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Exploring the Mathematical Confidence and Self-Efficacy of Primary/Junior Pre-Service Teachers

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Exploring the Mathematical Confidence and Self-Efficacy of Primary/Junior Pre-Service Teachers

By

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April 22, 2019

Declaration of Originality

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“A dream is a wish your heart makes.”

-Cinderella

Abstract

The topic of mathematics education in Ontario has become an increasing concern in the last decade, as mathematics standardized test scores among elementary students have been on a consistent downward trajectory since the early 2000s (Stokke, 2015). Teachers often identify their negative experiences and relationships with mathematics in their own schooling as affecting their attitudes towards mathematics and teaching mathematics. Teachers' own anxieties or negative relationships with mathematics can perhaps be inadvertently passed on to their students, further perpetuating the negative connotation that many individuals associate with mathematics (Bates, Latham, & Kim, 2011). The purpose of this study is to explore pre-service teachers' perceptions of their confidence and self-efficacy in teaching mathematics in a primary/junior teacher education program.

This study explored the nature of pre-service teachers' perceptions of their confidence and self-efficacy in learning to teach mathematics, which content areas are understood and not understood by the primary/junior pre-service teachers, and how their pre and post perceptions advance our understanding of their learning to teach Mathematics in the new two-year Bachelor of Education program in Ontario.

Research Topic: Elementary Mathematics Teacher Education

Keywords: Teacher Education, Mathematics Anxiety, Mathematics Teacher Efficacy, Primary/Junior Pre-Service Education

Dedication

I dedicate this work to my incredible family. You have always been a constant source of love, support, and guidance. I would not be here without you.

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List of Abbreviations

A	Agree
B.Ed.	Bachelor of Education
D	Disagree
EQAO	Education Quality and Accountability Office
JK	Junior Kindergarten
M.Ed.	Master of Education
MTEBI	Mathematics Teaching Efficacy Belief Instrument
MTOE	Mathematics Teaching Outcome Expectancy
OSTES	Ohio State Teacher Efficacy Scale
PMTE	Personal Mathematics Teaching Efficacy
REB	Research Ethics Board
SA	Strongly Agree
SD	Strongly Disagree
SK	Senior Kindergarten
STEBI	Science Teaching Efficacy Belief Instrument
STEBI-A	Science Teaching Efficacy Belief Instrument – In-Service
STEBI-B	Science Teaching Efficacy Belief Instrument – Pre-Service
TEBS-Self	Teacher Efficacy Beliefs System - Self
TES	Teacher Efficacy Scale
UN	Uncertain

Chapter 1: Introduction

Background and Context

The topic of mathematics education in Ontario has become an increasing concern in the last decade, as mathematics test scores on the Education Quality and Accountability Office (EQAO) test, among elementary students have been on a consistent downward trajectory since the early 2000s (Stokke, 2015). Following elementary school, many students reach the secondary school level and have already developed a pre-conceived notion they are not proficient in mathematics, prior to attempting higher level mathematics. One major factor that can be attributed to students' perceptions of their confidence in mathematics can be linked to classroom teachers (Boling, 1991; Wilkins, 2008).

In my experience as an occasional teacher and graduate assistant instructor in primary/junior teacher education mathematics courses, I have observed that many teachers and pre-service teachers are intimidated by mathematics and lack confidence in teaching mathematics. Additionally, due to past experiences, many pre-service teachers have admitted to lacking the actual content area knowledge to be able to effectively and efficiently teach mathematics in a meaningful and relevant manner.

Teachers often identify their negative experiences and relationships with mathematics in their own schooling as affecting their attitudes towards mathematics and teaching mathematics. Mathematics is a subject area in which people will openly state they are not proficient and strongly dislike, or even, hate. Recent studies show that a teacher's mathematical self and teaching efficacies are positively correlated (Bates et al., 2011; Stipek, Givven, Salmon, & MacGyvers, 2001). When a teacher does not believe he or she has a strong understanding of mathematics, that individual often appears to lack the confidence and efficacy to teach mathematics. Teachers' confidence and self-efficacy in teaching mathematics are directly related to their perceived confidence in their relationship with mathematics (Bates et al., 2011). Teachers' own anxieties or negative relationships with mathematics can perhaps be inadvertently passed on to their students, further perpetuating the negative connotation that many individuals associate with mathematics.

Definition of Terms

Mathematics education is the teaching and learning of mathematics by problem-solving, using appropriate formulae, and performing the correct computations (Ajayi & Lawani, 2015). In Ontario, there are five main strands in the elementary Mathematics curriculum: Number Sense and Numeration, Measurement, Geometry and Spatial Sense, Patterning and Algebra, and Data Management and Probability. Number Sense and Numeration includes general understanding of numbers and how various operations, such as addition, subtraction, multiplication, and division, can be applied to numbers. Measurement includes learning about units, distances, and other real-world applications of measurement in the sciences and social sciences. Geometry and Spatial Sense involves developing skills of spatial awareness and the inherent geometry of shapes present in daily surroundings. Patterning and Algebra requires students to learn to recognize, describe, and organize shapes. In later elementary years, it also involves the concepts of graphing, using tables, and understanding variables. Finally, Data Management and Probability use graphs and other calculations to make sense of real-world applications like polls, advertising trends, and estimations of health risks (Ontario Ministry of Education, 2005).

In the Ontario education system, a primary/junior teacher is an elementary school teacher who is qualified to teach students from Kindergarten to Grade 6. The primary division consists of Kindergarten to Grade 3 and the junior division consists of Grade 4 to Grade 6 (Ontario College of Teachers, 2017). They are certified by the Ontario College of Teachers to teach all subject areas.

In this study, mathematical confidence is described as the belief of the likelihood an individual has in his or her own abilities to learn, complete, and teach mathematical processes. Self-efficacy will be described as per Bandura's (1982) description: "how well one can execute courses of action required to deal with prospective situations". In short, self-efficacy is the strength of one's belief in his or her ability to understand mathematical concepts, not the individual's actual ability.

Many individuals also experience mathematics anxiety, defined as "a state of discomfort that occurs in response to situations involving mathematical tasks that are perceived as threatening to self-esteem" (Trujillo & Hadfield, 1999). Studies have shown many pre-service teachers exhibit higher levels of mathematics anxiety than students from any other undergraduate program (Bursal & Paznokas, 2006; Harper & Daane, 1998). Primary/junior teacher candidates are often the most greatly affected by these feelings as they teach all subject areas, regardless of undergraduate area of study.

Purpose of the Study

The purpose of this sequential explanatory, mixed methods study is to explore pre-service teachers' perceptions of their confidence and self-efficacy in learning to teach mathematics in a primary/junior teacher education program in the Faculty of Education at a university in Southwestern, Ontario, as well as, the primary/junior pre-service teachers' conceptualized knowledge. Their perceptions and their pre and post experiences in the program are used to examine the pedagogical distinctiveness of the mathematics education program. Data is used to assess and evaluate teacher candidates learning to teach mathematics in the new two-year Bachelor of Education program in a Southwestern university in the province of Ontario, Canada.

Research Questions

This study explores the following research questions:

a) What is the nature of pre-service teachers' perceptions of their confidence and self-efficacy in learning to teach mathematics in a primary/junior teacher education program in the Faculty of Education at a university in Southwestern, Ontario, Canada?

b) What content areas within the mathematics curriculum are understood and not understood by primary/junior pre-service teachers at the Faculty of Education at a university in Southwestern, Ontario, Canada?

c) How do their pre, during, and post experiences in the program advance our understanding of their learning to teach mathematics in the two-year Bachelor of Education program in the province of Ontario?

Philosophical Assumptions

My ontological beliefs are constructed by my lived experiences involving mathematics and by my interactions with others when learning and teaching mathematics. Within this study, the ontological beliefs of the participants are demonstrated by responses to open-ended questions during individual interviews. Responses are analyzed for major themes and reoccurring views and experiences that may affect individual perceptions of learning to teach mathematics. The epistemological assumptions of this research lead to a constructed version of reality, a combination of the pre-service teachers' lived experiences, their stories, and my interpretations of these events.

Axiological beliefs are considered by member checking. As a researcher, my experiences may have an impact on my perception of the meanings of the answers provided by participants. Member checking allows participants to work with me to ensure an accurate picture of the participants' experiences is displayed and portrayed within the research. The methodologically assumptions in this study include how I look at data collection through individual interviews as I have analyzed for underlying themes that are common throughout all or most of the participant responses. When common themes were present, participant responses were further dissected and analyzed for commonalities and differences between lived experiences, previous instruction, and program experiences.

Locating Myself in the Study

I locate myself in this study socially and politically in a complex and interconnected way that also seeks to explore and understand my own lived experiences as a woman teaching mathematics and science at the secondary school level. As a Caucasian female in my mid-20s, I am a Canadian citizen of Italian heritage. I rarely see individuals who look like me teaching either mathematics or science in the secondary schools I have visited. It has been my experience that these are male dominated fields, especially in mathematics. Most mathematics departments I have visited have very few women members. As an occasional teacher, my students are always surprised to see me as their mathematics teacher as they expect someone who is male, or at the very least, older. I often hear questions from students about whether or not I actually teach mathematics and if I would be able to aid with assigned questions.

I am also a graduate assistant instructing and doing research in both primary/junior first year foundations and second year methodology teacher education courses in a Faculty of Education. My relationship with mathematics is very complex due to my family background. I come from a middle-class family that always placed a very high level of importance on education and excelling academically. I rank my own confidence and self-efficacy in mathematics as very high as I see mathematics as a means of understanding and communicating about the world around us. I reject the notion that people are somehow born either mathematically inclined or not. I am particularly interested in pre-service teachers' attitudes towards mathematics and learning to teach mathematics because teacher perceptions have been shown to affect the engagement and quality of learning (Maulana, Opdenakker, & Bosker, 2014). When teachers feel more comfortable with the material and more confident in their abilities, they take more chances in lessons and are more welcoming to student questions. These actions encourage student learning and inquiry (Sengupta-Irving & Enyedy, 2015).

My Emic and Etic Positioning

As a researcher, my emic and etic positionings are brought to my study in complex and interrelated ways. Firstly, I bring an insider view as I was a pre-service teacher at a Faculty of Education. I have experienced teacher education, how classes are taught, and the types of assignments which are given. I have experienced time in placement where I went into another person's classroom and had to teach the material I was given. I am aware of major aspects of the teacher education program at this university and what knowledge and skills it hopes to pass on to pre-service teachers. I am currently a secondary mathematics and science classroom teacher. Especially in mathematics, this occupation gives me unique insights into the shortcomings of mathematics education in earlier academic years. I can clearly see the skills where students excel (ie. addition and subtraction) and where most students struggle immensely (ie. fractions). Finally, I was educated in the Ontario school system myself. I have been through primary grades where mathematics was not taught to a high standard. I remember going home and having my parents teach me, help me work ahead, or assist me with homework. I was lucky enough to have that option, but many students are not. I went through a school system where I had teachers offer us extra drama or physical education instead of a second mathematics block if we were well-behaved that day. Further setting up a notion that mathematics was somehow a punishment, not a useful tool that could help us interpret the world.

Aside from these similarities, I am also an outsider in this study. I was not a primary/junior pre-service teacher, nor did I ever complete any training in either of these divisions, and as such, I have never taught mathematics in an elementary school. I have helped younger family members with elementary mathematics, but I do not believe this compares to teaching the topic to 30 students, all with different learning styles and needs, in any way. Additionally, mathematics was something that came easily to me, especially in elementary school. I never struggled to learn new topics, and often times, I was assisting my friends, or finishing my classwork early and being directed by the teacher to help someone who was struggling. I do not fully understand the nervousness or anxiety that some people experience when faced with the chance of teaching mathematics. I always looked forward to mathematics and welcomed any opportunity to work on mathematics or teach it.

One of the driving forces behind this study is my work as a graduate assistant instructor in Year One primary/junior Mathematics Foundations and Year Two primary/junior Mathematics Methodology teacher education courses. I would like to use this study as a means of better understanding the lived experiences of primary/junior pre-service teachers and how these experiences shape their desire to learn and teach mathematics. In reading through Mathematics Narrative assignments from the pre-service teachers, I have noticed a trend that many individuals do not like mathematics because of certain teachers, do not take mathematics courses past the requirements, and are now tasked with finding creative and dynamic ways to make mathematics interesting to a new generation of students. I am eager to learn more about perceptions of the teacher education program and any effects the new two-year Bachelor of Education program may have on changing or improving perceptions of learning to teach mathematics.

Theoretical or Interpretive Frame

A social constructivist framework is used as the interpretive lens for this study (Creswell, 2012). This lens requires the researcher to consider and rely upon the views and interpretations of the participants, with respect to the issue or phenomenon being explored (Bronack, Riedl, & Tashner, 2006). In the case of this study, I am speaking to primary/junior pre-service teachers about their perceptions of their confidence and self-efficacy as they are learning to teach mathematics, in addition to quantitatively assessing their conceptual understanding of mathematical content areas. Participants have constructed responses based on their lived experiences with mathematics, which include their early experiences which have shaped and coloured their views towards learning and teaching mathematics. My research asks participants broad questions related to the survey results so they may develop and share their own opinions in an individual interview setting. My participants have varying views based on their own experiences, some positive and some negative. One potential bias I must consider is my belief in the nurturing portion of the nurture versus nature debate. I believe that given a proper foundation all individuals are capable of learning basic tasks and fundamentals related to any subject, including mathematics. Since my perceptions and thoughts can affect my interpretation of subjective participant responses, I must position myself in the study by reflecting on any biases and pre-conceived notions I bring with me throughout this research.

Chapter 2: Literature Review

The following introductory literature review is composed of two major themes: teacher efficacies, both self and teaching, and mathematics anxiety.

Literature Review Concept Map

The following literature review concept map can be used to organize some of the major papers and reoccurring themes identified throughout the literature review that was conducted for this study.

