017). Furthermore, through their instructors' promotion of self-efficacy, participants were able to realize many of the benefits of having a growth mindset towards their mathematical abilities (Anderson et al., 2018; Boaler, 2016; Dweck, 2006).

Themes of participants' peer interactions during their methods courses also emerged from the data analysis. Many participants, especially those with high ratings of MA, commented on how they were given the opportunity to share their mathematical anxieties openly with their classmates. This conversation was significant in helping reduce MA as participants realized many of their peers also had limited prior experience and were similarly concerned about learning and teaching mathematics, especially in the higher grades. These comments not only reflect the aforementioned importance of a safe classroom atmosphere (Reid & Reid, 2017), but also that participants felt the benefits of discussing their anxieties with their classmates as noted by Liu (2008). Methods courses also included peer collaboration in small-group problem-solving activities. Participants with high MA remarked that, through these activities, they observed that their peers also struggled with mathematical content. Others noted how students with strong mathematical backgrounds used their knowledge to help their peers and did not overwhelm the discussion. This finding is consistent with Gresham and Burleigh's (2019)

claims regarding the benefits of a positive classroom atmosphere. Finally, participants highlighted the benefits of having students practice teaching in small-group and whole-class activities, as they were able to learn from their peers and collect resources for their future practice. These results reflect ideas in the existing literature regarding the advantages of peer teaching opportunities (Gresham & Burleigh, 2019), peer-supported learning (Korthagen, 2010b), and the benefits of gathering specific instructional strategies during methods courses (Looney et al., 2017).

Another factor pertaining to participants' methods course experiences is their mathematical content knowledge. This theme is most significant in relation to the mathematics refresher course that participants completed in advance of their first-year methods course, a strategy that has been implemented in several Ontario Faculties of Education (Brown, 2016). As described in Chapter 4, this course was comprised of a criterion-referenced diagnostic quiz, followed by learning modules to review elementary mathematics content, and a final quiz for students to observe their level of improvement as a means of formative assessment (Drake et al., 2014). Many participants who had high levels of MA and limited mathematics training felt concerned about their ability to successfully complete the assessment and learning modules integrated in this online platform due to the content difficulty. Additionally, this diagnostic led them to worry about whether they would be successful in their methods course. These anxieties are consistent with the common fears amongst EPSTs about learning mathematics (Olson & Stoehr, 2019) and lacking mathematical content knowledge (Bates et al., 2013). One participant, Courtney, noted how she required tutoring from friends and family to review mathematical concepts in the diagnostic. In Reid and Reid's (2017) research, they

describe a program that provides additional coaching for EPSTs who score poorly on diagnostic assessments, and Courtney's experience suggests that she would have found this beneficial.

Other participants spoke more positively about the diagnostic assessment and review, as well at the mathematics content covered during the remainder of the methods course. Several participants claimed that the refresher course helped them recall content from the elementary mathematics curriculum, with Karen in particular noting her surprise at her success considering she had not completed any mathematics courses for nearly two decades. Many participants also described how the course increased their mathematical confidence and feelings of preparedness to teach mathematics, with some remarking that they would benefit from completing the diagnostic on a more frequent basis. Because many of the participants had not completed mathematics training since high school, consistent with many EPSTs in Ontario (Brown, 2013), this diagnostic assessment and review component of their methods course helped strengthen participants' foundational content knowledge, similar to results found by Reid and Reid (2017). Finally, during the face-to-face classes of the methods course, participants noted how they were able to expand their mathematical understanding through strategies such as the use of manipulatives. This finding is consistent with several studies noting the positive impacts of reform-basedinstructional strategies on EPSTs' mathematical understanding (Barrett, 2013; Gresham, 2007; Lake & Kelly, 2014; Quinn, 1997).

Mathematics methods courses not only review the content knowledge required for elementary education, but also give EPSTs an understanding of pedagogy and different instructional strategies. Tooke and Lindstrom (1998) note that courses emphasizing this

combination of both content and pedagogical knowledge helps to address EPSTs' mathematical anxieties. However, when this study's participants were asked to rate how their methods courses have influenced their mathematical anxieties on a Likert scale from 1 (significantly decreased) to 5 (significantly increased), results were varied. Five of the nine participants claimed the course had somewhat decreased (2) their anxieties, but the mean rating reflected nearly no change at 2.89 (*SD* = 1.17). Participants who felt the course lessened their anxieties mentioned how they benefitted from learning different approaches to teaching mathematics and techniques to help and encourage students with varied abilities. Karen particularly noted how her instructor helped her bridge the differences between the traditional methods she was familiar with from her past and the newer innovative techniques. These participants' experiences reflect findings in the literature regarding the benefits of instructors using multiple strategies (Gresham & Burleigh, 2019) and reform-based techniques to teach methods courses (Reid & Reid, 2017). Furthermore, multiple studies demonstrate how learning reform-based pedagogical strategies can decrease EPSTs' mathematical anxieties (Brown et al., 2011; Levine, 1993), which is consistent with the reflections of these participants.

Conversely, some participants felt their mathematics methods courses amplified their anxieties, specifically in terms of teaching mathematics. John was overwhelmed when learning these instructional techniques as he lacked the grounding in mathematics to connect content and pedagogy, again demonstrating the impact of his content-based fears (Bates et al., 2013). Other participants felt the pressures of engaging all students when learning about pedagogy in their methods courses. Some commented on the challenges of having to teach concepts in a different manner than the traditional way they were taught, which contradicts with Brown et al.'s (2011) finding that exposure to

reform-based strategies decreases EPSTs' MTA, but reflects Tait's (2006) claim that new conceptual understandings often require a paradigmatics shift from EPSTs' past experiences. Instead, the methods course made other participants aware of the varied pedagogical elements required in lesson planning, such as the influence of the classroom environment and making accommodations for individual students. These concerns are similar to findings from Brown et al. (2013) regarding EPSTs' concerns about planning and students' engagement, as well as Gresham's (2018) finding that in-service teachers' anxieties were influenced by the challenges of teaching.

Lastly, the variety of resources utilized in the mathematics methods course generally helped to ease participants' mathematical anxieties. Participants discussed how they were introduced to a range of manipulatives and web-based tools during their courses, which both helped with their own mathematical understanding and enjoyment and allowed them to collect materials for their future classrooms. Additionally, many participants found their textbook, *Making Math Meaningful to Canadian Students, K–8* (Small, 2015) to be an excellent resource, as it gave ideas for lesson activities, aligned well with curriculum expectations, and helped to explain common student misconceptions. These results are consistent with the literature discussing the benefits of exposure to specific teaching strategies (Looney et al., 2017) and how a variety of resources can help ease EPSTs mathematical anxieties in methods courses (Barrett, 2013; Finlayson, 2014; Gresham, 2007; Lake & Kelly, 2014; Quinn, 1997).

