How to Address The Needs of Mathematically Gifted Students?

By

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Abstract

Studies have shown that an advanced curriculum can positively affected the achievement of mathematically gifted students. However, other studies have shown that these students are often neglected and underchallenged in the classroom: for example, by being asked to repeat activities they have mastered a long time ago. This can result in mathematically gifted students ‘turning off’ learning due to boredom, not making appropriate progress, and ultimately underachieving at school. To explore how Ontario teachers are reportedly supporting mathematically gifted students in general education classrooms, I conducted three semi structured interviews with teachers in Toronto in the summer of 2016. I found that, from their perspective, it is difficult to judge if a student is mathematically gifted, enrichment is the most common accommodation strategy, they face more barriers than are mitigated by the supports they receive. I also found that teachers who position themselves as facilitators often enjoy the process of working with mathematically gifted children. This shows that teachers need supports in terms of identifying mathematically gifted students and relevant instructional strategies. The study recommends a specific policy on addressing the needs of gifted children be developed.

Key Words: mathematically gifted, mathematics education, gifted education
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Chapter 1: Introduction

1.0 Research Context

The Ontario Ministry of Education or OME (2001) defines giftedness as “an unusually advanced degree of general intellectual ability that requires differentiated learning experiences of a depth and breadth beyond those normally provided in the regular school program to satisfy the level of educational potential indicated” (p. 203). The OME also recognizes giftedness as an exceptionality and mandates that school boards provide special education programs for identified gifted students. In Ontario in 2012-2013, 28,860 students were identified as gifted (Brown, Newton, Parekh & Zaretsky, 2013). In the same study, 60% of these students were placed in regular classes while 40% of them were placed in special education classes. In the Toronto District School Board alone, 6,136 students were identified as gifted in the same academic year. Among them, 37% were placed in regular classes while 63% were placed in special education classes (Brown, Newton, Parekh & Zaretsky, 2013). Most school boards in Ontario provide in-class enrichment and begin formal gifted programs in grade 4 or 5 (full time self-contained classes and/or part time withdrawal) (Peel District School Board, 2009). However, the criteria of giftedness vary from school board to school board. In the Toronto District School Board, a psychological assessment indicating that the student is functioning at or above the 98th percentile is required (Toronto District School Board, 2015).

In the literature, there are various definitions of mathematical giftedness. The traditional definition is the ability to perform at the top 3%-5% in some standardized mathematics test (Sheffield, 2003). However, recent literature does not suggest using the standardized test results as the only tool to identify mathematically gifted students. A variety of other factors such as motivation and persistence are also used. The OME does not specifically define mathematical
giftedness. Furthermore, The Ministry does not further classify gifted students based on the areas that they were gifted, but their IEPs normally include this information and specific accommodations and modifications. However, the IEP for students identified as solely gifted are not required to include a transition plan (OME, 2004).

1.1 Research Problem

The National Council of Teachers of Mathematics or NCTM Taskforce on promising students (1980) has argued that “[t]he student most neglected, in terms of realizing their full potential, is the gifted student of mathematics. Outstanding mathematical ability is a precious societal resource, sorely needed to maintain leadership in a technological world” (p. 18). Winebrenner (2000) has shown that teachers may think gifted students do not need further support and can work on their own. Teachers may also lack relevant training in teaching gifted students. Therefore, many teachers are reluctant to address the needs of these particularly gifted children (Winebrenner 2000).

Gavin, Casa, Adelson, Carroll, and Sheffield (2009) found that an advanced curriculum positively affected the achievement of mathematically gifted students. However, they are often neglected and underchallenged in the classroom, for example by being asked to repeat activities they have mastered a long time ago. They are then likely to turn off learning due to incessant boredom and not make appropriate progress, and ultimately underachieve at school (NCTM Task Force, 1980; Govan, 2012; Colgan, 2009).

Despite the existence of this research; however, in Ontario there are no guides or policies for teachers to support mathematically gifted students. The OME special education guide for educators only briefly describes the needs of gifted students in general, let alone those of students with particular forms of giftedness. In addition, while there has only been limited
research on gifted education in Ontario, virtually no Ontario studies have been conducted on mathematical giftedness whether from the teacher’s or the student’s perspective.

If their needs are not addressed properly, they will not be motivated, lose interest in learning, and so underachieve at schools. Addressing the needs of mathematically gifted students so that they are motivated and challenged is therefore imperative since research has shown mathematically gifted students who learned mathematics in an accelerated curriculum were more likely to be in a STEM career, and earn more advanced degrees (Lupkowski-Shoplik, 2010).

Most Ontario generalist teachers do not have a mathematical background, and they may not have adequate content knowledge in math (Colgan, 2016). Interviewing teachers directly can allow them to share best practices, so that other teachers will be more confident in supporting mathematically gifted students in their classrooms.