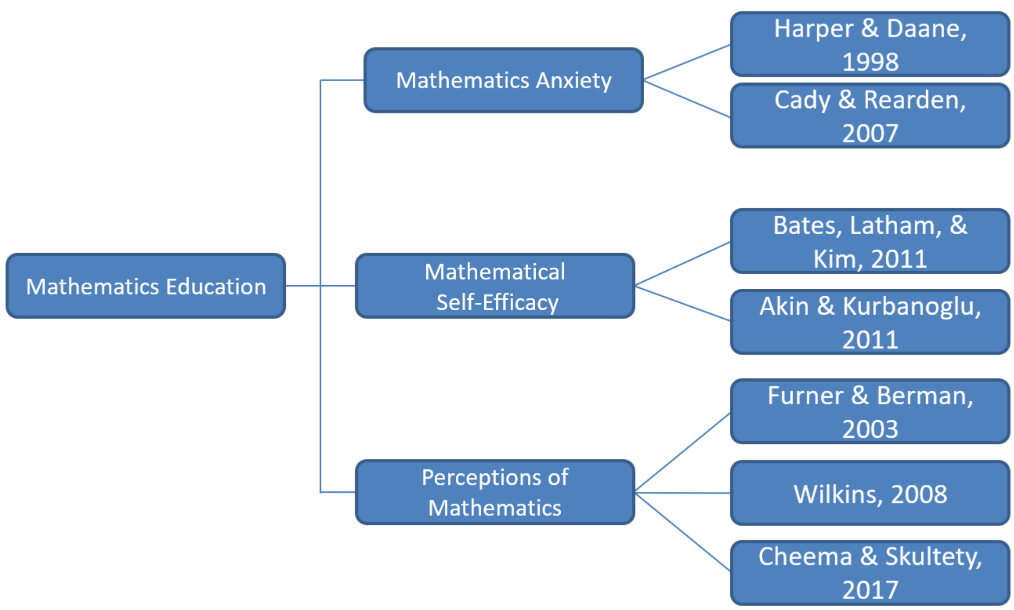

Figure 1. Concept map of major literature review topics.

Mathematics Anxiety

There has been a great deal of research conducted involving the idea of mathematics anxiety and elementary teachers, dating back a number of years. Research shows that many pre-service teachers exhibit high levels of mathematics anxiety, a greater percentage than students from any other undergraduate program (Bursal & Paznokas, 2006; Harper & Daane, 1998). Additionally, pre-service teachers do not exhibit these levels of anxiety when faced with teaching other subjects (Cady & Rearden, 2007; Gresham, 2007). Pre-service teachers who possess higher levels of mathematics anxiety are also less confident when faced with the task of having to teach mathematics (Gresham, 2008), which in turn, further propagates the sense of dread and uneasiness surrounding the overall study of mathematics.

Studies have shown that more women experience mathematics anxiety compared to men, and currently, approximately 90% of elementary school teachers are female (Stoehr, 2017). A striking finding in the research is that a female teacher who suffers from mathematics anxiety is more likely to negatively impact the academic achievement of the young girls in her classroom, compared to a male teacher or another female teacher who is more confident and less anxious with respect to teaching mathematics (Beilock, Gunderson, Ramirez, & Levine, 2010).

Mathematics anxiety can be linked back to the classroom experiences and teachers encountered by pre-service teachers years earlier in their academic careers (Furner & Berman, 2003; Harper & Daane, 1998). Pre-service teachers are influenced by their teachers' instructional practices, behaviours, and perceptions of mathematics in the classroom (Bekdemir, 2010).

Mathematics anxiety can be directly related to academic achievement through an inverse relationship (Novak & Tassell, 2017). In addition to resulting in lower test scores academically, mathematics anxiety may also be experienced with respect to social situations. Many individuals fear looking less intelligent or educated in front of peers or students, and as a result, experience higher levels of mathematics anxiety when teaching, learning, or using mathematics (Stoehr, 2017). Studies have also shown that a by-product of the anxiety faced by these individuals is mathematics avoidance (Ashcraft, 2002; Kelly & Tomhave, 1985). Since the anxiety levels of individuals rise when mathematics is conducted, they tend to avoid lessons, practicing, and even struggle to take in and process the given information, resulting in the development of further anxiety as the difficulty of topics progresses.

The use of manipulatives and other interactive teaching practices can be beneficial to individuals looking to lower the level of anxiety they face in the classroom (Vinson, 2001). In almost all cases, mathematics anxiety levels were greatly reduced once pre-service teachers were introduced to manipulatives, further reinforcing the importance of teaching students using manipulatives and a number of other multi-modal teaching practices.

Teacher Efficacies

As a teacher increases his or her own self-efficacy with respect to any content area, the overall subject area efficacy and competency of the teacher increases. Additionally, there has been a positive correlational shown between the self and teaching efficacies of teachers with respect to mathematics content (Bates et al., 2011), and subsequently in teaching performance and ability.

Pre-service teachers who have a greater belief in their mathematical abilities, show increased confidence in the classroom and are more likely to have increased mathematical teaching efficacy, compared to those who do not have a high mathematical self-efficacy (Bursal & Paznokas, 2006). Teacher efficacy beliefs can be used as a predictive factor of instructional quality and further student support (Ekstam, Korhonen, Linnanmaki, & Aunio, 2017). Confidence does not necessarily correlate to ability level

(Cheema & Skultety, 2017), but rather efficacy improves confidence levels. A teacher's actual ability or competency is often masked by nerves or feelings of unease.

An interesting aspect of teacher self-efficacy is that it can be affected by a number of litigating factors including student's thinking and the effectiveness of classroom management practices (Holzberger, Philipp, & Kunter, 2013). Another factor is that teacher self-efficacy can also be affected by one's interest in mathematics and his or her content area knowledge (Long & Woolfolk Hoy, 2006). Since research shows individuals are more likely to pursue further development and growth in areas of interest, the efficacy of teachers who enjoy mathematics is often higher when compared to the efficacy of teachers who do not enjoy the subject (Renninger & Hidi, 2011).

Additionally, pre-service teachers who exhibit higher mathematical self-efficacy are more confident and willing to try new lessons and methods of teaching mathematics (Bursal & Paznokas, 2006; Wilkins, 2008). New and innovative lessons can also peak student interest, increasing student engagement. Due to the positive correlation between self and teaching efficacies (Bates et al., 2011), and the negative correlation between mathematical teaching efficacy and mathematics anxiety (Akin & Kurbanoglu, 2011), it is beneficial to both students and teachers to increase the mathematical teaching efficacy of the teacher in order to reduce the level of mathematics anxiety in the classroom.

Measures of Self-Efficacy

Self-efficacy of teachers has been studied and measured for a number of years, using various instruments related to Bandura's theory of self-efficacy (1977).

One of the first instruments used to measure efficacy in teachers was the Teacher Efficacy Scale (TES) developed by Gibson and Dembo in 1984. It was based on

Bandura's theory of self-efficacy, but asked questions related to general teaching efficacy, not just self-efficacy. The TES consisted of 30 multiple choice with six options: *strongly disagree, moderately disagree, disagree slightly more than agree, agree slightly more than disagree, moderately agree,* and *strongly agree*.

An instrument specifically related to science teacher efficacy was developed by Enochs and Riggs in 1990 called the Science Teaching Efficacy Belief Instrument (STEBI). It consisted of 25 multiple choice questions with five possible Likert responses: *SA – strongly agree, A – agree, UN – uncertain, D – disagree,* and *SD – strongly disagree*. Two versions were developed. The STEBI-A was the suggested instrument for in-service teachers, while the STEBI-B was recommended for pre-service teachers. The STEBI-B was later adapted by Enochs, Smith, and Huinker in 2000 as an instrument to measure efficacy in mathematics teacher called the Mathematics Teaching Efficacy Belief Instrument (MTEBI). It consisted of 21 multiple choice questions with five possible Likert responses: *SA – strongly agree, A – agree, UN – uncertain, D – disagree,* and *SD – strongly disagree*. Thirteen of the questions are related to Personal Mathematics Teaching Efficacy (PMTE) and eight are about one's Mathematics Teaching Outcome Expectancy (MTOE).

In 2001, Tschannen-Moran and Woolfolk Hoy developed an efficacy instrument based on efficacy for instructional strategies, classroom management, and student engagement. The instrument was called the Ohio State Teacher Efficacy Scale (OSTES). It consisted of 24 Likert scale questions, with options ranging from one to nine.

One of the more recent efficacy instruments is the Teacher Efficacy Beliefs System-Self (TEBS-Self) instrument developed by Dellinger, Bobbett, Olivier, and Ellett in 2008. This instrument was based on Bandura's original theory. The TEBS-Self instrument was designed to measure three key features: teachers' self-efficacy, teachers' work-group collective efficacy, and teachers' faculty collective efficacy. The main focus was the first subsection of teacher self-efficacy with a specific focus on tasks that relate to effective teaching and learning (Dellinger et al., 2008). It consisted of 31 multiple choice questions with four options: *weak beliefs in my capabilities, moderate beliefs in my capabilities, strong beliefs in my capabilities,* and *very strong beliefs in my capabilities*.

For the purposes of this study, the MTEBI was adapted and given to participants, with additional questions relating to confidence in teaching and learning mathematics.

Perceptions of Mathematics

Teachers often identify their negative experiences and relationships with mathematics in their own schooling as affecting their attitudes towards mathematics and teaching mathematics. Likewise, students often associate negative experiences with classes and subjects to the classroom teacher (Koza, 2015). Students who perceived their classrooms as being mastery-oriented and challenging, reported higher levels of mathematical self-efficacy, which translated to improved test scores in comparison to their counterparts in classrooms without these traits (Fast, Lewis, Bryant, Bocian, Cardullo, Rettig, & Hammond, 2010).

Boaler (2016) also presented an interesting assessment of mathematics education and how current mathematics research is not widely-used, or in instances, even known, by mathematics teachers in her TEDx Talk about surprising factors around mathematics learning. This is a major limitation when it comes to understanding or implementing current literature in elementary mathematics classrooms. School boards and individual educators are constantly looking for new initiatives or programs that will increase the academic performance of students in mathematics classes. There is a great deal of research that has been conducted and published regarding mathematics classrooms and best practices in terms of the meaningful teaching of students, but much of it is not easily accessible or readily available (Boaler, 2016; Harbin & Newton, 2013; Swars, Smith, Smith, Carothers, & Myers, 2018). For example, Boaler (2016) presents research about the using fingers for counting and adding. This research showed that the use of fingers improves mathematical abilities and is a greater predictor of academic success in later grades and years of study. She states most educators have no idea about this research and actually discourage students from using finger counting because it is childish. This is only one example of research results that could be beneficial to students, but they are not presented to educators.

In addition to less than modern teaching practices, many students tend to have an opinion that they will never be proficient in the study of mathematics, no matter what they try (Calandrelli, 2015). As such, over the years, a classroom culture of avoidance seems to have developed (Calandrelli, 2015). In her 2015 TEDx Talk at Oregon State University, Calandrelli addresses the societal acceptance of STEM illiteracy. Mathematics is a subject area in which people will openly state they are not proficient and strongly dislike, or even, hate. For example, when a student states he or she is ‘bad at math’, other students, teachers, even parents, will accept this statement, tell the student it is alright, and to try his or her best. Often times, individuals reply with affirmations that, they too, are not very good where mathematics is concerned. This propagates the idea that mathematics is not for everyone and the mentality of struggling through the subject as best as one can and then moving on to something else.

Elementary Mathematics in Ontario Schools

Elementary mathematics in the Ontario school system is broken down into five overall strands: Number Sense and Numeration, Measurement, Geometry and Spatial Sense, Patterning and Algebra, and Data Management and Probability (Ontario Ministry of Education, 2005). Previous research has shown elementary pre-service teachers exhibit minimal understanding of the conceptual based knowledge and theory that is required to teach elementary mathematics (Kajander, 2010). It is important to support new and upcoming teachers, so they have the skills to effectively support the youth in their classrooms.

Supporting students, especially at an early age, is a crucial factor in determining the future success and understanding of a child. Elementary students are more likely to engage in new topics whole-heartedly, while adolescent learning can be affected by outside factors, such as emotional and social factors (Gura, 2005). When teachers have a deeper understanding of elementary mathematics, they are able to assist students in making meaningful connections to the material. Mathematics topics can be related to one another, and students can learn to become independent learners and critical thinkers when given the opportunity to explore the connections between topics (Bohan, 1990). Promoting problem-solving in early years can create a better foundation for later learning. *Figure 2* briefly describes three types of supports that foster and support the development of positive perceptions of mathematics within elementary classrooms.

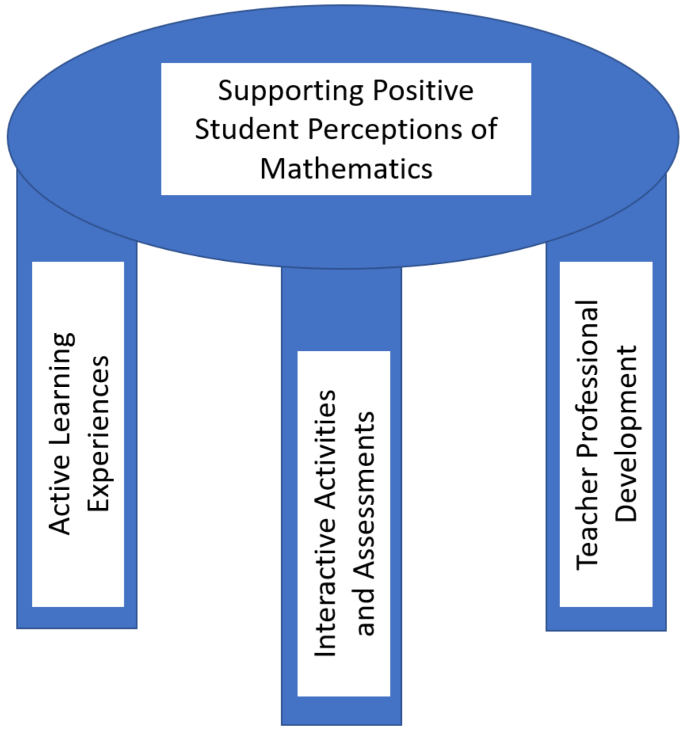

Figure 2. Three key factors that can support the development of positive mathematics perceptions.