Influence of Field Experiences on Mathematical Anxieties

Along with mathematics methods courses, this study also aimed to examine the impact of participants' field experiences on their mathematical anxieties, which are discussed in this section in connection with the literature. Firstly, this study involved

participants in the third and fourth cohorts of Ontario's new 2-year teacher education program, implemented in September 2015. These changes doubled the required amount of time for pre-service teachers to spend in practicums from 40 to 80 days (Ontario Ministry of Education, 2013). Cole (1995) found that extended field experiences in teacher education programs lead to greater teacher efficacy, but this study's participants had mixed opinions on how these extended placements influenced their mathematical anxieties. While five of the nine participants claimed their field experiences either significantly (1) or somewhat decreased (2) their mathematical anxieties on a 5-point Likert scale, the mean rating of 2.78 (SD = 1.09) showed a minimal reduction on average. The noteworthy factors contributing to these mixed results as emerged from the data analysis are outlined below, including a discussion of their alignment with existing research on this topic.

Teacher education students are paired with a mentor teacher in each of their field experiences, and participants felt that their mentor teachers' characteristics had a considerable influence on their practicum experiences. Many participants spoke highly of their mentor teachers' interpersonal skills, which helped them feel more at ease about teaching mathematics in a classroom setting. These attributes included being approachable, encouraging, and understanding. Other participants spoke of their mentor teachers' familiarity with the mathematics curriculum, willingness to share resources from past years, or expertise in other areas of teaching such as special education. Though this proficiency was initially daunting for one participant, Courtney, ultimately she and the other participants felt more successful in their teaching experiences when their mentors shared this wisdom. Moreover, participants appreciated when their mentor

teachers made the effort to review their lesson plans, provide individualized support, and give routine feedback and support. Other participants in this study were not so fortunate and were paired with mentor teachers who heightened their anxieties during their practicums. These negative outcomes were due to incidences of lacking awareness of reform-based techniques and not providing assistance or being inaccessible. These varied qualities are all reflected in Perkins's (2016) study of how a mentoring project impacted EPST's MA. In this study, mentors were selected based on six criteria: experience, professional responsibility, mathematical confidence, teaching expertise, appropriate personal attributes, and time. As outlined above, the results of this thesis study's data analysis regarding the role of mentor teachers reflects the importance of these six qualities. Participants felt more at ease when their mentor teachers displayed these attributes, but when they lacked these characteristics, participants experienced increased anxiety. These findings are echoed by İmre and Akkoç (2012), who highlight the importance of selecting mentors with adequate pedagogical content knowledge. Participants benefitted from their mentor teachers' knowledge of the mathematics curriculum and instructional techniques but were hindered when their mentor teachers were unfamiliar with reform-based pedagogy. Lastly, the benefits of mentor teachers who provided support and suggestions in comparison with the consequences of those who denied participants the opportunity to try new techniques is also consistent with the literature. Reid and Reid (2017) suggest encouraging mentor teachers to allow their teacher candidates to take risks, reflecting the findings in this thesis study.

Other factors that were influential in participants' field experiences were the use of different instructional strategies and resources. During their interviews, some

participants remarked that they felt more comfortable about teaching mathematics from observing their mentor teachers' pedagogical techniques and their positive effects on students, which Brown et al. (2012) found to decrease mathematical anxieties. These practices, however, were not always reform based. One participant, Abby, described the significant impact of watching her mentor teacher use direct teaching strategies, and noted how she enjoyed using his teaching style in her practicum. As Dillon (2017) notes, teacher candidates' practicum experiences may not resemble the innovative strategies introduced in methods courses. Instead, pre-service teachers may opt to utilize the same pedagogical style of their mentors (Swars et al., 2009), a result that was true in Abby's case. In contrast, other participants felt significant frustration when their mentor teachers used a traditional pedagogical style. Nicole specifically outlined how her mentor teacher discouraged her from taking risks and attempting reform-based techniques in her lesson planning. This is reflective of Reid and Reid's (2017) finding that EPSTs often face pressures to teach in a transmissive style during their field experiences. However, when participants were afforded the opportunity to use a wide variety of techniques and resources, they generally enjoyed their practicums and felt a reduction in their anxiety. To this end, participants discussed how they appreciated being able to use manipulatives, differentiation-based games, Smartboards, and various online platforms in their teaching. This is consistent with Reid and Reid's (2017) research highlighting the importance of giving EPSTs a chance to try new techniques in classroom settings. Furthermore, though Brown et al. (2012) note that using unknown resources in field experiences provoked anxiety in EPSTs, this was not accurate for this study's participants, who enjoyed the chance to try out these new tools.

Analysis of the data revealed many instances of participants noting how the grade level they were assigned to teach in their field experiences influenced their levels of anxiety. Overall, participants felt comfortable teaching lower grades, especially those who rated their MA and MTA at or above the median score of 6 out of 10. These participants discussed the simplicity of the mathematical concepts and the ease with which they could integrate fun and engaging activities into their lessons. Only one math-anxious participant, Abby, noted that she had trouble teaching kindergarten due to the kinds of pedagogical techniques necessary for such young students, but she affirmed that she had no trouble with the content. These findings are thus mostly consistent with the existing research, as studies demonstrate that EPSTs with high MA feel more comfortable overall when teaching lower grades (Gresham, 2018; Stoehr, 2017a). On the contrary, teaching in the higher grades was a source of worry for two participants, Abby and John. They shared concerns about the difficulty of curriculum expectations, lacking the depth of understanding to explain concepts flexibly, and keeping pace with high ability students. Again, these concerns reflect Bates et al.'s (2013) findings about the prevalence of fears towards a lack of content knowledge. In addition, Abby and John's concerns are similar to those described by Swars et al. (2009), who claim that EPSTs have higher MA and decreased efficacy when teaching higher grades. It should also be noted that of the five participants in the Primary/Junior program, only Abby had taught in a junior level class. Thus, while the other four participants may have shared Abby's concerns about higher level grades, it was not possible to gain their reflections on actual experiences teaching in upper elementary classes.

Another theme based on participants' reflections on their field experiences concerned evaluations. Participants appeared to experience anxiety about being assessed while practice teaching when they were pressured to use teaching methods that did not align with their preferred style, or when they received confusing messages about their mentor teachers' expectations. Teacher candidates are also observed and evaluated by a faculty advisor during their placements, and a few noted that this caused them to feel additional stress. These findings align with those of Perkins (2016), who noted the high-stakes nature of field experiences, and Olson and Stoehr (2019), whose research suggested that EPSTs feel high anxiety when being evaluated. This was not the case for all participants, however, as some were untroubled about their assessments. A few participants described how they did not feel stress as they expected they would have areas that needed improvement, or that they perceived their formal evaluation to be no more worrisome than their mentor's routine feedback. Thus, while some evaluation experiences mirrored Perkins's (2016) and Olson and Stoehr's (2019) findings of increasing anxiety, this was not true of all participants.