1.2 Purpose of the Study

The purpose of this qualitative study is to understand how Ontario middle school teachers are currently addressing the needs of mathematically gifted children. To explore this topic, I will interview a sample of these teachers about barriers and supports, reported teaching practices, identification of mathematically gifted students, and teacher feelings about teaching mathematically gifted children. It is my hope that by sharing the findings with other Ontario educators and researchers, they can not only have more tools to teach mathematically gifted students, but they can also feel more comfortable teaching them.

1.3 Research Questions

The central research question guiding this study is: How are Ontario middle school teachers currently addressing the needs of mathematically gifted children? Sub-questions to further guide the inquiry include:
• How do teachers reportedly identify mathematically gifted students?
• What instructional strategies do teachers reportedly employ to teach mathematically gifted students?
• What barriers and supports are teachers experiencing when teaching and supporting mathematically gifted students?
• How do teachers feel about teaching mathematically gifted students?

1.4 Background of the Researcher

The topic of mathematically gifted students is particularly fascinating to me, since I was also considered a mathematically gifted student. From a young age, I excelled in mathematics and found school mathematics to be extremely easy and unchallenging. The mathematics lessons for me in both primary and secondary schools were always boring and uninteresting because I had mastered them a long time ago. My teachers recognized that I was gifted in mathematics but they did not do anything to differentiate the curriculum or provide enrichment to address my needs.

At around the age of nine, my parents enrolled me in weekend mathematical olympiad classes. I enjoyed them very much since they challenged me to think and to work at a higher level. Two years later, I took the WISC-IV test and was diagnosed as gifted. Despite the fact that I was not supported in the regular classroom, I took enrichment courses offered by local universities and the Hong Kong Academy for Gifted Education. I also participated in Johns Hopkins Center for Talented Youth (CTY) talent search and enrolled in its summer programs. I really enjoyed working with other mathematically gifted peers as we worked at a similar level and could challenge one another.
Before I completed my secondary education, I was offered early admission to the department of mathematics at a local university in Hong Kong. I was really delighted that I could learn some advanced mathematics and be challenged since the secondary school math curriculum was far too easy for me.

While completing my undergraduate degree in mathematics, I started teaching a group of mathematically gifted students at my alma mater in an enrichment course. I enjoyed challenging gifted students and studying something hard together with them. I also helped at the CTY summer program for a few years. These experiences prompted me to consider a career in teaching, and teaching gifted students in particular.

I am now in a teacher education program and I am interested to know how teachers can better support mathematically gifted students both inside and outside of the classroom. My experience, both as a mathematically gifted student and as a teacher of mathematically gifted students, will allow me to better understand the needs of mathematically gifted students and the importance that they are motivated and challenged at school. One drawback is that it may be difficult for me to consider the perspectives of math teachers with limited mathematical background given my own position in relation to the topic.

1.5 Overview of the Research Project

To respond to the research questions I conducted a qualitative research study using purposeful sampling to interview three elementary teachers who have experiences with, strategies for, and feelings about working with mathematically gifted children. In Chapter Two I review the literature in the areas of gifted education and mathematics education. In Chapter Three I elaborate on the study’s methodology. In Chapter Four I report my research findings and discuss their significance in light of the existing research literature. Finally, in Chapter Five I
identify the implications of the research findings for my own teacher identity and practice, and for the educational research community more broadly. I also articulate a series of questions raised by the research findings, and point to areas for future research. References and a list of appendices are found at the end.
Chapter Two: Literature Review

2.0 Introduction

In this chapter, I review the literature in the areas pertaining to mathematically gifted students, interventions and instructional strategies for mathematically gifted students, as well as teacher perceptions of and experiences of teaching mathematically gifted students. More specifically, I review the varying definitions of mathematical giftedness, various methods to identify the mathematically gifted, and characteristics exhibited by mathematically gifted students. Next, I review research on interventions and instructional strategies for mathematically gifted students, including enrichment, acceleration, differentiation, grouping, curriculum design and extra-curricular activities. Finally, I investigate what teachers think about teaching mathematically gifted students and the challenges they face when teaching the mathematically gifted.

For simplicity, unless otherwise stated, any references and discussions on giftedness or gifted students in this chapter refer to mathematical giftedness and mathematically gifted students.