Recently, the Ministry of Education in conjunction with the Government of Ontario have released a proposal for a new mathematics curriculum that goes back to basics and teaches the fundamental mathematics concepts required for success, rather than the discovery mathematics curriculum that has been used in recent years. The new curriculum will incorporate some rote memorization in the form of learning basic concepts, such as mental mathematics for addition, subtraction, multiplication, and division (Lilley, 2019).

Standardized Testing

Standardized testing has been shown to have a negative effect on students' confidence and self-esteem. Standardized testing can provoke feelings of self-doubt and anxiety. Many theorists (Bruno-Jofre, 2014; Noddings, 2007) in education have debated about the worth of standardized testing and if the information gleaned from these tests is a valuable contribution to education, both in classrooms and at policy-making levels. Nel Noddings (2007) believed the focus of education should be on the whole child and that educators have a responsibility to educate a child intellectually, as well as, spiritually and socially. Additionally, standardized testing often does not account for differences in students, such as race, religion, or socioeconomic status. Students from more affluent lifestyles that are not within minority culture groups tend to perform better (White, Stepney, Hatchimonji, Moceri, Linsky, Reyes-Portillo, & Elias, 2016). As such, questions arise about the information these tests provide. Does the overall learning experience of the students decrease as teachers work to ready students to perform well on a government test that does not necessarily appeal to the students' learning styles?

Teachers can also be greatly affected by the external pressures placed on them to have their students obtain high scores on standardized testing. Teachers who teach in areas with predominantly marginalized youth, tend to have less opportunities to teach authentically, as they are rushing through the curriculum and teaching to the test, rather than providing students with a chance to inquire, explore, contextualize, and consolidate (Sanchez-Suzuki & Zuniga, 2018).

Recent announcements from the Ministry of Education in Ontario have proposed a mathematical proficiency test that pre-service teachers must take and pass in order to become certified to teach in the province of Ontario (Rizza, 2018). Additionally, teachers who are currently certified may also be asked to complete and pass yearly mathematics tests to maintain their certification (Jeffords, 2019). These tests may lead to an increase in mathematics anxiety and a reduced mathematical self-efficacy in Ontario teachers.

Student Achievement

Maslow's Hierarchy of Needs (1943) states that before an individual can focus on higher levels of the pyramid, such as the problem-solving and creativity required o be successful in mathematics, the basic needs of the student must be met. This includes feeling safe and accepted in the classroom, cared for by adults in the building, being well-rested, and having enough to eat and drink. Teacher have the ability to satisfy some, if not all of these needs, at least for the duration a student's school day. Student outcomes and achievement can be accurately predicted by a teacher's confidence and self-efficacy with respect to teaching and learning mathematics (Woolfolk and Hoy, 1990). An additional factor in supporting student achievement is the promotion of a growth mindset, and the idea that mistakes are a necessary part of the learning process. Teachers who have stronger beliefs in their own abilities welcome more student questions and are less judgemental of students' mistakes and shortcomings when learning new material (Ashton & Webb, 1986). Redirecting students to better strategies after making mistakes can assist in developing problem-solving skills and motivate students to try again, acting as a driving force to future success (Christensen, Horn, & Johnson, 2008).

Hypotheses Based on Literature and Research Questions

Based on the existing body of literature and the research questions the following are the hypotheses:

Research Question One: What is the nature of pre-service teachers' perceptions of their confidence and self-efficacy in learning to teach mathematics in a primary/junior teacher education program in the Faculty of Education at a university in Southwestern, Ontario, Canada?

Hypothesis One: Participants will demonstrate improved confidence and self-efficacy following the completion of a mathematics education course and placement experiences.

Research Question Two: What content areas within the mathematics curriculum are understood and not understood by primary/junior pre-service teachers at the Faculty of Education at a university in Southwestern, Ontario, Canada?

Hypothesis Two: Participants will demonstrate improved mathematical conceptual understanding and competency in mathematics following the completion of a mathematics education course and placement experiences.

Research Question Three: How do their pre, during, and post experiences in the program advance our understanding of their learning to teach mathematics in the two-year Bachelor of Education program in the province of Ontario?

No hypothesis is made for this research question, as the aim is to explore major themes revealed during individual interviews.

Chapter 3: Research Methodology

Overview

A sequential explanatory, mixed methods research design is the method used for this research (Creswell, 2012). Such a design has been selected because given the individuals who had the option of participating in the study, there was no way to assign truly randomized groups of people. This phenomenological study (Moustakas, 1994) also focuses on a specific division of pre-service teachers who are taking specific mathematics teacher education courses. Data was collected from a number of sources to assess the student perceptions of the mathematics methodology courses. The aim of the survey portion of the study was to measure the perceived mathematical confidence and self-efficacy of primary/junior pre-service teachers and was used to make connections between demographics and views of mathematics, as such connections arose.

The study also obtained quantitative data in the form of a Grade 6 level Mathematics test pre- and post-teacher education course and is discussed herein. The test was used to assess the mathematical competency and content area understanding of the pre-service teachers prior to and after completing their respective mathematics teacher education courses based on their cohort year. The study used qualitative research methods with the data collected from individual interviews with a selection of pre-service teachers regarding their perceptions of the new two-year teacher education program and their perceived mathematical confidence and self-efficacy. A combination of the data collected was used to formulate recommendations for practical implications and applications in the classroom. Further descriptions of each data collection instrument are provided within the chapter.

Pre-service teachers were asked to complete a mathematical efficacy survey and a mathematical competency test by their professor to assess their mathematical confidence and self-efficacy. Participants completed the same efficacy survey and a similar competency test (same concepts and different numbers) before and after taking the respective Mathematics Education course for their year of study. Participants generated a unique identification code at the beginning of the survey and competency test each time they completed it, which allowed for participant pre- and post-responses to be paired together. The identification code was written at the top of each page of the survey and test in case the pages became separated for any reason. Participants were also asked during the individual interviews to compare their mathematical self-efficacy before, during, and after the teacher education program. All participants were asked to complete the efficacy survey and competency test.

Following Research Ethics Board (REB) approval, a subset of four pre-service teachers from this group were randomly selected by the researcher and asked to partake in the individual interview process. A stratified random sample was used to select a sample that was representative of the program. The sampling considered gender and cohort year. Since the interviews provided qualitative data about the program itself and how the pre-service teachers view their confidence and self-efficacy, they did not need to be related back to specific surveys or tests. This maintained the confidentiality and anonymity associated with the survey and test responses.

Participants were initially contacted through the Blackboard Learning Management System for their specific course. A letter of information (Appendix A) and a note outlining the research (Appendix B) were posted on Blackboard prior to the mathematical confidence and efficacy pre-survey (Appendix C) and pre-test (Appendix D) and post-survey and post-test (Appendix E) administration. Contact was made with the participants on the day of the survey and test administration in class. Since the Mathematics Foundations and Mathematics Methodology classes are mandatory for each respective cohort, these locations encompassed the full target population for the survey. Surveys were distributed in class, folded, sealed in an envelope, and placed into a survey collection box at the front of the classroom which was collected by the professor when all students had completed the survey. If students were absent the day the survey was administered, they were given the option to complete the survey during the next class and to place their survey into the survey collection box, but none of the participants chose to do so. A similar process occurred for the competency test which was administered on the same day as the survey administration. If participants were consistently not in class, their responses were not collected, and therefore, not included in the data. Since the research aim was to explore perceptions of pre-service teachers' mathematical confidence and self-efficacy and whether or not the Bachelor of Education Mathematics Foundations and Methodology courses were helpful, the participant needed to attend class regularly. Individual interviews were conducted at the Faculty of Education. Responses were recorded, transcribed, and later reviewed by the participants.

Sampling Techniques

Purposeful sampling was used to select all primary/junior pre-service teachers at a Faculty of Education in Southwestern, Ontario, Canada, in Mathematics Foundation and Methodology courses. All students within his classes were given the option to complete the efficacy survey and mathematics test during class time. Participants were divided into three groups: concurrent students in Year One of the Bachelor of Education program, consecutive students in Year One of the Bachelor of Education program, and consecutive students in Year Two of the Bachelor of Education program. Survey data collected from second-year pre-service teachers was also used comparatively with the first-year data. All participants were recruited from the primary/junior division of teacher candidates taking the Mathematics Foundations and Mathematics Methodology classes at the Faculty of Education.

Mathematical Confidence and Efficacy Pre- and Post-Survey

The efficacy questions in the survey have been adapted in part from the Mathematics Teaching Efficacy Belief Instrument developed by Huinker and Enochs (1995), which is a variation of the Science Teaching Efficacy Belief Instrument developed by Enochs and Riggs (1990). The mathematical efficacy instrument has been used in a number of research studies, later published in peer-reviewed journals and articles, and has been formally tested for validity (Enochs, Smith, & Huinker, 2010). The demographic questions and questions regarding mathematical confidence were added to better align with the research questions. The adapted survey was reviewed by professors in education, specifically those who teach mathematics education classes, to establish content validity. Edits were made based on expert feedback from professors. The survey was piloted prior to use. It was given to recent primary/junior Bachelor of Education graduates, mainly in the Master of Education program or students who were still connected to the Faculty of Education in some way. Again, edits were made with respect to question clarity. Every year, the instructor provides his students with a pre- and post-efficacy survey as a form of program development. For the Fall 2018 course, I adapted the survey as per the direction of the instructor who assigned this task to me as a portion of my graduate assistantship duties. The instructor provided the surveys to the participants, and ensured the data was kept in a secure location before releasing it to me after obtaining REB approval.

Mathematical Conceptual Understanding Pre- and Post-Test

The mathematical competency test was created based on the five major strands within the elementary mathematics curriculum. The test consisted of the same five multiple choice demographic questions as the survey and five short-answer questions that required the participants to show their work and thinking process. All tests were marked by the researcher to ensure the greatest level of consistency when assigning overall scores. All tests were marked following completion of the Mathematics Education courses to ensure participants did not feel undue pressure as the researcher was also the course graduate assistant in the fall semester. Previous versions of the Grade 6 Mathematics EQAO test were used as a question bank, with questions being modified to meet the curriculum expectations, as these questions had already been reviewed prior to use. The Grade 6 curriculum was selected as it is the upper limit of a primary/junior teacher's level of qualification. As with the efficacy survey, the competency test was reviewed by professors in education, including those that teach the Mathematics Education courses to establish content validity. Required edits and changes were made. The test was then piloted using the same sample of teachers who agreed to pilot the efficacy survey. The research ethics committee suggestions and recommendations were also taken into consideration prior to test administration. As with the mathematical confidence and efficacy surveys, the professor often provides his students with a pre- and post-test for conceptual understanding as a form of program assessment. For the Fall 2018 course, I created new versions of the tests as per the direction of the instructor who assigned this task to me as a portion of my graduate assistantship duties. The professor provided the tests to the participants, and ensured the data was kept in a secure location before releasing it to me after obtaining REB approval.

Individual Interviews

The individual interviews provided qualitative data about the pre-service teachers' feelings towards mathematics and their confidence when faced with the prospect of having to teach mathematics in their classrooms. Pre-service teachers also answered open-ended questions to provide feedback about the program (Appendix F). The questions helped to collect information about their learning experience throughout the program, which topics were worthwhile in covering, which additional topics could have been added, if the pre-service teachers felt they exhibited lower levels of mathematics anxiety when planning or teaching, and how the teacher education program did or did not improve their mathematical self-efficacy throughout the course. Participants constructed responses based on their lived experiences with mathematics, which may include their early experiences which have shaped and coloured their views towards learning and teaching mathematics. The researcher asked participants broad questions, so they had the opportunity to develop and share their own opinions. Participants had varying views based on their own experiences, some positive and some negative, which are further explored in *Chapter 4*.

Ethical Considerations

There were a number of ethical considerations made in the process of this research. REB approval was sought and obtained prior to the administration of the pre-survey, pre-test, or commencement of individual interviews. Approval was also obtained from the professor who used his classes as participant pools for the study. This action ensured that the survey and test did not undermine the beliefs of the professor, and in fact, aligned with the overall themes of the course.

Precautions were taken and resources were available for participants who may have experienced issues related to mathematics anxiety when taking the survey, the test, or discussing their experiences with mathematics in later individual interviews. Mathematics anxiety can be very severe for some individuals and it is extremely important that supports were put in place for these individuals. Information for counselling services was available for participants who were also given the option to withdraw from completing the survey, the test, or participating in the individual interviews at any time prior to submission of responses and final member checking.

Confidentiality of responses has been maintained for a number of reasons. Participants need to know their individual responses will not influence the researcher, professors, administration, or their overall performance in the class in any way. Additionally, confidentially has been maintained for the participants who will be seeking employment in the near future. Participants needed to be aware that their responses would not be shared or be held against them when trying to obtain teaching positions following completion of the program. Finally, participants were separated when completing the survey and test to reduce the risk of participants viewing or influencing the answers provided by other participants on the survey or test. Surveys and tests had unique identification codes and have been and are currently stored in a secure location until the original data is ultimately destroyed following completion of the study. Confidentiality has been maintained by the researcher regarding the information provided in individual interviews.