Finally, data analysis reveals the significance of the opportunity to work with students in authentic settings. For some participants, this experience was critical in decreasing their mathematics teaching anxieties. These participants detailed how they found it helpful to see students' real solutions, observe that students were not experts with the course material, and witness students experiencing success in their classes. These findings reflect İmre and Akkoç's (2012) claims that observing students allows EPSTs to experience insights into their students and their learning needs. Other participants mentioned instances where they made errors in mathematical calculations or

terminology in front of their students. In these occurrences, the participants outlined how they reacted positively, diffusing the situation or perceiving their mistakes as a learning opportunity. While Brown et al. (2012) found that making mathematical mistakes led EPSTs to experience higher anxiety, this was not true for these participants. In contrast to the above experiences, one participant, Karen, noted how she became aware of students' varied ability levels and special education needs during her field experience, which heightened her anxiety. These concerns regarding lesson planning and differentiated instruction were also found in Brown et al.'s (2011) study of EPSTs' mathematical anxieties, as well as Gresham's (2018) study of the factors influencing in-service teachers' MA. Lastly, a few participants complained how missing certain opportunities increased their level of anxiety, including concerns of lacking experience teaching in the junior level grades and not being able to try out reform-based teaching strategies with students. These findings reflect Reid and Reid's (2017) research stating the importance of allowing EPSTs to practice newly learned instructional strategies in classroom settings.

Synthesis of Mathematics Methods Courses and Field Experiences

This section discusses the interrelationships between participants' mathematics methods courses and their field experiences in connection with the existing literature. When discussing the connection between these two teacher education components, several participants noted the similarities in their philosophies. This alignment was reflected in the use of similar teaching styles and pedagogical approaches, including problem-based learning and an emphasis on real-world applications. These strategies were introduced in participants' mathematics methods courses and either used by their mentor teachers, or participants themselves employed these techniques as student

teachers. In addition, participants noted how their field experiences and methods courses aligned in terms of resources, included using course notes and their textbook while planning lessons for their practicum. This connection gave participants the opportunity to observe and attempt these new approaches in authentic classroom settings, which Reid and Reid (2017) highlight as a critical component of teacher education programs. Moreover, participants were able to apply the concepts and strategies learned in their methods courses to their practicum experiences, affording them the benefits of so doing as claimed by Novelli and Ross (2017). In contrast, some participants complained of an incongruence between their methods courses and field experiences. One participant, Nicole, outlined how her practicum teacher employed traditional techniques, including a reliance on skill-and-drill worksheets, and pressured her to do the same, while another participant described how he was encouraged to give a test instead of a more authentic form of evaluation. These experiences reflect the theory and practice divide highlighted by Korthagen (2010a) that Novelli and Ross (2017) find to be a common grievance of EPSTs, and the pressure EPSTs often feel to teach transmissively (Reid & Reid, 2017).

Another theme that emerged from the data analysis was the importance of how participants' mathematics methods courses and field experiences teaching mathematics were scheduled. Some participants had the opportunity to teach mathematics immediately after they completed their methods course in Year 1. They commented on the benefits of having recently reviewed key mathematics content through their course's diagnostic assessment, being able to utilize newly acquired pedagogical strategies immediately, and being able to compare the two experiences to find a balance suitable to their teaching style. As reflected by Novelli and Ross (2017), these participants were afforded the

advantages of applying course concepts to classroom settings. In contrast, some participants were not as fortunate in how their methods courses and field experiences were sequenced. Karen, who had not yet taught mathematics in a practicum, complained of lacking the opportunity to practice concepts taught in the methods course soon after she had been exposed to them. Unlike the participants discussed above, Karen was not given the opportunity to develop her skills through application of these course concepts (Novelli & Ross, 2017). Meanwhile, John taught mathematics only after completing both methods courses. He found this scheduling hindered him due to his lack of content knowledge, as he was able to feel more comfortable with mathematics after his practicum. Because of this reflection, he felt it would have been beneficial to teach mathematics in between his two methods courses in order to better understand the theoretical discussions in Year 2. John's struggles echo Reid and Reid's (2017) claims of the importance of field experiences for EPSTs' mathematical knowledge for teaching.

Anticipated Future Mathematics Teaching Style

The above themes reflect participants' past experiences with mathematics and how their anxieties have been altered during their teacher education programs. This theme presents a discussion of how participants envision their futures as mathematics teachers, influenced by their background characteristics and teacher education experiences. When asked to describe how they view themselves teaching mathematics when in-service, three of the nine participants outlined how they imagine using a mixed approach. They highlighted how they wanted to retain elements of the transmissive style they were exposed to as K–12 students, while incorporating some of the innovative techniques to which they were exposed during the teacher education program. In particular, Abby's experiences with a traditional mentor teacher in a junior level

practicum were highly influential in this regard, as she observed the success of his methods with the students. These participants' views of their future pedagogical approaches reflect Reid and Reid's (2017) findings that EPSTs often feel inclined to maintain the old techniques used in their elementary and secondary mathematics classes. Furthermore, Abby's case highlights how the instructional strategies used in field experiences may not resemble the reform-based ideas of methods courses (Dillon, 2017), and that EPSTs often adopt the approaches used by their mentor teachers (Swars et al., 2009). Interestingly, Oliver had relatively low MA and MTA, giving himself a rating of 3 out of 10 on both of these measures, but envisioned himself frequently employing traditional pedagogical techniques in his future career. This case contrasts with Wertheim and Leyser's (2002) claim that teachers with higher self-efficacy tend to utilize more innovative practices.

The other six participants described how they saw themselves employing many innovative techniques in their future careers. While elementary teachers with low self-efficacy or high MA tend to resort to lecture-based teaching (Gresham, 2008), this was not true of many participants in this study. These participants noted how they intend to use a variety of instructional approaches, focus on differentiating content in interesting ways, and emphasize student choice, contradictory to findings in the literature that many math-anxious teachers' styles are similar to those used when they were elementary students (Doruk, 2014; Levine, 1993) and instead reflecting the constructivist strategies that math-anxious EPSTs in Finlayson's (2014) research hoped to employ in their future practice. One participant, Courtney, who had high MA and highly negative past experiences in mathematics, described how she hoped to make math fun, engaging, and interactive, comparable to Brown et al.'s (2011) and Gresham's (2018) findings that

EPSTs with MA may display positive attitudes when teaching to hide their negative views from their students. Similarly, a few participants reflected on how they related to struggling students based on their past experiences and hoped to prevent them from developing the same difficulties and negative attitudes. This is consistent with Gresham's (2018) description of how teachers with MA often see their past selves reflected in their students. Lastly, several participants noted that they hoped to connect course material to real-life applications through problem solving, a level of challenge that Chang and Beilock (2016) highlight as being influential in helping students achieve at high levels and which Tait (2006) found that a majority of her former methods course students continued to utilize in-service.

This study's results were overall consistent with the literature on the mathematical anxieties of EPSTs. Analysis of both quantitative and qualitative data revealed that participants had similar increasingly negative experiences in their K–12 education as found in prior research, leading many participants to develop long-standing mathematical anxiety. Participants felt similar levels of anxiety towards both doing and teaching mathematics, with many concerns about the mathematics content and their ability to convey information to students. Participants' experiences in their teacher education program revealed a variety of ways in which methods courses and field experiences impact their mathematical anxieties, both in terms of affecting trait levels of anxiety and highlighting scenarios that elicit state anxious reactions. When mathematics methods courses offered a welcoming environment and helped EPSTs review content, participants felt a reduction in MA reflected in prior studies, however, being exposed to reform-based techniques had both positive and negative impacts. Likewise, participants' sentiments about their mentor teachers' characteristics and pedagogical techniques during field

experiences aligned with findings in the literature, but participants overall felt more comfortable about being evaluated and making mistakes with students than prior studies would suggest. The interrelationships of these two elements of teacher education helped alleviate participants' MA when they were given the opportunity to apply their course learning to their practicum, but this study revealed the importance of scheduling in teacher education programs that is lacking in the literature. Finally, participants' anticipated future teaching styles marked a departure from the literature, as some participants with low or moderate MA plan on using transmissive strategies, while many with higher levels of MA embraced the reform-based techniques.

Implications

The purpose of this study was to examine the impact of a teacher education program on EPSTs' mathematical anxieties. As a result, this study has implications to the practice of various education stakeholders, including teacher educators, mentor teachers, and faculty administrators, on how they can better support math-anxious EPSTs in overcoming their fears. Accordingly, this study also has implications at the provincial level as improvements to teacher education would help achieve the Ontario Ministry of Education's (2014, 2016, 2019) objectives to improve elementary mathematics and renewed goals for education. This study also has implications for theory by extending the research base and providing an enhanced understanding of state and trait mathematical anxieties amongst EPSTs (Hannula, 2018; Spielberger, 1966). Finally, this study's findings suggest implications for future research related to EPSTs' MA and teacher education. As outlined in Chapter 3, this study's findings are not generalizable to the larger population due to the emphasis on qualitative methods and the small sample size,

rather, resonance was achieved through transferability and naturalistic generalization (Tracy, 2010). As a result, this study's implications are intended as points for consideration by education stakeholders, and its findings offer suggestions which would benefit from the support of further research. The following sections detail these implications for practice, theory, and future research.

Implications for Practice

This study examines the perspectives of EPSTs at one Ontario Faculty of Education in the third and fourth cohorts of Ontario's revised teacher education program. Beginning in September 2015, this new program increased the length of teacher education programs from two to four semesters and doubled the required time spent in field experiences from 40 to 80 days (Ontario Ministry of Education, 2013). In studying this group of pre-service teachers, this study provides an enhanced understanding of the impact of this new program on EPSTs' mathematical anxieties, highlighting its strengths and areas for improvement. This study's findings are thus relevant to the practices of teacher educators, Faculty of Education administrators, mentor teachers, and education policy makers in the province of Ontario. These implications will be discussed as related to mathematics methods courses, field experiences, and the synthesis of these two components.

Analysis of the data revealed a variety of ways in which teacher educators' mathematical anxieties were influenced by their mathematics methods courses. Nearly all participants experienced a decrease in anxiety from factors such as their course instructors' enthusiasm and encouragement, sharing and collaborating with their peers, and working with a wide variety of resources. Some also felt that the course's review of

mathematical content and emphasis on learning reform-based pedagogical strategies made them feel more at ease about doing and teaching mathematics. On the contrary, many participants' mathematical anxieties increased when they had trouble solving mathematical problems, felt a lack of connection between content and pedagogy, or became overwhelmed with pedagogical strategies and responsibilities. These results have implications for teacher educators and faculty administrators when designing and instructing elementary level mathematics methods courses.

Several participants' reflections highlighted areas where changes in the structure of mathematics methods courses would have helped them feel more at ease. Firstly, many participants appreciated the ability to review mathematics content through the online diagnostic assessment completed prior to beginning the course, a strategy being implemented in many Ontario Faculties of Education (Brown, 2016). However, many others were anxious about its level of difficulty due to their limited mathematics education, common amongst EPSTs in Ontario (Brown, 2013; Casey, 2017b). They were concerned about the quiz component of the diagnostic, and what their achievement level implied for their ability to be successful in the course. As a result, this study's findings suggest the potential benefits of restructuring this diagnostic assessment. As high-stakes timed tests can create anxiety for individuals with any level of MA (Geist, 2010), this restructuring could include providing more initial information about the diagnostic and what its results suggest for one's ability to perform in the course. This change could lessen participants' anxious reactions to the diagnostic and prevent them from feeling significant stress when beginning the course. Likewise, several participants noted how it would have been helpful to discuss challenging concepts from the diagnostic during the

course itself, implying the potential benefits of using the diagnostic as an assessment tool of participants' prior knowledge. This would allow instructors to find curriculum areas that require further review and provide students with resources to address these deficiencies.

Beyond the diagnostic assessment, participants highlighted areas where the adjustments to the course curriculum and increased supports would have decreased their anxious sentiments. Several participants described the challenges they experienced connecting content and pedagogy, which Kajander et al. (2013) note as critical for pre-service teachers, citing causes like a lack of content knowledge or familiarity with the elementary mathematics curriculum. In turn, increased grade-by-grade review of both mathematics content and pedagogical techniques could enhance EPSTs' pedagogical content knowledge (Shulman, 1987). In addition, one participant, Nicole, noted how she appreciated when the instructors of her methods courses for other subjects made connections to mathematics. As most EPSTs lack significant mathematical training (Brown, 2013; Casey, 2017b), emphasizing interdisciplinary connections and instructional strategies in mathematics methods courses could enhance both their understanding and enjoyment of mathematics. Moreover, providing additional supports for participants who lack mathematical content knowledge, a common fear amongst EPSTs (Bates et al., 2013) that was often mentioned by this study's participants, could help reduce the many harmful effects of this deficiency. This could be achieved by providing participants with access to the diagnostic program, Elevate My Math, throughout the course as suggested by a few participants. In so doing, methods course students could access its review modules as they feel necessary during the course to

increase their familiarity with mathematical processes. Another option would be for teacher educators and/or faculty administrators to organize a peer tutoring program. Some participants mentioned they sought out coaching from family or friends with strong mathematical background during their methods courses, but other students may not have access to such supports. As a result, the facilitation of a tutoring program connecting math-anxious EPSTs with peers, such as Junior/Intermediate or Intermediate/Senior teacher candidates specializing in mathematics, who are confident with the subject material may help to alleviate their content-related fears. Such supplementary training is already being offered in another Ontario Faculty of Education (Reid & Reid, 2017), and could also have significant benefits for teacher candidates in other faculties of education. Furthermore, this coaching would assist EPSTs in preparing for the newly implemented Mathematics Proficiency Test as a requirement for teacher certification in Ontario (mathproficiencytest.ca).