Post-Collection Processing of Data

At the beginning of the survey and test, students were given a short procedure to follow in order to create a unique identification code. The code consisted of the second letter of the participant's first name, the first two letters of the participant's mother's name, the last letter of the participant's last name, the number of letters in the participant's first name, and their program year. Pre-service teachers were also given an example at the end of the survey, for clarity. The example read, "For example, a participant named Mary Smith who has a mother named Juliana and is in second year would have the code: **AJUH42**". In the event that a duplicate identification code occurred, demographic information was recorded to be used to differentiate between respondents. For example, if the participant in the example has a twin brother named Gary Smith, the identification code for each participant would be the same, but the demographic information would not match (i.e. Gary would circle male and Mary would circle female). These details would be used to ensure the pre-survey would be matched to the corresponding post-survey and the pre-test would be matched to the corresponding post-test. Within the current study, no duplicate codes occurred.

Survey responses were collected pre- and post-class using a Likert scale ranging from "Strongly Agree to Strongly Disagree" which was later numbered from one to five for analysis. The options were *strongly agree, agree, neither agree nor disagree, disagree,* and *strongly disagree.* Data was first quantitatively analyzed using descriptive statistics to look for trends between mathematical confidence and efficacy. Comparative trends were evaluated for pre- and post-class responses and between first year concurrent, first year consecutive, and second year consecutive pre-service teachers. Data was then analyzed using descriptive and inferential statistics. Generalizations could not be made based on the sample size, but initial trends could be identified.

Mathematical competency test responses were collected and scored pre- and post-class using open-ended, short answer questions related to the Grade 6 curriculum. Data has been quantitatively analyzed following similar methods, strategies, and testing types as the survey responses.

Individual interview responses were catalogued, organized, and analyzed by theme. All individual interviews were recorded and qualitatively analyzed according to general, proposed themes, which include: confidence in learning to teach mathematics, confidence in teaching mathematics, efficacy in learning to teach mathematics, perceptions of learning to teach mathematics, perceptions of the new two-year Bachelor of Education program, and any other emerging themes.

Participants were sent a transcription of the recordings in order to member check and to ensure accuracy of interpretation. Participants were then be given the opportunity to amend their responses after reading transcriptions. Comparisons of perceptions, confidence, and self-efficacy have been analyzed and explored. When common themes presented, participant responses were further dissected and analyzed for commonalities and differences between lived experiences, previous instruction, and program experiences.

Limitations

One limitation associated with this study is the ability to generalize the findings. This study consists of the primary/junior pre-service teachers in Year One and Year Two at the Faculty of Education at a university in Southwestern Ontario in one professor's sections of Mathematics Foundation and Methodology classes. The sample size is not large enough to generalize the results after one trial. Additionally, the survey and test were only given to students at one university, making it even more difficult to attempt to generalize the findings. However, this study does not seek to generalize, but rather to explore the subtle nuances and their reflections on the lived experiences of a group of pre-service teachers as they share their experiences and perceptions of learning to teach mathematics, as well as, further develop their own competencies in learning and teaching mathematics. Results could become generalizable with the addition of more trials. These trials could include more sections from varying years at the same university in Southwestern Ontario or from additional sections of comparable Mathematics Education courses at different universities in Southwestern Ontario. Due to the current sample size, findings cannot be generalized as they reflect only one cohort of students which could be stronger or weaker than the average abilities displayed by larger groups of pre-service teachers.

This study has only been conducted with pre-service teachers from the Faculty of Education at one university in Southwestern, Ontario. Additionally, all participants are from the primary/junior division. Pre-service teachers who are confident in mathematics and those who are not confident in their abilities to teach mathematics were recruited.

Another limitation may be the response rate of the student participants. Participants were provided with a hard copy of the survey, followed by the test, that were distributed in all sections of both the Mathematics Foundations and Mathematics Methodology classes taught by the same professor. The survey contained all multiple choice or Likert scale questions. The test contained all short answer questions. The survey and test were distributed closer to the middle of the class. The reasoning for this time selection is that it is hypothesized this time would provide the best opportunity to collect the most responses. If the survey and test were administered at the start of the class, students may be late and miss the survey and test or be rushed to complete them. If the survey and test were administered at the end of class, students may take the opportunity to leave class early for the day. In the middle, the hope is that students would be more willing to fill out the survey and test and provide thoughtful answers.

An additional limitation is the use of self-reporting measures. When asking the pre-service teachers to assess their confidence and efficacy, there is no way, in the current model, to assess whether the pre-service teachers' interpretations of themselves are an accurate representation. If a participant believes he or she is good at mathematics and an effective mathematics teacher, he or she will answer as such. Conversely, if a participant does not believe in his or her ability to complete or teach mathematics, his or her survey responses will reflect this belief, whether or not the belief is accurate.

Finally, pre-service teachers may feel obligated or pressured to respond to the post-survey and post-test more positively than the pre-survey and pre-test, as a result of the experiences in their Mathematics Foundations or Mathematics Methodology classes. Once again, since the participants are self-reporting it may be difficult to identify the occurrence of this phenomenon. Participants may have liked the class or the professor and feel as if their latter responses should be increased to “prove” the class was meaningful or relevant to their learning experiences. One way to negate this was to clearly state the responses will, in no way, impact the status of the professor or the grades received in the class, but rather be used to add to or strengthen varying components of the classes, for future students.

Chapter 4: Results and Discussion

This chapter discusses the data collection process, in conjunction with the analysis of both the quantitative and qualitative data collected from participants in order to answer the research questions.

Analysis of Mathematical Confidence and Efficacy Pre- and Post-Surveys

The mathematical confidence and efficacy pre- and post-surveys administered to participants consisted of three main components: demographic questions, questions regarding participants' perceived views of their confidence in mathematics, and questions related to the participants' perceived mathematical efficacy. Data in the latter two sections was collected using a Likert scale with five options: strongly agree, agree, neither agree nor disagree, disagree, and slightly disagree which were enumerated from one to five, respectively.

Of the 28 first year concurrent students who were administered the survey, 28 completed the pre-survey and 28 completed the post-survey. Due to improper code generation or the lack of code provided 26 completed pre- and post-survey responses were catalogued. Of the 28 first year consecutive students who were administered the survey, 28 completed the pre-survey and 26 completed the post-survey. Improper code generation or surveys with no recorded code resulted in 22 completed pre- and post-survey responses being catalogued. Finally, of the 55 second year consecutive students who were given the survey, 49 completed the pre-survey and 35 completed the post-survey. Due to improper code generation, lack of code generated, or submitted surveys that were left completely blank 26 completed pre- and post-survey responses were catalogued. A summary of responses numbers has been recorded in *Table 1*.

Table 1: Number of Responses and Pairings for Mathematical Confidence and Efficacy Pre- and Post-Survey

Cohort	Number of Surveys Administered	Number of Pre-Survey Responses	Number of Post-Survey Responses	Number of Matched Pre- and Post-Survey Responses
Year One Concurrent	28	28	28	26
Year One Consecutive	28	28	26	22
Year Two Consecutive	55	49	35	26

As *Table 1* outlines, there was a high participant response rate in both of the Year One classes. The Year Two class had an initially good response rate, followed by a sub-standard post-survey response rate. Of the received Year Two responses, a number of participants either provided answers without providing a code or chose to seal a blank survey into the submission envelope.

Table 2 displays the descriptive statistics for the participants' perceived views of their confidence in teaching and learning mathematics

Table 2: Participant Views of Mathematics

Survey Question	Cohort	Pre-Survey		Post-Survey	
		Mean	Standard Dev.	Mean	Standard Dev.
I feel confident trying new teaching methods or mathematics lessons with my students.	Year 1 Concurrent	2.68	0.89	2.14	0.58
	Year 1 Consecutive	2.64	0.97	2.23	0.75
	Year 2 Consecutive	2.41	1.01	2.17	0.81
I seek out new opportunities for mathematics professional development.	Year 1 Concurrent	2.75	0.87	2.25	0.63
	Year 1 Consecutive	2.89	0.94	2.23	0.80
	Year 2 Consecutive	2.37	0.83	2.23	0.86

Previous experiences with mathematics influence future experiences.	Year 1 Concurrent	1.93	0.75	1.86	0.69
	Year 1 Consecutive	1.93	0.80	1.77	0.58
	Year 2 Consecutive	2.06	0.87	2.23	0.86
My previous experiences with mathematics influence my teaching methods.	Year 1 Concurrent	2.25	0.83	1.96	0.82
	Year 1 Consecutive	2.46	0.78	2.08	0.83
	Year 2 Consecutive	2.35	0.85	2.17	0.94
I am good at mathematics.	Year 1 Concurrent	2.96	0.82	2.71	0.75
	Year 1 Consecutive	3.00	0.89	2.81	0.83
	Year 2 Consecutive	2.84	0.98	2.54	0.81
I enjoy teaching mathematics.	Year 1 Concurrent	2.75	0.63	2.50	0.73
	Year 1 Consecutive	3.07	0.80	2.65	0.78
	Year 2 Consecutive	2.57	1.05	2.69	0.82
I enjoy(ed) learning mathematics.	Year 1 Concurrent	3.14	1.16	2.25	0.87
	Year 1 Consecutive	3.00	1.13	2.62	1.04
	Year 2 Consecutive	2.90	1.15	2.77	1.17
I am a good mathematics teacher.	Year 1 Concurrent	2.96	0.19	2.54	0.73
	Year 1 Consecutive	3.14	0.64	2.85	0.53
	Year 2 Consecutive	2.80	0.86	2.57	0.69
Total Views of Mathematical Confidence Average	Year 1 Concurrent	2.68	0.81	2.28	0.73
	Year 1 Consecutive	2.77	0.88	2.41	0.78
	Year 2 Consecutive	2.54	0.96	2.42	0.88

The mean and standard deviation of each response, by cohort year, have been summarized in *Table 2*. The closer the mean is to one, the more the participants selected strongly agree for each of the statement. Since each of the statements relates to a teacher's confidence in their mathematical abilities to learn and teach, the lower the average, the more confident the respondents perceived themselves to be. Comparison of the means shows that the average mean response decreased for all three subgroups of the participants, which should be expected as within the time frame of the pre-survey to the post-survey, participants completed a Mathematics Education course and two in-school placements, where many participants had the opportunity to teach mathematics. The average means of the pre-survey responses closely align with the general assumption of how the averages should fall. The first-year consecutive students who generally have the least amount of classroom teaching and education experience scored the highest average of 2.77, meaning as a group, they felt the least confident. The concurrent cohort who are in their first year of the Bachelor of Education program exhibited a lower average than the consecutive first years, which is to be expected given that they have had the opportunity to partake in classroom observations prior to starting in the Faculty of Education. There average score was 2.68. Finally, the year two consecutive students scored the lowest average of the three groups, 2.54, which may be due to the fact that second year students have had previous mathematics education courses at the Faculty of Education and a greater number of observational and teaching placements in elementary classrooms.

The average means of the confidence questions on the post-survey reveal some interesting findings. After completing a semester long Mathematics Education course and two placements in the first semester, the year one concurrent students demonstrated a decrease in their average by 0.4, to an overall score of 2.28, meaning that participants are more likely to agree they were good at learning mathematics, teaching mathematics, and that overall they enjoyed mathematics. The first-year consecutive students decreased their average by 0.36, to a score of 2.41. The improvement in their average is similar to that of the first-year concurrent students who were also taking their first Mathematics Education course but remains higher. One contributing factor could be the year one consecutive students still have less classroom experience than both their year one concurrent and year two consecutive counterparts. Finally, the year two consecutive students decreased their average score by 0.12, to an overall average score of 2.42, which was almost identical to the average of the first-year consecutive students. While the sample size is far to small to generalize results, one hypothesis to support the alignment of the two averages could be that this is generally the level a primary/junior pre-service teacher will reach with respect to elementary mathematics if they have not been focused on the teaching professions from the onset of their undergraduate coursework and degrees. Additionally, it stands to reason the year two consecutive students would show the smallest decrease in their scores as they have previously taken Mathematics Education courses, as well as, taken part in elementary teaching placements.

The full pre- and post-survey consisted of 25 efficacy questions. Some questions were used as a form of data checking to see if participants would provide similar answers to questions that were asking the same information but in different ways. Six of the 25 questions have been selected for further analysis and *Table 3* displays the descriptive statistics for the participants' perceived self- and teaching-efficacy in elementary mathematics for the selected questions.

Table 3: Participant Views of Mathematical Self- and Teaching-Efficacies

Survey Question	Cohort	Pre-Survey		Post-Survey	
		Mean	Standard Dev.	Mean	Standard Dev.
I am constantly looking for better ways to teach mathematics.	Year 1 Concurrent	2.25	0.78	1.85	0.64
	Year 1 Consecutive	2.14	0.79	1.96	0.71
	Year 2 Consecutive	1.96	0.81	1.91	0.56
I am able to teach mathematical concepts effectively.	Year 1 Concurrent	2.96	0.50	2.54	0.57
	Year 1 Consecutive	2.75	0.51	2.54	0.63
	Year 2 Consecutive	2.43	0.61	2.44	0.69
Previous gaps in mathematics education can be overcome by good teaching.	Year 1 Concurrent	2.11	0.56	2.04	0.73
	Year 1 Consecutive	2.18	0.66	2.00	0.48
	Year 2 Consecutive	2.20	0.70	2.29	0.67
Low mathematics achievement is generally not the fault of teachers.	Year 1 Concurrent	3.36	0.81	3.50	0.78
	Year 1 Consecutive	3.54	0.68	3.65	0.83
	Year 2 Consecutive	3.47	0.61	3.18	0.82
I understand mathematics concepts well enough to be effective in teaching mathematics.	Year 1 Concurrent	2.43	0.62	2.43	0.78
	Year 1 Consecutive	2.54	0.73	2.46	0.80
	Year 2 Consecutive	2.45	0.83	2.44	0.85

When teaching mathematics, I welcome student questions.	Year 1 Concurrent	1.71	0.75	1.79	0.49
	Year 1 Consecutive	1.93	0.80	1.77	0.70
	Year 2 Consecutive	1.53	0.64	1.85	0.81
Total Self- and Teaching-Efficacies of Selected Questions Average	Year 1 Concurrent	2.47	0.68	2.36	0.67
	Year 1 Consecutive	2.51	0.70	2.40	0.70
	Year 2 Consecutive	2.34	0.71	2.35	0.74

The mean and standard deviation of each response, by cohort year, have been summarized in *Table 3*. As with the confidence scores, the closer the mean value is to one, the higher the participants view their self- and teaching-efficacies as they relate to elementary mathematics. The first-year concurrent cohort demonstrated an initial average mean score of 2.47 which is moderate. There was little change between the pre- and post-survey responses leading to a slight decrease of 0.11, to an overall average of 2.36 in the post-survey responses. The first-year consecutive cohort scored an overall mean of 2.51 on the pre-survey, which also decreased by 0.11, to a value of 2.40 on the post-survey. These small decreases demonstrate that for the two first-year cohorts, both concurrent and consecutive, the Mathematics Education course and placement did not profoundly affect their perceived efficacy, even though they became more confident in their abilities. The second-year consecutive cohort showed a negligible change reporting their self- and teaching-efficacies with a pre-survey score of 2.34 and a post-survey score of 2.35, differing by only 0.01. This insignificant change in efficacy of the second-year participants shows that for this specific group of students, the second year of the program and placements did not further improve their efficacy, even though it did improve their overall confidence levels.

Interestingly the values of the average means of self- and teaching-efficacies of the post-surveys are very similar among all three cohort groups. While the sample size is too small to generalize, this result could lead to future predictions that pre-service teachers may not develop efficacy far beyond this point while they are still in teacher education programs.

Parametric tests can also be performed on the confidence and efficacy dataset, as the data is continuous, and the means are being compared to one another. Since the data was collected on paper copies of the survey in class, the data was transferred to an Excel spreadsheet, at which time the pre-survey responses were paired with their corresponding post-survey responses, based on the unique identification code generated by participants. Overall, the first-year concurrent cohort, first-year consecutive cohort, and second-year consecutive cohort resulted in 26 matches out of a possible 28, 22 matches out of a possible 28, and 26 out of a possible 55, respectively, and as previously reflected in *Table 1*. In order to further protect the identities of the participants, the code listed within *Table 4* will be changed. 1ConcXX represents the first-year concurrent students, with XX being changed to 01, 02, 03, and so on for each new pairing. 1ConsXX and 2ConsXX are used for the first-year consecutive students and second-year consecutive students, respectively, following the same rules for arbitrary numbering. Additionally, the individual averages for each respondent reflect only the scores of the questions which were analyzed in *Table 2* and *Table 3*. Bolded values in the table represent a decrease in confidence or efficacy for specific participants from the pre-survey to post-survey stage.

Table 4: Paired Confidence and Efficacy Scores from Pre- and Post-Survey

Code	Pre-Confidence	Post-Confidence	Pre-Efficacy	Post-Efficacy
1Conc01	2.25	2.00	2.83	2.17
1Conc02	2.50	**2.63**	2.33	**3.33**
1Conc03	3.13	2.38	2.33	1.83
1Conc04	2.75	2.13	2.33	2.33
1Conc05	2.50	1.63	2.17	1.67
1Conc06	3.13	2.00	2.50	2.50
1Conc07	2.50	2.25	2.67	2.67

1Conc08	3.75	2.75	2.33	**3.00**
1Conc09	2.63	2.13	2.33	2.33
1Conc10	2.88	2.50	2.67	2.33
1Conc11	2.25	2.00	2.33	2.33
1Conc12	2.75	2.25	2.33	2.33
1Conc13	2.63	2.63	2.67	2.67
1Conc14	2.88	2.25	2.50	2.00
1Conc15	3.13	1.75	3.00	2.17
1Conc16	2.63	2.00	2.17	1.67
1Conc17	2.38	2.00	2.17	1.83
1Conc18	3.13	2.50	3.17	2.67
1Conc19	1.75	1.75	2.17	**2.50**
1Conc20	3.13	2.38	2.33	**2.50**
1Conc21	2.38	**2.63**	2.50	2.33
1Conc22	2.88	2.88	2.50	2.33
1Conc23	2.50	2.50	3.00	2.83
1Conc24	2.88	**3.00**	2.67	2.33
1Conc25	3.00	2.38	2.50	2.33
1Conc26	1.50	1.38	2.17	1.83
1Cons01	2.75	2.38	2.17	2.17
1Cons02	3.00	2.00	2.50	**2.67**
1Cons03	2.88	2.13	2.17	2.00
1Cons04	3.38	2.13	2.33	2.00
1Cons05	2.63	2.50	2.33	2.33
1Cons06	2.38	2.25	2.50	2.33
1Cons07	3.00	2.25	2.17	**2.33**
1Cons08	3.38	2.25	3.17	2.33
1Cons09	3.00	3.00	2.83	**3.17**
1Cons10	1.38	1.38	2.50	2.00
1Cons11	2.63	**3.25**	2.83	**3.00**
1Cons12	3.00	**3.13**	2.17	**2.33**
1Cons13	2.38	2.25	1.83	**2.00**
1Cons14	3.38	2.63	3.17	2.67
1Cons15	3.38	2.63	2.67	**2.83**
1Cons16	2.63	2.63	2.67	2.67
1Cons17	2.13	**2.25**	2.33	2.00
1Cons18	3.25	2.13	2.50	2.50
1Cons19	2.25	2.25	2.17	2.17
1Cons20	3.13	3.00	2.67	2.67
1Cons21	2.38	2.00	2.83	2.33
1Cons22	2.75	2.13	2.50	2.17
2Cons01	2.38	2.25	2.50	2.33
2Cons02	2.13	1.50	2.17	2.00
2Cons03	2.25	**2.50**	2.17	**2.33**
2Cons04	2.38	2.38	2.17	2.17

2Cons05	2.38	**2.63**	2.00	**2.33**
2Cons06	2.88	**3.00**	2.50	**3.50**
2Cons07	1.88	1.50	2.33	**2.50**
2Cons08	1.88	1.88	2.50	2.17
2Cons09	3.88	3.25	3.50	3.33
2Cons10	2.63	2.38	2.17	2.00
2Cons11	2.50	2.38	2.67	2.17
2Cons12	3.25	2.63	1.83	**2.00**
2Cons13	2.88	2.88	2.17	2.17
2Cons14	3.63	3.13	2.33	**2.67**
2Cons15	1.13	1.00	2.33	1.67
2Cons16	2.63	2.50	2.33	**2.50**
2Cons17	2.00	1.88	1.83	**2.00**
2Cons18	2.25	**2.50**	1.83	**2.50**
2Cons19	1.88	1.88	2.33	2.17
2Cons20	2.88	**3.00**	2.33	**2.50**
2Cons21	1.75	**2.00**	2.50	**2.67**
2Cons22	2.38	2.25	2.17	1.83
2Cons23	2.50	2.25	2.67	2.33
2Cons24	2.75	**3.50**	3.00	2.50
2Cons25	2.75	2.50	2.83	2.00
2Cons26	3.50	2.38	2.83	2.17

In many cases, when a participant exhibited a decrease in confidence, their efficacy also decreased. Interestingly, a number of participants noted much lower efficacy in the post-survey compared to the pre-survey, but their confidence levels increased. There were a few instances of participants having decreased confidence and increased efficacy, but these cases happened much less frequently. These cases contrast the literature that increased confidence should result in an increased efficacy level (Bates et al., 2011), resulting in a more confident teacher (Ekstam et al., 2017).

Analysis of Mathematical Conceptual Understanding Pre- and Post-Tests

The pre- and post-test to assess the mathematical conceptual understanding of the participants consisted of two major parts: demographic questions and five open-ended response questions, each relating to one of the strands of the Grade 6 elementary mathematics curriculum in Ontario. Responses to the open-ended questions were graded and the corresponding grades and average are provided herein.

Of the 28 first year concurrent students who were administered the test, 28 completed the pre-test and 28 completed the post-test. All 28 pre- and post-tests could be accurately matched based on the identification codes generated by the participants. Of the 28 first year consecutive students who were administered the test, 28 completed the pre-test and 26 completed the post-test. Improper code generation or tests with no recorded code resulted in 23 completed pre- and post-test responses being catalogued. Finally, of the 55 second year consecutive students who were given the test, 49 completed the pre-test and 33 completed the post-test. Due to improper code generation, lack of code generated, or submitted tests that were left completely blank 24 completed pre- and post-test responses were catalogued. A summary of responses numbers has been recorded in *Table 5*.

Table 5: Number of Responses and Pairings for Mathematical Conceptual Understanding Pre- and Post-Tests

Cohort	Number of Tests Administered	Number of Pre-Test Responses	Number of Post-Test Responses	Number of Matched Pre- and Post-Test Responses
Year One Concurrent	28	28	28	28
Year One Consecutive	28	28	26	23
Year Two Consecutive	55	49	33	24

As *Table 5* outlines, there was a high participant response rate in both of the Year One classes. The Year Two class had an initially good response rate, followed by a sub-standard post-test response rate. This finding is consistent with the response rate of the pre- and post-surveys distributed to students. Of the received Year Two responses, a number of participants either provided answers without providing a code or chose to seal a blank test into the submission envelope. The volume of non-coded or blank post-tests was highest in the Year Two cohort. This could be a result of increased performance anxiety as the students in this cohort are closer to seeking employment and did not want to submit a test, or admit to themselves, they may not be as prepared to teach mathematics as they should be.

Table 6 displays the average scores attained by the participants, as well as the strands and cohort.

Table 6: Average Participant Scores on Mathematics Questions

Elementary Mathematics Strand Addressed	Cohort	Pre-Test		Post-Test	
		Mean	Standard Dev.	Mean	Standard Dev.
Number Sense and Numeration	Year 1 Concurrent	0.86	0.26	0.88	0.21
	Year 1 Consecutive	0.79	0.28	0.81	0.31
	Year 2 Consecutive	0.79	0.34	0.70	0.32
Measurement	Year 1 Concurrent	0.45	0.47	0.50	0.47
	Year 1 Consecutive	0.66	0.42	0.48	0.45
	Year 2 Consecutive	0.55	0.49	0.53	0.48
Data Management and Probability	Year 1 Concurrent	0.70	0.36	0.76	0.41
	Year 1 Consecutive	0.79	0.36	0.71	0.42
	Year 2 Consecutive	0.69	0.44	0.79	0.37
Patterning and Algebra	Year 1 Concurrent	0.79	0.41	0.90	0.30
	Year 1 Consecutive	0.75	0.43	0.77	0.42
	Year 2 Consecutive	0.86	0.35	0.76	0.43
Geometry and Spatial Sense	Year 1 Concurrent	0.34	0.42	0.31	0.42
	Year 1 Consecutive	0.50	0.46	0.37	0.45
	Year 2 Consecutive	0.42	0.48	0.38	0.46
Total Mathematical Conceptual Understanding Average	Year 1 Concurrent	3.14	1.41	3.35	1.08
	Year 1 Consecutive	3.49	1.24	3.14	1.28
	Year 2 Consecutive	3.31	1.49	3.16	1.34

The mean and standard deviation of each graded response, by cohort year, have been summarized in *Table 6*. The closer the mean of the strands is to one, the more the participants demonstrated a strong understanding of the question related to the respective strand, as each question was graded out of one. Participants received marks for demonstrating problem-solving skills and using foundationally sound mathematical strategies. There were multiple, acceptable methods of answering each question. The overall average consists of each of the strand averages being added together. The closer the overall average is to five, the closer the participants were to attaining a perfect score on the open-ended questions.

As a whole, each subgroup of participants struggled with two major sections of the test: Measurement and Geometry and Spatial Sense. Many participants who attempted the pre- or post-tests struggled to formulate a response to these two questions. Many participants attempted the questions and scored a zero or attempted the rest of the test but left one or both of the above questions blank.

Comparison of the means shows that the average mean response increased for the Year One concurrent cohort, which is the expected result as within the time frame of the pre-test to the post-test, participants completed a Mathematics Education course and two in-school placements, where many participants had the opportunity to teach mathematics, and refresh their knowledge of mathematical concepts. The interesting finding is the overall averages of the Year One and Year Two consecutive cohorts both decreased. This means that not only did the subgroups not have a strong grasp on the subject material at the time of the pre-test, but their conceptual understanding ultimately deteriorated over the course of the semester. This is especially troublesome for the Year Two cohort and will be discussed later in this chapter.

Analysis of the pre-tests of the Year One concurrent students shows an initial test average of 3.14 out of 5, or approximately 63%, while the average post-test score was 3.35 out of 5, or approximately 67%. While the test scores showed some improvement from pre- to post-test, this improvement is still not remarkable. The average score on the post-test was still below the provincial average of 70%. These tests were administered to individuals who could be responsible for teaching Grade 6 level Mathematics to students within their own classroom. There are a number of participants who attained perfect scores, but of the 28 participants, nine scored 2.5 or lower on the final post-test meaning they earned 50% or less on a Grade 6 level Mathematics test based upon EQAO questions that Ontario Grade 6 students are expected to answer.

As previously discussed, the pre- and post-tests for the Year One consecutive students shows an interesting trend in that the overall scores of the post-test were lower than those of the pre-test. The average pre-test score was 3.49 out of 5, or approximately 70%, while the average post-test score was 3.14 out of 5, or approximately 63%. Of the 26 participants who completed the post-test, 11 scored 2.5 or lower, meaning they scored 50% or less overall. These findings lead to questions about what may have changed or affected their abilities to problem solve and correctly answer questions that were very similar to the original question types they were able to reason through successfully. One source of the error could be due to increased performance anxiety. For example, participants had already seen another version of the test in the pre-test so they may have wanted to show an increased performance, thereby creating a feeling of increased pressure to show the new knowledge they had obtained. Additionally, participants may have become frustrated at still not knowing how to effectively solve the problem, so they gave up on trying to think through the problem in a logical manner and left questions blank. Many of the tests had small notes written on them either apologizing for not knowing the answer, expressing their frustration in having to complete certain problems, and second guessing their answers, even when the answers were correct. As is evident from the scores and the standard deviations, the responses from participants were extremely varied.