The results of this study also offer feedback for teacher educators in terms of the culture they foster in their mathematics methods courses. Many participants offered considerable praise for their instructors' messages of encouragement and emphasis on developing a growth mindset towards mathematics, which had a substantial influence on easing their mathematical anxieties. This finding suggests that course instructors should continue their efforts to foster such positive mathematical attitudes, as they help EPSTs to overcome their anxieties for learning mathematics (Gonzalez-De Hass et al., 2017; Stoehr & Olson, 2017) and reduce the harmful impacts of common myths surrounding one's mathematical capabilities (Anderson et al., 2018; Boaler, 2016; Dweck, 2006). Moreover, encouraging EPSTs to adopt a growth mindset and examine issues of student confidence

within methods courses (Gonzalez-De Hass et al., 2014) may prevent them from passing on negative messages about mathematics to their future students (Boaler, 2016). These findings regarding the benefits of emphasizing growth mindsets suggest it may also be beneficial for instructors to provide greater opportunities for reflection on one's MA as found by both Hollingsworth and Knight-McKenna (2018) and Wilson (2018). Finally, participants noted how they profited from hearing about their fellow classmates' mathematical anxieties, as it helped them realize others shared their concerns. This finding suggests that instructors should include opportunities for such dialogue in their methods courses. This could include such activities as whole-class discussions, a helpful strategy that one participant recalled from her first-year course, or online forum posts, the benefits of which have been observed by Liu (2008). As evident in Chapter 4, such a safe and supportive classroom atmosphere will likely be significant in helping reduce MA amongst EPSTs.

This study's qualitative data analysis also uncovered several themes relating to how participants' field experiences influenced their mathematical anxieties. Overall, participants' anxieties were reduced when paired with supportive mentor teachers who utilized reform-based strategies, while teaching younger grades, when they were able to access a variety of resources, and upon observing their students experiencing success. The opposite was true when participants had distant mentor teachers, felt pressure regarding the use of pedagogical styles or being evaluated, in teaching upper elementary classes, and upon witnessing the wide range of needs in today's classrooms. Though there are several logistical complications for faculty and school administrators in arranging pre-service teachers' field experiences, these results provide suggestions for

faculty administrators and mentor teachers that could help reduce EPSTs' mathematical anxieties.

When reflecting on their field experiences, many participants highlighted the influence of their mentor teachers on their level of comfort in teaching mathematics. Mentor teachers helped participants feel at ease when they were approachable, had strong pedagogical content knowledge and many resources, and provided individualized guidance. In contrast, participants were more anxious when mentor teachers were unaware of reform-based approaches, did not assist with lesson planning, and were overall unsupportive. These findings suggest the benefits of working to set up field experiences with skilled mentor teachers, for example, a school's elementary math lead, who have a desire to help train pre-service teachers. Though logistically challenging, Perkins (2016) outlined six criteria – experience, professional responsibility, mathematical confidence, teaching expertise, appropriate personal attributes, and time – used to select teachers in a program for math-anxious EPSTs which could be utilized as a guide for choosing such mentor teachers. Furthermore, pre-service teachers often adopt their mentors' teaching style (Dillon, 2017), thus when participants are paired with mentor teachers who use transmissive styles, they may abandon the reform-based techniques learned in their methods courses, as was true of one participant, Abby. Accordingly, if faculty administrators are able to pair EPSTs with teachers who use innovative strategies, this would have positive impacts on their future teaching style. Where the above efforts in selecting mentor teachers may not be possible due to logistical constraints, the alignment of methods courses and field experiences is critical in teacher education (Capraro et al., 2010; Kajander et al., 2013; McDonnough & Matkins, 2010),

thus it may be helpful to simply provide them with supplemental information about the methods courses' teaching philosophy and supporting math-anxious teachers. As Reid and Reid (2017) highlight the benefits of having mentor teachers support risk-taking, this could help familiarize mentor teachers with the aims of using reform-based strategies. Moreover, as some participants noted that they were calmer simply when their mentor teachers showed understanding for their anxieties, providing mentor teachers with strategies to show such supports may help math-anxious EPSTs have more positive practicum outcomes.

The results of this study in terms of the interrelationships between methods courses and field experiences suggest that modifications to the scheduling of teacher education programs could be influential in reducing EPSTs' mathematical anxieties. Several participants highlighted how teaching mathematics immediately after their first-year methods course reduced their anxiety, as they had recently reviewed key concepts and were able to immediately practice instructional strategies, while others wished they had such an opportunity. As Reid and Reid (2017) highlight, field experiences are vital to developing EPSTs' mathematical knowledge for teaching and allowing them to attempt different pedagogical techniques. Accordingly, these findings suggest that introducing a mandatory mathematics component in this first practicum experience after completing the first-year methods course would improve students' self-efficacy for teaching mathematics. Furthermore, participants generally felt less anxiety about teaching mathematics in early grades, especially in the Primary/Junior program, when compared with the upper elementary levels, a common pattern in EPSTs' MA (Swars et al., 2009). As Emma specifically noted, her positive experiences teaching primary mathematics

provided her with increased confidence to work with students in the junior grades. As a result, attempting to schedule field experiences by grade level, for example, one's first practicum would be in a primary class with the second practicum at the junior level, may help ease EPSTs' MTA by allowing them to begin in a less threatening classroom environment.

Finally, it may be beneficial for teacher educators or faculty administrators to introduce structural changes in elementary teacher education programs to reduce EPSTs' mathematical anxieties. Several participants noted the benefits of working in authentic settings, including observing students' problem-solving approaches, assessing their level of ability, and developing pedagogical techniques. However, EPSTs generally find field-experiences to be high-stakes (Perkins, 2016), and some participants expressed concerns when being evaluated in this setting. As a result, it may be beneficial to introduce reforms to mathematics methods courses or teacher education programs that allow participants access to these settings without the pressures of evaluation. While some EPSTs are able to gain such experience prior to their teacher education programs, such as Abby's employment experience as an educational assistant, many others will not have such opportunities. A review of the literature suggests potential ways this could be accomplished, including arranging opportunities to tutor elementary students (Gresham & Burleigh, 2019), plan and conduct small-group activities for a group of students (Novelli & Ross, 2017), or simply reflect on observations of an elementary class or expert teachers (İmre & Akkoç, 2012; Tait, 2006). Such opportunities would allow EPSTs to benefit from the reductions in anxiety afforded by working with real students without the conflicting pressures of being evaluated.

Implications for Theory

This thesis study extends the existing literature on the mathematical anxieties of EPSTs and how these anxieties are impacted during teacher education programs. By focusing on both mathematics methods courses and field experiences as the two major components of teacher education programs, this study was able to address gaps in prior research as outlined in Chapter 2. Many prior studies have focused solely on the impact of mathematics methods courses on EPSTs' MA, however, few have examined the influence of field experiences on mathematical anxieties and their synthesis with these methods courses. This study was able to address this discrepancy by providing a better understanding of the impact of these practicum teaching experiences on MA and MTA, highlighting themes concerning mentor teachers, pedagogical techniques, and working in authentic settings, amongst others. Furthermore, in focusing on the interrelationships between mathematics methods courses and field experiences, this study contributes to the literature by demonstrating the importance of their philosophical alignment, use of resources, and sequencing during teacher education programs. Lastly, this study extends research undertaken by others concerning how EPSTs' background experiences and characteristics not only contribute to their development of mathematical anxieties, but how they influence their mathematical anxieties during teacher education.

The conceptual framework of this study is Spielberger's (1966) conceptualization of state and trait anxiety. While distinct from general anxiety (Hannula, 2018), MA may be examined as a state reaction to specific mathematical contexts or as a stable trait of one's personality (Radišić et al., 2015), though the latter is more common in the existing literature (Hannula, 2018; Roos et al., 2015). This study provides an enhanced

understanding of both situations in teacher education programs that provoke state math-anxious reactions, as well as how EPSTs' trait MA is influenced during mathematics methods courses and field experiences, highlighting where there are connections to their background experiences, as outlined below.

Spielberger (1966) highlights the importance of determining the probability that a given stimuli will invoke a state anxious response, most commonly reported through introspective reports. This study contributes to the theory on state anxiety by revealing specific situations during teacher education programs—both mathematics methods courses and field experiences—that provoke math-anxious reactions. For many participants, these state anxious reactions occurred in relation to the online diagnostic assessment and review that was completed prior to beginning their methods course. Similar tools have been implemented in many faculties of education throughout Ontario as a means of improving EPSTs' content knowledge (Brown, 2016), however, for many EPSTs with MA, this tool was a source of great anxiety. Several participants experienced heightened levels of anxiety in this scenario due to an inability to recall mathematical procedures or concerns about its impact on their ability to be successful in the course. These anxieties were often related to a lack of prior mathematical training, and mirrored fears from participants' negative experiences as K–12 mathematics students. On the contrary, others felt that using this tool helped alleviate their mathematical anxieties. For those who performed well on the assessment and were able to understand the mathematical concepts, the diagnostic program helped calm their nervous feelings about their content knowledge, thus demonstrating the idiosyncratic nature of EPSTs' state anxious responses to this tool (Spielberger, 1966). A key element of the course that

helped all participants prevent or reduce state anxious responses was the positive culture and safe learning environment of the course. Several participants noted situations from their past where they felt embarrassed from being compared to their peers, thus, it would have been reasonable that peer activities in the mathematics methods course caused these participants anxiety. However, due to the welcoming atmosphere of the course, participants consistently expressed that they felt comfortable in situations of working collaboratively and solving problems with their peers, thus preventing the induction of a state anxious response in these scenarios (Spielberger, 1966).

Analysis of the data regarding participants' field experiences also highlight particular stimuli that cause state anxious reactions for EPSTs. Several of these instances are related to the attitudes and behaviours of their mentor teachers. When mentor teachers showed understanding towards mathematical anxieties and provided individualized encouragement or coaching, participants felt at ease. In contrast, in situations where mentor teachers were dismissive of participants' ideas or provided insufficient support, participants experienced frustration and increased anxiety. Furthermore, participants' initial state anxious reactions were influenced by the grade level to which they were assigned in their field experiences. In general, participants who taught younger grades began their practicums with considerably less stress than their peers in older grade levels—a finding that is congruent with the previously noted literature (Gresham, 2018; Stoehr, 2017a). Those who learned they would be teaching upper elementary, however, noted their immediate worries about the more difficult content level, in part related to their own lack of mathematical training, demonstrating a rapid anxious reaction to this situation. Finally, participants found that their ability to access resources in their field

experiences was a major factor in determining their level of anxiety. Those whose practicums had many resources felt at ease about their abilities to plan engaging lessons, while those in resource-limited schools felt increases stressors of needing to search online or find their own materials. As outlined by Spielberger (1966), these reactions are transitory in nature as they relate to the specific contexts of these field experiences.

Their teacher education program also had long-term impacts on participants' trait mathematical anxieties. Scheduled in the first semester of their teacher education program, many participants entered their first-year mathematics methods course with long-standing MA. These anxieties were largely due to negative experiences they had in their K–12 mathematics education, reflective of how trait anxieties are generally dispositions influenced by one's past experiences (Spielberger, 1966). For these participants, their course instructor helped to make them feel more comfortable with mathematics and reduce this level of anxiety. Several participants noted how their course instructor helped them feel excited about the subject and encouraged them to adopt a growth mindset towards their mathematical abilities, diminishing their level of trait math-anxiety by improving their confidence to face mathematical situations. Others noted how they were afforded the opportunity to share their anxieties with their peers throughout the course. This interaction allowed many participants to realize their classmates experienced similar mathematical concerns, thereby reducing trait anxieties related to feelings of inadequacy in comparison to other EPSTs. One element of the course that had mixed impacts on participants' mathematical anxieties was the exposure to reform-based pedagogical techniques. Learning about varied instructional techniques and methods to differentiate course content helped some feel more comfortable at the prospect of

teaching mathematics, but for others, this departure from the traditional techniques they were used to from their K–12 experiences made them worried about their ability to be a successful educator. In both instances, participants experienced a change in their level of trait MTA, as this learning altered their perceptions of mathematics education and disposition to experience anxiety (Spielberger, 1966).

Participants' field experiences also impacted their trait mathematical anxieties, or their likelihood of experiencing state anxious reactions in mathematical situations (Spielberger, 1966). As field experiences offer EPSTs the opportunity to practice teaching, these changes are largely related to participants' MTA. Mentor teachers' coaching and pedagogical approaches were one key factor, as participants whose mentors offered them the opportunity to take risks and try new instructional strategies felt more self-efficacious in their teaching practice and thus less anxious overall. The grade level to which participants were assigned also made an impact on their trait anxieties. Those who were assigned lower grades were largely able to benefit from these positive mastery experiences, thereby increasing their feelings of self-efficacy for teaching primary mathematics (Bandura, 1977). Similarly, though participants who were assigned higher grades had initially intense state anxious reactions, their trait mathematical anxieties decreased after successfully teaching upper elementary classes as they gained more confidence working with harder content. Finally, authentic interactions with students led to a change in trait anxiety in many participants. Through observing student work and witnessing that previously held concerns about high achievers were not accurate, many anxious participants were able to overcome worries about working with older students. On the contrary, some participants witnessed the significant range of individual learning

needs in a classroom, increasing their likelihood of experiencing anxiety when lesson planning and during classroom instruction (Spielberger, 1966).