Analysis of the pre- and post-tests for the Year Two consecutive students displays a trend that is similar to the Year One consecutive students, in that the post-test average score was less than the average pre-test score. The average pre-test score was 3.31 out of 5, which is approximately 66%, while the average post-test score was 3.16 out of 5, which is approximately 63%. Of the 33 post-test responses, 13 participants scored 2.5 or lower, for a total score of 50% or less. Once again, these findings lead to questions about what may have caused the decreased performance, and unique to the Year Two cohort, the decreased response rate. As with the Year One consecutive cohort, the decreased performance could be a result of performance anxiety related to taking a similar test or giving up, as it may be viewed as better to not try at all, rather than try and perform poorly. There could be additional contributing factors for the Year Two cohort in that they did not want to take a test so close to graduation and entering the job market that could have perceived negative effects. Additionally, some of the cohort may have become apathetic by the end of the semester, as they were ready to go back to placement and did not want to focus on theory-based methodology classes any longer. As with their first-year counterparts, many tests were left blank, students did not identify themselves through a code, and notes were left on questions pertaining to their feelings about the test.

Most of these notes were negative, although the students who performed well would often put a smiley face on their questions to convey their understanding.

Pre- and post-test data can also be compared for individual participants using their uniquely generated identification code. As with the pre- and post-surveys, the data was collected on paper copies of the test in class. Each question on the test was marked and the data was transferred to an Excel spreadsheet, at which time the pre-test grades were paired with their corresponding post-test grades, based on the unique identification code generated by participants. Overall, the first-year concurrent cohort, first-year consecutive cohort, and second-year consecutive cohort resulted in 28 matches out of a possible 28, 23 matches out of a possible 28, and 24 out of a possible 55, respectively, and as previously reflected in *Table 5*. Once again, to further protect the identities of the participants, the code listed within *Table 7* will be changed. 1ConcXX will represent the first-year concurrent students, with XX being changed to 01, 02, 03, and so on for each new pairing. 1ConsXX and 2ConsXX will be used for the first-year consecutive students and second-year consecutive students, respectively, following the same rules for arbitrary numbering. These codes do not necessarily match the codes given to the pre- and post-survey codes in *Table 4*. Bolded values in the table represent an overall average of 2.5 or less to pinpoint the number of participants who scored 50% or lower on the pre-test and post-test.

Table 7: Paired Mathematical Conceptual Understanding Pre- and Post-Test Scores

Code	Pre-Test Overall Average	Post-Test Overall Average
1Conc01	5	3
1Conc02	5	3.5
1Conc03	**2**	**2**
1Conc04	4	**2.5**
1Conc05	3.5	4

1Conc06	5	5
1Conc07	4	4.5
1Conc08	4.5	5
1Conc09	**2.5**	**2**
1Conc10	3.5	4
1Conc11	**0.5**	3
1Conc12	**2.5**	**2**
1Conc13	**2.5**	3
1Conc14	**1**	**2.5**
1Conc15	5	3.5
1Conc16	3	4
1Conc17	3.5	4
1Conc18	**2**	3.5
1Conc19	**2.5**	**2**
1Conc20	4.5	4
1Conc21	5	4
1Conc22	**1**	**1**
1Conc23	**1.5**	**2.5**
1Conc24	**1.5**	3.5
1Conc25	**2.5**	3.5
1Conc26	**1.5**	5
1Conc27	5	5
1Conc28	3.5	4
1Cons01	4	**2.5**
1Cons02	**1.5**	**2.5**
1Cons03	**2.5**	**2.5**
1Cons04	5	5
1Cons05	**1.5**	**2**
1Cons06	4.5	3.5
1Cons07	4.5	**2**
1Cons08	4	5
1Cons09	4.5	4.5
1Cons10	3	**2.5**
1Cons11	4.5	4.5
1Cons12	4.5	**2**
1Cons13	**1**	**2.5**
1Cons14	5	4
1Cons15	4	3
1Cons16	**2.5**	**0.5**
1Cons17	5	5
1Cons18	**2.5**	**1**
1Cons19	5	4.5
1Cons20	3.5	3
1Cons21	**1.5**	**1**
1Cons22	3	3

1Cons23	4	4
2Cons01	5	4.5
2Cons02	3.5	**1.5**
2Cons03	5	3
2Cons04	4	4
2Cons05	**1.5**	**2.5**
2Cons06	3.5	3
2Cons07	4	5
2Cons08	5	5
2Cons09	**2**	**1.5**
2Cons10	3	3
2Cons11	5	3.5
2Cons12	**2**	**2**
2Cons13	3	**2**
2Cons14	4.5	5
2Cons15	3.5	3.5
2Cons16	4.5	3.5
2Cons17	5	4
2Cons18	4	4
2Cons19	5	**2.5**
2Cons20	4.5	4
2Cons21	5	4.5
2Cons22	3	5
2Cons23	4.5	4.5
2Cons24	4	**2.5**

Overall, there were 23 pre-test scores at or below 2.5 and 26 post-test scores at or below 2.5. From these scores, 17 participants scored 2.5 or lower on both the pre- and post-test. This means 6 participants who initially performed in the 50% and below range were able to bring their score above 50%. The interesting finding is that 9 participants who scored 50% or lower on the post-test had initially passed the pre-test. This means over the course of the semester, which included a Mathematics Education course and two placements, these participants actually showed a decreased conceptual understanding of the strands within elementary mathematics. These findings could be due to increased mathematics anxiety and fear of looking unprepared or under-qualified (Stoehr, 2017) or mathematics avoidance faced by participants (Ashcraft, 2002; Kelly & Tomhave, 1985).

Analysis of Individual Interviews

Individual interviews were conducted with four teacher candidates who took part in the quantitative part of the study, including the surveys and tests. One student was selected from each section of the primary/junior Mathematics Education courses who were enlisted to participant. This resulted in one Year One concurrent student, one Year One consecutive student, and two Year Two consecutive students. Three females and one male were interviewed. Of the participants, three completed or are in the process of completing undergraduate degrees in Psychology, while one of the interviewed candidates completed an undergraduate degree in Business administration. The interviews demonstrated a few major themes that are described herein.

Relationship with mathematics. Both first-year respondents noted that prior to the Bachelor of Education program, they did not have a strong relationship with mathematics, whereas both of the second-year respondents said that their relationship with mathematics was good, but not necessarily a major part of their lives. One interviewed candidate responded, “I did math if I needed it…it didn’t give me any particular anxiety or worry. It wasn’t something I was particularly excited about or passionate about, but it’s just math.”, when asked about her relationship with mathematics.

When asked about their current relationship with mathematics following their Mathematics Education courses and placement experiences, all four participants reported feeling more confident and comfortable than they had prior to the Bachelor of Education program. They noted the use of manipulatives in class was helpful to them in understanding the content and coming up with new and creative ways to teach the lessons to elementary students and effectively support their learning. One respondent who had previously had a very negative relationship with mathematics noted, “As of right now, I actually do enjoy math which is a big plot twist for me. I am actually excited about teaching it. I find that I go home, and I want to lesson plan because I want to teach kids and reach the kids that were like me that struggle with math. I feel like it’s motivating almost.”, which speaks to the positive experiences students are having within the program and in elementary classrooms.

Perceived mathematical confidence and self-efficacy. All four participants noted that prior to enrolment in the Bachelor of Education program, they had low or very low confidence and self-efficacy with respect to mathematics, especially when asked about teaching mathematics. Following the Mathematics Education courses and placement experiences throughout the semester, participants stated they were more confident and comfortable in the classroom. One respondent noted, “It’s [math] how we understand the world in some ways and so getting kids to see that was a lot of fun for me and making it really real-life applicable.” As participants were given more opportunities to teach, they developed new and more engaging lessons. The responses from the interviewed teacher candidates aligned with the pre- and post-survey responses from the full primary/junior classes. Each of the first-year cohorts displayed increased confidence and self-efficacy from survey responses and the second-year cohort reported average pre- and post- confidence and self-efficacy scores that were almost the same.

Perceived mathematical abilities. A number of participants shared they were originally unsure how to effectively teach mathematics to elementary students. When asked to describe one challenge regarding her teaching one respondent noted:

> "My biggest challenge with the B.Ed. program and math is the language around mathematics because, for example, with Grade 2s, you go to describe, 'let's take half of something…' and they haven't learned fractions yet…like it's such an obvious term for me. I thought I was really simplifying my language and even that was still not the right language for them, so it was a lot of meeting them where they are at."

The challenges faced by a number of the pre-service teachers centred around trying to use appropriate terminology for younger students, breaking down concepts into smaller components, and assessing elementary students. Overall, interview respondents reported feeling better about their mathematics teaching abilities following Mathematics Education courses and placement experience. This finding aligned with the scores of the mathematical conceptual understanding pre- and post-test written by the first-year Concurrent cohort. Conversely, the first- and second-year Consecutive cohorts scored lower on the post-test compared to the pre-test, raising questions about the abilities of pre-service teachers to self-report on their teaching abilities and mathematics content area knowledge.

Perceived preparedness and readiness to teach. All four participants noted that they felt unprepared or wished they had more training in the area of mathematics assessment. Participants noted it was difficult to make assessments that could be used authentically for a diverse group of learners, in primary grade levels, or in elementary mathematics classes in general. Multiple participants noted they would like more time to delve into theory and the curriculum documents prior to the beginning of placement. One participant stated, "I think it needs to have more of like a theory based, maybe a couple weeks theory based and then we can focus on practicality, like using it in the classroom, how would we use these manipulatives in different ways, getting familiar with the terminology that every grade level uses, assessment for math even.", which echoes the sentiments of the other interviewed candidates. The participants felt a lot of instructional time was spent on specific lessons instead of overall strategies for planning and teaching mathematics lessons to primary students. One participant thought it might be beneficial to try a teaching model, even for a few weeks, as follows:

> "For Primary/Junior, start the first class as a "JK/SK" class and how you would go about making centres focused on math - and what the curriculum is looking for and what activities and how you would teach it to that grade level. And then have the class (teacher candidates) come up with different centre ideas that would meet curriculum expectations and then elaborate as a class why that would work well/why it may not work well or how to improve it. And then how as a teacher you can assess them (tests, hands-on activities, observations, etc.) Then the next class would be Grade 1 and the next Grade 2 and discuss the curriculum and come up with ways to teach it to the Grade 1 or 2 students, and then next class Grade 3 and talk about EQAO and how to prep the students for that and how to handle that as a teacher, and continue up until Grade 6. Also, what needs to be taught first, like what your first math class would be like and where you would go from there to meet the next expectation."

It was interesting to see that there was a common misconception among the pre-service teachers. Many seemed to be under the false impression that the purpose of Mathematics Foundation and Mathematics Methodology classes is to provide exact lessons or toolkits that can be directly transferred to the classroom. Pre-service teachers do not seem to understand the importance of Mathematics Education courses, in the sense that they are designed to teach pre-service teachers to understand how to interpret the mathematics curriculum to develop age-appropriate, student-centred lessons that are meaningful and effective for students. Many pre-service teachers look at the program as direct training where they should be provided resources. Generally, there is little consideration given to scaffolding their knowledge to learn how to transfer their understanding to students.

The themes derived from these interviews closely aligned with the opinions primary/junior pre-service teachers provided in their Mathematics Narrative assignment that was submitted for their Mathematics Education course. Many students within the course noted they initially had a very negative relationship with mathematics due to prior experiences, but after having been exposed to positive course and placement experiences and after being given accessed to a number of teaching tools, such as manipulatives, they felt much more confident going into the classroom. These findings align with previous research that teacher candidates face high levels of anxiety when faced with the prospect of teaching mathematics (Bursal & Paznokas, 2006; Harper & Daane, 1998), but with more experience and the use of new tools and teaching methods, the anxiety is reduced (Vinson, 2001).

Relationship between the Data

This section makes connections between the data obtained in the confidence and efficacy pre- and post-survey and the mathematical conceptual understanding pre- and post-test. An overview of the data can be found in *Table 8*.

Table 8: Overall Comparison of Average Survey and Test Responses

Cohort	Pre-Confidence	Post-Confidence	Pre-Efficacy	Post-Efficacy	Pre-Test	Post-Test
Year One Concurrent	2.68	2.28	2.47	2.36	3.14	3.35
Year One Consecutive	2.77	2.41	2.51	2.40	3.49	3.14
Year Two Consecutive	2.54	2.42	2.34	2.35	3.31	3.16

The data for the first-year concurrent students is aligned with the hypothesis of how the data should be related. The overall level of confidence and efficacy increased from the pre-survey taken at the beginning of the semester to the post-survey taken at the end of the semester after the Mathematics Education course and elementary placements. This makes sense as having more opportunities to practice teaching and learning mathematics should lead to an increase in confidence and efficacy. The Year One concurrent cohort also demonstrated an increase in their overall scores on the post-test, compared to the pre-test. This may be due to the fact they had the opportunity to refresh their knowledge of mathematics and see how mathematics is taught in elementary classrooms.

The data for the first-year consecutive students is more interesting. As with their concurrent counterparts, the Year One consecutive students displayed an overall increase in confidence and efficacy from the pre-survey to the post-survey after they had gained some educational and classroom experience. The portion of the data that is thought-provoking is that even though the pre-service teachers reported higher levels of confidence and efficacy, their conceptual understanding post-test scores were much lower than their pre-test scores. As discussed previously, there could be a number of factors that lead to this occurrence and it would be interesting to investigate further if the suggested factors were in fact along the correct line of thinking.

The data for the second-year consecutive students is quite similar to the first-year consecutive cohort data. The Year Two consecutive cohort showed a small increase in confidence and a negligible change in efficacy between the pre-survey and post-survey. It stands to reason this subgroup would show the smallest difference with respect to confidence and efficacy out of the three subgroups because the second-year students have already had a year of classes and placement experience at the Faculty of Education. They are honing their skills in second year as opposed to experiencing teaching in an elementary classroom for the first time. As with the first-year consecutive cohort, the second-year consecutive cohort displayed a decrease in scores on the post-test compared to the pre-test, which has been previously discussed.

Ultimately, even though the interview candidates were selected from all cohorts they shared similar views and sentiments of their post experiences. All of the interviews aligned with the data of the first-year concurrent cohort but deviated from the Year One and Year Two consecutive cohorts. These results may bring to light an issue with self-reporting measures. Participants are noting, on surveys and in interviews, that they feel more comfortable and that they believe they have increased or improved their skills in teaching and learning mathematics, when actual conceptual data shows information contrary to this perceived view.

Overall, the research conducted was a mixed methods, sequential explanatory study that aimed to have the qualitative data explain or advance our understanding of the quantitative data. The qualitative data obtained from individual interviews aligned with the literature on the subject. As pre-service teachers were provided with more opportunities to learn and develop skills through Mathematics Education courses and placement experiences, they developed a better relationship with mathematics, which in turn led to increased confidence, self-efficacy, and mathematical abilities. Increases to these factors should result in pre-service teachers who feel a greater readiness and preparedness to teach. These were the major themes taken from the individual interviews. The qualitative data aligned with the quantitative data obtained from the confidence and self-efficacy pre- and post-surveys and the literature, in that each cohort group reported increased confidence and self-efficacy from the beginning of the semester to the end of the semester. Interestingly, the qualitative data contradicted the quantitative data obtained from the mathematical conceptual understanding pre- and post-test. Even though responses from participants aligned with the literature, stating their perceived mathematical abilities had improved over the course of the semester, the actual results showed that only the Year One Concurrent cohort showed improved test scores, while the Year One Consecutive and Year Two Consecutive cohorts displayed decreased mathematical abilities in terms of pre- and post-test scores.

Chapter 5: Conclusions and Future Work

Conclusions

This work has demonstrated the significant need for specific programming related to the development of primary/junior pre-service teacher mathematics education and content area knowledge. The results of the pre- and post-surveys regarding mathematical confidence and self-efficacy demonstrated an increased feeling of preparedness and readiness to learn and teach mathematics following the Mathematics Education courses offered to the pre-service teachers at the Faculty of Education. Additionally, interviews with participants support the results of the surveys. The issue related to these findings is that the overall competency level of the pre-service teachers' content area knowledge was problematic on both the pre- and post-test that was designed to assess conceptual understanding of each of the five strands of the elementary mathematics curriculum. Furthermore, within two of the participant subgroups, the Year One and Year Two consecutive students, the level of competency and conceptual understanding demonstrated actually decreased.

Within this study, three research questions and two hypotheses were addressed: *Research Question One*: What is the nature of pre-service teachers' perceptions of their confidence and self-efficacy in learning to teach mathematics in a primary/junior teacher education program in the Faculty of Education at a university in Southwestern, Ontario, Canada?

Hypothesis One: Participants will demonstrate improved confidence and self-efficacy following the completion of a mathematics education course and placement experiences.

Findings: Primary/junior pre-service teachers perceive themselves as having moderate confidence and self-efficacy that increases over the course of a semester in the Bachelor of Education program. This finding is common at all cohort levels.

Research Question Two: What content areas within the mathematics curriculum are understood and not understood by primary/junior pre-service teachers at the Faculty of Education at a university in Southwestern, Ontario, Canada?

Hypothesis Two: Participants will demonstrate improved mathematical conceptual understanding and competency in mathematics following the completion of a mathematics education course and placement experiences.

Findings: The number sense and numeration, data management and probability, and patterning and algebra strands of the curriculum were somewhat understood, and the measurement and geometry and spatial sense strands of the elementary mathematics curriculum were not understood very well by any of the cohort groups. Overall, there was a large distribution of responses to each question and none of the questions were answered to a high standard. None of the cohorts achieved a post-test average of 70% or more, which is the provincial average set for students in the Ontario school system.

Research Question Three: How do their pre, during, and post experiences in the program advance our understanding of their learning to teach mathematics in the two-year Bachelor of Education program in the province of Ontario?

No hypothesis has been made for this research question, as the aim is to explore major themes revealed during individual interviews. Individual interviews provided insight into the perceptions of the pre-service teachers in the two-year program. Participants liked using manipulatives in their teaching, trying lessons that could be used in an elementary classroom, and expressed interest in learning more about elementary mathematics assessment practices. Even so, participants showed a false understanding of the meaning and purpose of the mathematics education courses, in that, they believed the course should provide them with a full toolkit for teaching rather than help them to develop the necessary skills to understand and teach mathematics effectively.

Future Work

From the conclusions above, future work in this field can be related to building the mathematical competency of pre-service teachers, prior to their entrance into the teaching profession as in-service teachers. Mathematics education in Ontario has become increasingly disconcerting in the last decade. One of the roots of this concern is a teacher's mathematical competency. As an extension of this thesis, I would like to perform a sequential explanatory mixed methods study to assess the impact of a needs-based elementary mathematics development program on the competency and confidence of elementary pre-service teachers who will be expected to pass a mathematics proficiency test in order to become a certified Ontario teacher (Rizza, 2018).

In the time period from 2003 to 2011, the percentage of Grade 3 students meeting the Ontario Mathematics standards on the EQAO have fallen from 71 to 67 percent, while the percentage of Grade 6 students meeting the provincial standard fell from 61 to 54 (Stokke, 2015). As such, the Ontario Ministry of Education recently announced that all new teachers will be required to take and pass a mathematics proficiency test before they can be certified to teach in the province of Ontario (Rizza, 2018). Even in its early stages, many elementary pre-service teachers have expressed anxiety when faced with the prospect of having to pass a proficiency test, raising questions about the best ways to support pre-service teacher development and further support their learning beyond the mathematics education courses currently offered to all pre-service teachers. A teacher's content area knowledge and positive attitude towards the subject can be positively correlated (Wilkins, 2008). Teachers with a lack of confidence in teaching mathematics can propagate the problem of decreased interest in the study of mathematics (Copley, 2004; Copple, 2004; Sarama and DiBiase, 2004). Building confidence in the early stages of a teacher's career is beneficial to both the teacher and the students (Elliott, Isaacs, & Chugani, 2010). With the newly proposed proficiency test, building pre-service teacher competency and confidence at an early stage is essential. Therefore, providing elementary pre-service teachers with the opportunity to increase their mathematical competency and confidence prior to graduation is paramount to overall student success, in learning the content, developing strategies, and improving standardized test scores.

I would like to study the impact of additional differentiated programming in relation to increasing the mathematical competency and confidence of elementary pre-service teachers as they prepare for the Ministry of Education mathematics proficiency test, and ultimately, to teach mathematics effectively in elementary classrooms.

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Appendix A

Cover Letter

Dear Primary/Junior Division Bachelor of Education Student,

My name is Emilia Iacobelli and I am currently a graduate student in the Faculty of Education, completing my Master of Education, under the supervision of Dr. Geri Salinitri. The purpose of this research is to explore the mathematical confidence and self-efficacy of primary/junior pre-service teachers. Mathematical confidence will generally be described as the belief of the likelihood an individual has in his or her own abilities to learn, complete, and teach mathematical processes and self-efficacy will be described as the strength of one's belief in his or her ability to understand mathematical concepts, not the individual's actual ability. By conducting this study, we will gain insight into the perceptions of confidence and self-efficacy of primary/junior pre-service teachers with respect to teaching and learning elementary mathematics and attempt to use this information to find new methods of building the two areas.

I am asking you to donate 30-45 minutes of your time to complete this survey and competency test in class. Your name will not be recorded on the survey or test, but rather, you will generate a unique identification code which will be used by the researcher when analyzing and comparing responses. As such, your individual responses will remain anonymous and confidential.

Research Ethics Board approval has been obtained, as well as, the approval of your instructor. The social risks of completing the survey are very low as responses cannot be identified by the researcher. It is possible that a colleague may witness your participation and/or answers during class, but preventative measures will be taken to avoid these risks. All collected surveys will be housed in a secure location in which only the researcher has access and responses will be destroyed after September 1, 2019. The participants may benefit directly from the research by obtaining a better understanding of their own confidence and self-efficacy in teaching and learning mathematics. This research may also benefit the scholarly community by adding to the advance of knowledge in the area of elementary mathematics education.

Participation in the survey is voluntary and participants may refuse to answer questions or withdraw from the study at any point during the data collection. Withdrawn responses will be removed from the dataset, not included in the analysis, and destroyed accordingly.

If you would like to view a summary of the research findings, they will be available, upon request, after April 1, 2019. Please email emilia@uwindsor.ca to request the results.

By agreeing to complete the survey, you are allowing future use of the data in subsequent studies, publications, and presentations. Any questions about your rights as a participant can be directed to the Research Ethics Coordinator at the University of Windsor, by phone at (519) 253-3000 ext. 3948, or by email at ethics@uwindsor.ca.

Your support in this research endeavour is truly appreciated.

Thank you for your assistance,

Emilia Iacobelli
M.Ed. Candidate
emilia@uwindsor.ca

Appendix B

Blackboard Note of Information to Participants

Dear Primary/Junior Pre-Service Teachers,

My name is Emilia Iacobelli and I am completing a research study as part of my Graduate Program thesis (M.Ed). I am seeking Pre-Service Teachers to complete a Mathematical Efficacy Survey and Mathematical Conceptual Understanding Test (no higher than Grade 6 level Mathematics), in class. The purpose of the study is to explore the mathematical confidence and efficacy of primary/junior pre-service teachers, as well as their conceptual understanding. Please review the attached Letter of Information. If you have any questions regarding the study, questions can be directed to emilia@uwindsor.ca. More information will be provided today during class, as well as the survey and test to those individuals who choose to participate.

Thank you in advance for your support,

Emilia

Appendix C

Mathematical Confidence and Efficacy Survey

PLEASE READ: Do you willingly consent to the following survey and understand you can withdraw, without consequence, at any time prior to data analysis in January 7, 2019?

a. Yes
b. No

Identification Code

You will be generating a unique identification code to be used for data analysis.
Your code will be the second letter of your first name, the first two letters of your mother's first name, the last letter of your last name, the number of letters in your first name, and your program year. For example, a participant named Mary Smith who has a mother named Juliana and is in second year would have the code: **AJUH42**

Please clearly record your identification code on the line provided and on the line at the top of each page (4 sides in total, two pages front and back): ________________________

Demographic Questions

1. What is your gender?
   a. Male
   b. Female
   c. I choose not to identify with any options provided
2. What is your current age?
   a. 18-22
   b. 23-25
   c. 25-28
   d. 28 and older
3. Where did you attend elementary school?
   a. In Ontario
   b. Outside Ontario, but still in Canada
   c. The United States of America
   d. Outside of Canada and the United States
4. What is the maximum education level you have obtained?
   a. Undergraduate (General)
   b. Undergraduate (Honours)
   c. Graduate (Master's Degree)
   d. Graduate (Doctoral)
   e. Other (please specify): ____________________________________
5. What is your highest level of mathematics education?
   a. Grade 9
   b. Grade 10
   c. Grade 11
   d. Grade 12
   e. Undergraduate
   f. Graduate
   g. Post-Graduate

Views of Mathematics

Please indicate the degree to which you agree or disagree with each statement below by circling the appropriate word(s) under each question. Please be sure to clearly circle **ONE** response.

6. I feel confident trying new teaching methods or mathematics lessons with my students.

Strongly Agree   Agree   Neither Agree Nor Disagree   Disagree   Strongly Disagree

7. I seek out new opportunities for mathematics professional development.

Strongly Agree   Agree   Neither Agree Nor Disagree   Disagree   Strongly Disagree

8. Previous experiences with mathematics influence future experiences.

Strongly Agree   Agree   Neither Agree Nor Disagree   Disagree   Strongly Disagree

9. My previous experiences with mathematics influence my teaching methods.

Strongly Agree   Agree   Neither Agree Nor Disagree   Disagree   Strongly Disagree

10. I am good at mathematics.

Strongly Agree   Agree   Neither Agree Nor Disagree   Disagree   Strongly Disagree

11. I enjoy teaching mathematics.

Strongly Agree   Agree   Neither Agree Nor Disagree   Disagree   Strongly Disagree

12. I enjoy(ed) learning mathematics.

Strongly Agree   Agree   Neither Agree Nor Disagree   Disagree   Strongly Disagree

13. I am a good mathematics teacher.

Strongly Agree   Agree   Neither Agree Nor Disagree   Disagree   Strongly Disagree

Efficacy Questions

Please indicate the degree to which you agree or disagree with each statement below by circling the appropriate word(s) under each question. Please be sure to clearly circle **ONE** response.

14. A student's performance in mathematics is directly related to the effort put forth by the teacher.

Strongly Agree   Agree   Neither Agree Nor Disagree   Disagree   Strongly Disagree

15. I am constantly looking for better ways to teach mathematics.

Strongly Agree Agree Neither Agree Nor Disagree Disagree Strongly Disagree

16. Even though I spend a lot of time preparing and lesson planning, I do not teach mathematics as well as I do most subjects.

Strongly Agree Agree Neither Agree Nor Disagree Disagree Strongly Disagree

17. A student's academic improvements can be related to the teacher having found a more engaging way to share the material.