Implications for Future Research

This study examined how the mathematical anxieties of EPSTs were impacted by their teacher education program. Several recommendations can be made for future studies examining this topic in terms of the selection of site(s) and participants. Firstly, this study involved participants in both the Primary/Junior (Grades K–6) and Junior/Intermediate (Grades 4–10) divisions of this program. As outlined in Chapter 3, Primary/Junior teachers are generalists, but those in the Junior/Intermediate program specialize in one subject area. Though attempts were made to recruit Junior/Intermediate pre-service teachers whose subject specialization was mathematics, none volunteered to participate. Future research could enhance multivocality (Tracy, 2010) by recruiting mathematics specialists from this group and comparing their experiences to EPSTs in other subject areas. Furthermore, due to the nature of qualitative research, the findings of this study are unique to its specific context (Yilmaz, 2013). The results of this study are transferrable to other teacher education programs (Tracy, 2010), but the individual attributes of each program will inevitably have different outcomes for EPSTs' MA. In Ontario, many faculties of education have made changes to the structure of their programs to emphasize elementary mathematics (Brown, 2016) beyond the required changes implemented as part of the new four-semester teacher education program (Ontario Ministry of Education, 2013). Accordingly, future research would benefit from recruiting participants from several universities, which would allow for a comparison of the unique effects of these different programs and strategies to reduce MA. Finally, this study only recruited

participants from the consecutive teacher education program, which requires students to have first completed an undergraduate degree. However, examining the mathematical anxieties of students in the concurrent teacher education program, who can enroll immediately after secondary school, may reveal different effects. In Ontario, this concurrent program was increased from 5 to 6 years beginning in September 2015, meaning that the class of 2021 will be its first graduating cohort. This presents a unique opportunity to study this new program for its impact on EPSTs' MA.

Additionally, the province of Ontario has made changes to the requirements for teacher certification since the time of this study's data collection which present new opportunities for research. Most notably, the Ministry of Education has introduced the Mathematics Proficiency Test (MPT) as a requirement for all teachers certified after March 31, 2020, regardless of division (EQAO, 2020), making Ontario the first province to implement such a policy (Alphonso, 2019b). As outlined in Chapter 1, this test evaluates aspiring teachers on their knowledge of the mathematics curriculum from Grades 3 to 9, as well as testing their understanding of both general and mathematics-specific pedagogy. This study's five Year 1 participants will likely complete their teacher education programs in June 2020 and will thus be required to write the MPT, however, these details had not been announced until after data collection in early 2019 and thus were not included in this study. However, the introduction of such a high-stakes test will likely be a source of added anxiety for EPSTs who experience MA at disproportionately high levels (Brady & Bowd, 2005; Gresham, 2007; Novak & Tassell, 2017). As a result, future research would benefit from examining the specific impacts of this new policy on EPSTs' mathematical anxieties. Moreover, teacher candidates completing the MPT will

also complete the Mathematics Attitude and Perceptions Survey (MAPS), which will assess their sentiments towards mathematics (EQAO, 2020). Pre-service teachers' responses to the MAPS could thus be a valuable data source studying EPSTs' MA.

Finally, several participants' comments during their individual interviews are striking as potential areas for future research. One area that could merit further exploration is differences in participants' ages. While not a focus of this study, two of the nine participants had been out of secondary school for nearly two decades, while the remainder had recently completed their undergraduate education. These older participants, Karen and Nicole, both commented on how their work and daily life experiences over these past decades helped reduce their MA. Though Malinksky et al. (2006) found no major difference in EPSTs' levels of MA based on age, Troesch and Bauer (2017) suggest that second career teachers may have increased self-efficacy resulting from past mastery experiences. This finding was true of Karen and Nicole and could merit further examination in future studies. The study's Primary/Junior participants also had mixed opinions regarding which grade levels they found easiest to teach. While some found their primary mathematics classes to be easy, Emma and Abby, who both had high or moderate MA and high MTA, commented on the struggles they experienced teaching early elementary classes due to their unique behavioural needs and pedagogical approaches. This contradicts existing literature, which claims that EPSTs with MA experience lower levels of anxiety when teaching younger grades (Gresham, 2018; Stoehr, 2017a). As this reduced anxiety is largely related to the simplicity of the content knowledge, it may be beneficial to study instead how pedagogical needs of younger grades impact EPST's MA. Lastly, Nicole mentioned how she appreciated the fact that

her course instructor was both a woman and a person of colour, reflective of her own characteristics, which represent underrepresented populations in mathematics. Previous research has demonstrated the positive effects of having professors who represent diversity for students in minority groups (Prado-Olmos et al., 2007), thus, as in Nicole's case, examining this effect in EPSTs with MA may uncover similar benefits.

Conclusion

The purpose of this study was to examine the impact of a teacher education program on EPSTs' mathematical anxieties. To achieve this aim, this study examined participants' experiences in mathematics methods courses and field experiences, their background characteristics, and the interrelationships between these three elements. Findings revealed how participants' prior experiences led to the development of their anxieties for doing and teaching mathematics, and the variety of ways in which teacher education programs alleviated or augmented these anxious sentiments. These findings uncovered both specific scenarios likely to provoke anxious reactions, and elements of teacher education that have longer-term impacts on one's anxiety, in line with Spielberger's (1966) conception of state and trait anxiety. These results are an important factor in addressing the issues with elementary level mathematics education in Ontario as outlined in Chapter 1. The Ontario Ministry of Education's (2016, 2019) recent math strategies have targeted improving achievement in elementary mathematics, in part by supporting and evaluating teachers of these grades. Findings from this study illustrate the ways in which the newly implemented four-semester teacher education program has impacted EPSTs' mathematical anxieties, offering recommendations for teacher educators, faculty administrators, mentor teachers, and policy makers to better support

EPSTs' development of self-efficacy for teaching mathematics. Furthermore, this study has revealed potential areas for further research on this topic, particularly in light of the new math-related requirements for teacher certification in Ontario (Ontario Ministry of Education, 2019). Accordingly, this study's findings and implications suggest that EPSTs' mathematical anxieties and teacher education in this province will continue to be a critical area of study towards meeting goals of improving elementary level mathematics in Ontario.