Strongly Agree Agree Neither Agree Nor Disagree Disagree Strongly Disagree

18. I am able teach mathematical concepts effectively.

Strongly Agree Agree Neither Agree Nor Disagree Disagree Strongly Disagree

19. Underachieving student scores are likely a result of poor mathematics teaching.

Strongly Agree Agree Neither Agree Nor Disagree Disagree Strongly Disagree

20. In general, I am not an effective mathematics teacher.

Strongly Agree Agree Neither Agree Nor Disagree Disagree Strongly Disagree

21. Previous gaps in mathematics education can be overcome by good teaching.

Strongly Agree Agree Neither Agree Nor Disagree Disagree Strongly Disagree

22. Low mathematics achievement is generally not the fault of teachers.

Strongly Agree Agree Neither Agree Nor Disagree Disagree Strongly Disagree

23. A low-achieving student's progress in mathematics can be attributed to extra attention being given by the teacher.

Strongly Agree Agree Neither Agree Nor Disagree Disagree Strongly Disagree

24. I understand mathematics concepts well enough to be effective in teaching mathematics.

Strongly Agree Agree Neither Agree Nor Disagree Disagree Strongly Disagree

25. Using manipulatives to explain mathematics to students is difficult to do.

Strongly Agree Agree Neither Agree Nor Disagree Disagree Strongly Disagree

26. The teacher's efforts are partially responsible for the student's achievements in mathematics.

Strongly Agree   Agree   Neither Agree Nor Disagree   Disagree   Strongly Disagree

27. A teacher's effectiveness in teaching mathematics is directly related to the students' overall achievement in mathematics.

Strongly Agree   Agree   Neither Agree Nor Disagree   Disagree   Strongly Disagree

28. If parents comment that their child is showing more interest in mathematics at school, it is probably due to the performance of the child's teacher.

Strongly Agree   Agree   Neither Agree Nor Disagree   Disagree   Strongly Disagree

29. When a teacher increases his or her effort in the classroom, there is little change in the students' mathematical achievements.

Strongly Agree   Agree   Neither Agree Nor Disagree   Disagree   Strongly Disagree

30. I typically struggle to answer students' questions about mathematical content.

Strongly Agree   Agree   Neither Agree Nor Disagree   Disagree   Strongly Disagree

31. I wonder if I have the necessary skills to teach mathematics.

Strongly Agree   Agree   Neither Agree Nor Disagree   Disagree   Strongly Disagree

32. Given the option, I would not ask a principal to evaluate my mathematics teaching.

Strongly Agree   Agree   Neither Agree Nor Disagree   Disagree   Strongly Disagree

33. When a student struggles to understand a mathematical concept, I am usually at a loss as to how to help the student better understand it.

Strongly Agree   Agree   Neither Agree Nor Disagree   Disagree   Strongly Disagree

34. When teaching mathematics, I welcome student questions.

Strongly Agree   Agree   Neither Agree Nor Disagree   Disagree   Strongly Disagree

35. I do not know what to do to engage students in mathematics.

Strongly Agree   Agree   Neither Agree Nor Disagree   Disagree   Strongly Disagree

Appendix D

Mathematical Conceptual Understanding Pre-Test

PLEASE READ: Do you willingly consent to the following survey and understand you can withdraw, without consequence, at any time prior to data analysis in January 7, 2019?

a. Yes
b. No

Identification Code

You will be generating a unique identification code to be used for data analysis.
Your code will be the second letter of your first name, the first two letters of your mother's first name, the last letter of your last name, the number of letters in your first name, and your program year. For example, a participant named Mary Smith who has a mother named Juliana and is in second year would have the code: **AJUH42**

Please clearly record your identification code on the line provided and on the line at the top of each page (4 sides in total, two pages front and back): ______________________

Demographic Questions

1. What is your gender?
   a. Male
   b. Female
   c. I choose not to identify with any options provided

2. What is your current age?
   a. 18-22
   b. 23-25
   c. 25-28
   d. 28 and older

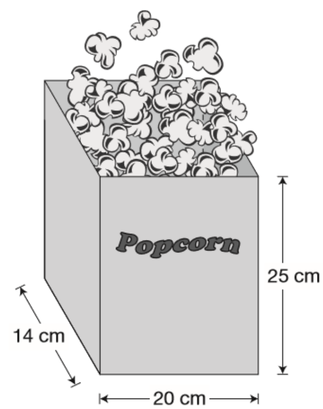
3. Where did you attend elementary school?
   a. In Ontario
   b. Outside Ontario, but still in Canada
   c. The United States of America
   d. Outside of Canada and the United States

4. What is the maximum education level you have obtained?
   a. Undergraduate (General)
   b. Undergraduate (Honours)
   c. Graduate (Master's Degree)
   d. Graduate (Doctoral)
   e. Other (please specify): ____________________________________

5. What is your highest level of mathematics education?
   a. Grade 9
   b. Grade 10
   c. Grade 11
   d. Grade 12
   e. Undergraduate
   f. Graduate
   g. Post-Graduate

6. Mr. Scott plans a class trip for the 30 students in his class.
   He must pay the following costs per student:
   • admission: $3.80
   • bus: $10.40
   • snack: $5.55
   • supplies: $7.31
   Round the costs to the nearest dollar and use them to estimate the total cost for the 30 students. Show your work.

7. The container of popcorn pictured below is in the shape of a rectangular prism.



   What is the smallest amount of paper needed to make this container? Show your work.

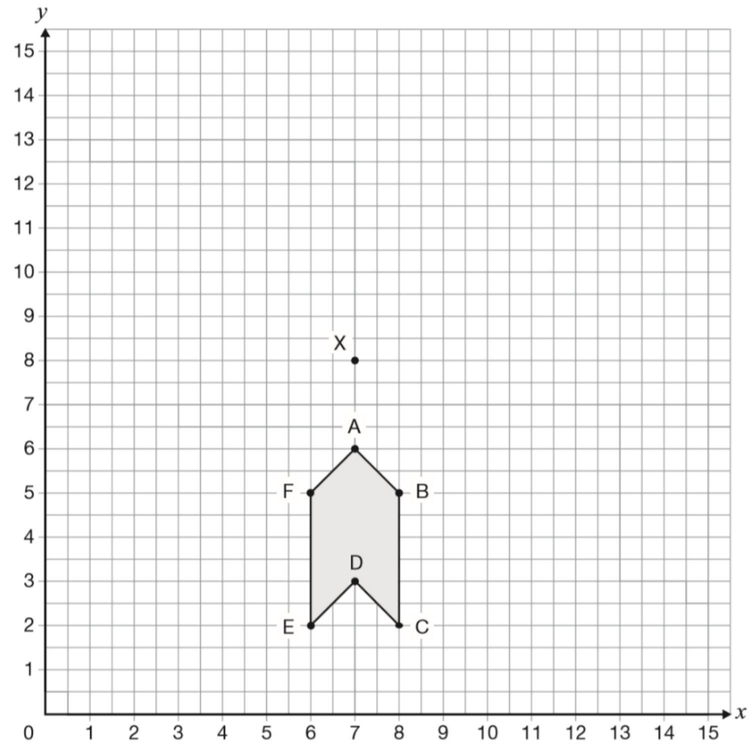
8. Toby has a bag of 40 coloured blocks. Without looking, he reaches in and pulls one block out. Complete the table below to determine the probability of choosing a red, green, purple or yellow block. Show your work.

Colour	Number in Bag	Probability of Choosing a Block of this Colour
Red	6	
Green	10	
Purple		
Yellow		0.2

9. Consider the repeating pattern below.

If the pattern continues in the same way, what will the 54th term be?

10. Rotate the hexagon below 90° counter-clockwise about Point X. Draw this image of the hexagon.



Record the coordinates of the image of Point C. Image of Point C: (,   )

<u>Extra Work Space (will not be scored):</u>

Appendix E

Mathematical Conceptual Understanding Post-Test

PLEASE READ: Do you willingly consent to the following survey and understand you can withdraw, without consequence, at any time prior to data analysis in January 7, 2019?

a. Yes
b. No

Identification Code

You will be generating a unique identification code to be used for data analysis.
Your code will be the second letter of your first name, the first two letters of your mother's first name, the last letter of your last name, the number of letters in your first name, and your program year. For example, a participant named Mary Smith who has a mother named Juliana and is in second year would have the code: **AJUH42**

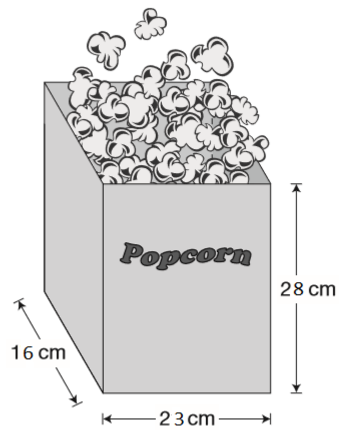
Please clearly record your identification code on the line provided and on the line at the top of each page (4 sides in total, two pages front and back): ________________________

Demographic Questions

1. What is your gender?
   a. Male
   b. Female
   c. I choose not to identify with any options provided
2. What is your current age?
   a. 18-22
   b. 23-25
   c. 25-28
   d. 28 and older
3. Where did you attend elementary school?
   a. In Ontario
   b. Outside Ontario, but still in Canada
   c. The United States of America
   d. Outside of Canada and the United States
4. What is the maximum education level you have obtained?
   a. Undergraduate (General)
   b. Undergraduate (Honours)
   c. Graduate (Master's Degree)
   d. Graduate (Doctoral)
   e. Other (please specify): ____________________________________
5. What is your highest level of mathematics education?
   a. Grade 9
   b. Grade 10
   c. Grade 11
   d. Grade 12
   e. Undergraduate
   f. Graduate
   g. Post-Graduate

6. Mr. Scott plans a class trip for the 25 students in his class.
   He must pay the following costs per student:
   • admission: $4.35
   • bus: $11.32
   • snack: $5.78
   • supplies: $8.03
   Round the costs to the nearest dollar and use them to estimate the total cost for the 25 students. Show your work.

7. The container of popcorn pictured below is in the shape of a rectangular prism.



   What is the smallest amount of paper needed to make this container? Show your work.

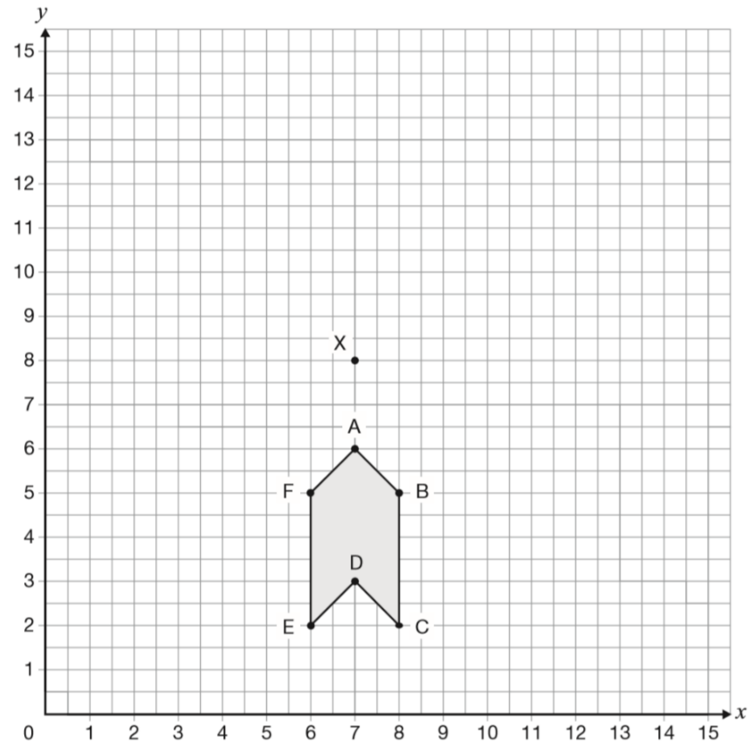
8. Toby has a bag of 50 coloured blocks. Without looking, he reaches in and pulls one block out. Complete the table below to determine the probability of choosing a red, green, purple or yellow block. Show your work.

Colour	Number in Bag	Probability of Choosing a Block of this Colour
Red	8	
Green	12	
Purple		
Yellow		0.4

9. Consider the repeating pattern below.

If the pattern continues in the same way, what will the 56th term be?

10. Rotate the hexagon below 90° clockwise about Point X. Draw this image of the hexagon.



Record the coordinates of the image of Point C. Image of Point C: (,   )

Extra Work Space (will not be scored):

Appendix F

Individual Interview Protocol and Questions

Please do not identify yourself by name, student number, etc. during this interview. You will be audio recorded during this session to ensure accurate data collection. All information will be kept strictly confidential. Audio recordings will be erased after September 1, 2019.

If you are uncomfortable answering any of the questions, please recognize your right to not respond to the questions that cause feelings of discomfort. Please remember you have the right, as a participant, to withdraw from the study, without consequence, until March 15, 2019. You will be sent a transcription of this interview and given the opportunity to amend your responses until March 15, 2019, at which point your responses are finalized if you have not withdrawn from the study.

1) In what area(s), did you obtain your undergraduate education and what is your current year in the B.Ed. program?

2) Prior to enrollment in the B.Ed. Program, how would you describe your overall relationship with mathematics?

3) Prior to enrollment in the B.Ed. Program, how would you describe your confidence and efficacy with respect to learning and teaching mathematics?

4) Did you teach mathematics in either of your placements this semester?

5) What aspect of teaching mathematics, if any, was most exciting for you? Why?

6) What aspects of teaching mathematics, if any, did you find most challenging?

7) Did you encounter any experiences in the classroom that were unexpected or for which you felt unprepared?

8) How would you describe your current relationship with mathematics?

9) How would you describe your confidence and efficacy with respect to learning and teaching mathematics after completing a mathematics education course?

10) What aspects of the course did you find most helpful in your learning?

11) What would you suggest to the course developers and instructors to improve the course in its ability to prepare teacher candidates to teach mathematics in an elementary classroom?

12) Do you have any additional comments or information you would like to share?

Vita Auctoris

NAME:	Emilia M. Iacobelli
PLACE OF BIRTH:	Windsor, ON
YEAR OF BIRTH:	1994
EDUCATION:	St. Thomas of Villanova Catholic Secondary School, LaSalle, ON, 2012
	University of Windsor, B.Sc. [H], Windsor, ON, 2017
	University of Windsor, B.Ed., Windsor, ON, 2017
	University of Windsor, M.Ed., Windsor, ON, 2019