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Appendix A

Online Questionnaire

Thank you for agreeing to participate in this research project. This questionnaire should take 5-10 minutes to complete. Please note that all your responses will be kept confidential and any identifying characteristics will only be accessible to the Primary Student Investigator, Sarah Gannon. Should you have any questions or concerns, you may contact her by email (xxxxxx@brocku.ca) or phone (XXX-XXX-XXXX). After completing this form, you will be contacted by Sarah Gannon via email to set up an individual interview. This project has been reviewed and received ethics clearance through the Research Ethics Board at Brock University #REB–18–115.

Thank you for taking the time to complete this questionnaire!

1. Name: _____
2. Email: _____
3. Phone number: _____
4. What is your gender? (Select one)
    - Male
    - Female
    - Other
5. What is your program of study? (Select one)
    - Primary/Junior
    - Junior/Intermediate
6. In which year of your program are you currently enrolled? (Select one)
    - Year 1
    - Year 2

7. If you are a student in the J/I program, what is your teachable subject? (Select one)
    - Dramatic Arts
    - English
    - French
    - Geography
    - Health and Physical Education
    - History
    - Mathematics
    - Music
    - Science
    - Visual Arts

8. In which faculty/faculties did you complete your undergraduate degree? (Please check all that apply)
    - ☐ Arts
    - ☐ Business
    - ☐ Health Sciences
    - ☐ Humanities
    - ☐ Mathematics and Sciences
    - ☐ Social Sciences
    - ☐ Other: _____

9. Did you complete any mathematics or statistics courses in your undergraduate program? (Select one)
    - Yes
    - No

10. If yes, how many undergraduate mathematics or statistics courses did you complete? (Select one)
    - ○ 1
    - ○ 2
    - ○ 3
    - ○ 4
    - ○ 5
    - ○ 6 or more

11. What is the highest level of mathematics you completed in secondary school? (Select one)
    - ○ Grade 10 or below
    - ○ Grade 11
    - ○ Grade 12

12. Which of the following mathematics course levels did you complete in secondary school? (Please check all that apply)
    - □ University
    - □ University/College
    - □ College
    - □ Workplace
    - □ Other: _____

13. How would you rate your personal experiences as a K-12 mathematics student? (Select one per row)

	Mostly negative	Somewhat negative	Neutral	Somewhat positive	Mostly positive
Grades K–3	○	○	○	○	○
Grades 4–8	○	○	○	○	○
Grades 9–12	○	○	○	○	○

14. How was your overall performance in your K-12 mathematics classes? (Select one per row)

	Mostly F's (less than 50%)	Mostly D's (50–59%)	Mostly C's (60–69%)	Mostly B's (70–79%)	Mostly A's (80–100%)
Grades K–3	○	○	○	○	○
Grades 4–8	○	○	○	○	○
Grades 9–12	○	○	○	○	○

15. On a scale from 1 to 10, how math anxious are you? (Select one)

	1	2	3	4	5	6	7	8	9	10	
Not anxious	○	○	○	○	○	○	○	○	○	○	Very anxious

16. On a scale from 1 to 10, how anxious are you about teaching mathematics? (Select one)

	1	2	3	4	5	6	7	8	9	10	
Not anxious	○	○	○	○	○	○	○	○	○	○	Very anxious

17. During your teacher education program, how have each of the following affected your anxiety towards mathematics? (Select one per row)

	Significantly decreased	Somewhat decreased	No change	Somewhat increased	Significantly increased
Courses about teaching mathematics	○	○	○	○	○
Practicum experiences (any subject)	○	○	○	○	○

Overall teacher education program	○	○	○	○	○

18. Did you teach any mathematics in your student teaching internship or practicums? (Select one)
    - ○ Yes
    - ○ No

19. If yes, which of these experiences included mathematics? (Please check all that apply)
    - □ Internship
    - □ Practicum #1
    - □ Practicum #2

20. In which grade levels were each of you student teaching placements? (Please check all that apply)

	K	1	2	3	4	5	6	7	8	9	10
Internship	○	○	○	○	○	○	○	○	○	○	○
Practicum #1	○	○	○	○	○	○	○	○	○	○	○
Practicum #2	○	○	○	○	○	○	○	○	○	○	○

Appendix B

Interview Protocol

Preamble:

Thank you again for agreeing to participate in my thesis study. To reiterate, the information you share during this interview will be kept confidential. Your name will not appear in any report resulting from this study; however, with your permission, anonymous quotations may be used. You will have an opportunity to review and potentially revise your interview transcript to ensure its accuracy. The entire interview will take approximately 30–45 minutes. You can of course skip questions or pause the interview as you feel necessary.

Interview Questions:

1. Could you tell me a bit about your overall feelings towards mathematics?
    a. You rated your level of math anxiety as a __ out of 10 *(see questionnaire #15)*. Can you elaborate on this rating?
    b. You rated your level of anxiety about teaching math as a __ out of 10 *(see questionnaire #16)*. Can you elaborate on this rating?
2. *(For participants who responded "yes" to questionnaire #9):* What are some of the mathematics courses that you completed in your undergraduate program?
3. You rated your experiences as a K–12 math student as _____ *(see questionnaire # 13)*. Please describe why you gave these ratings.
    a. Tell me about some memorable moments, good or bad, from your experiences as a K–12 math student.

   b. *(For participants with significant differences in their responses for questionnaire #14):* You showed a significant change in your overall performance between grades _____ and _____. What do you think led to this change?

4. You stated that your courses about teaching mathematics have _____ your anxiety towards mathematics *(see questionnaire #17)*. Could you explain why you feel that way?
   a. Please describe some particular experiences from these courses that affected your mathematics anxiety.
      i. PROBES: Refresher course / Resources / Discussions / New teaching strategies / Manipulatives / Technology
5. You stated that your student teaching placements have _____ your anxiety towards mathematics *(see questionnaire #17)*. Could you explain why you feel that way?
   a. Please describe some particular experiences from your placements that affected your mathematics anxiety.
      i. PROBES: Associate teacher / Resources / Grade level / Evaluation
6. Can you describe any similarities and/or differences between your courses about teaching mathematics and your experiences with mathematics in your field placements?
   a. Did you notice any differences in teaching philosophy between these experiences (e.g., more traditional, more innovative)? Please explain.

7. You stated that your overall teacher education program has _____ your anxiety towards mathematics *(see questionnaire #17)*. Could you explain why you feel that way?
    a. Please describe some particular experiences from your program that affected your mathematics anxiety.
        i. PROBES: Professional development / Culture / Other courses
8. Are there any other experiences (in teacher education or otherwise) that have positively or negatively affected your anxiety towards mathematics? If so, please explain.
9. How do you envision your mathematics teaching style in the future?
10. Is there anything you would like to add to this topic which we have not discussed today?

Thank you very much for your time.