2.1 Definitions of Mathematical Giftedness

Math talent is hard to describe since children manifest mathematical talent in different ways (Gavin, Firmender & Casa, 2013). One of the earliest scholars to study mathematically gifted students was Vadim Krutetskii (1976). Through his twelve-year study (1955-1966), he classified mathematically talented students into three types: those who reasoned abstractly with an algebraic cast of mind, those who had strong spatial skills with a geometric cast of mind, and those who had a combination of both. Gardner’s (1993) theory of multiple intelligences defined logical-mathematical intelligence as the ability to detect patterns, reason logically and think
deductively, which “began as sheer pattern ability in infancy and developed through symbolic mastery of early childhood and the notations of the school years” (p. 28). More recently, Kontoyianni, Kattou, Pitta-Pantazi & Christou (2013) have described mathematical giftedness as a combination of mathematical ability (spatial, quantitative, qualitative, casual, inductive and deductive reasoning) and mathematical creativity (fluency, flexibility and originality).

2.1.1 Identification of mathematically gifted students

In terms of general giftedness, a grade level achievement test may not find exceptionally talented students due to the ceiling produced in testing, which occurs when a number of students have reached the highest attainable score in the test. Lupkowski-Shoplik and Assouline (1993) were two of the first researchers to identify and differentiate talented students who performed in the 95th -99th percentiles for their age group. They gave talented fifth graders the Secondary School Admission Test, which was designed for seventh graders. They found that the test successfully differentiated moderately talented students from exceptionally talented students.

Identification of mathematically gifted students is not a simple process since it cannot be assumed that teachers will automatically know how to identify them (Koshy, Ernest & Casey, 2009). Due to the fact that the concept of giftedness is complicated, multiple assessments that are reliable and valid should be used. These include out-of-level assessments, motivation/persistence scale or observation when solving difficult problems, learning portfolios, teacher recommendations and grades in previous math courses (Stambaugh & Benbow, 2010). In a survey conducted by Koshy, Ernest & Casey (2009), it was reported that teachers in the UK found the process of identifying gifted students challenging due to difficulty in observing students within the recommended structure of mathematics lessons. It was also reported that
Achievement tests are a common tool used to identify gifted students since they are considered to be more objective. A student scoring at 95 percentile or above on a grade-level achievement test is usually considered gifted (Dimitriadis, 2013; Rotigel & Fello, 2004). However, test scores may not be the best way to identify gifted students since some of them may not be good test takers (Ayebo, 2010). In addition, test results often only show how well students can perform routine operations and repeat already seen patterns rather than creating new solutions (Juter and Sriraman, 2011). Therefore high achievers are not necessarily the same as gifted students.

Pvlekovic, Zekic-Susac and Durdevic (2010) compared three different methods of identifying mathematically gifted students and developed an expert system. The expert system was developed to determine if a child is mathematically gifted based on several predetermined factors. Teachers would feed data into the expert system by answering a number of questions. The system was then compared to teachers’ estimations of mathematical giftedness based on their subjective evaluation and experience, and psychologists’ estimations based on standard progressive Raven’s matrices and interviews. They found that teachers identified far fewer students as mathematically gifted compared to psychologists and the “expert system”. Sak (2005) developed a three-mathematical minds model to identify mathematically gifted students, but the validity of the model did not score highly.

In sum, there are many tools to identify mathematically gifted students and a combination of them is recommended by the extant literature to ensure validity and reliability. Nevertheless, identification should be an ongoing process rather than a procedure since children demonstrate
talent at different times and gifted children develop at different rates (Deal & Wismer, 2010; Gavin, Firmender & Casa, 2013).

### 2.1.2 Characteristics of mathematically gifted students

As noted, Vadim Krutetskii was one of the first researchers to study mathematically gifted students. Lester and Schroeder (1983) subsequently summarized twelve cognitive characteristics of mathematically gifted students based on Krutetskii’s twelve-year study. One of the attributes was the ability to reverse the reasoning process (switch from a direct to a reverse train of thought), which gifted students performed with relative ease. This is usually observed when moving from a theorem to its converse, or from direct proof to proof by contradiction (Juter & Sriraman, 2011).

According to Krutetskii (as cited in Freiman, 2003), children with a mathematical cast of mind ask many mathematical questions all the time. They strive to make the phenomena of the environment mathematical, for instance, by estimating the speed of the bus they travel in. Freiman (2003) defined mathematical cast of mind as “a unique combination of psychological traits that enable young children to think in structures, to formalise, to generalise, and to grasp relations between different concepts…and thus solve different mathematical problems more successfully” (p. 127). Among the twelve characteristics, having a mathematical cast of mind is constantly cited as a characteristic of mathematically gifted students and it may begin at a very young age (Freiman, 2003).

In a teaching experiment, Hekimoglu (2004) found that his subject (a mathematically gifted student) was confident, able to use mathematical knowledge flexibly and creatively, understand and apply mathematical ideas swiftly, see patterns, think abstractly and transfer concepts to unfamiliar situations. In addition, mathematically gifted students crave more
challenging problems, achieve mastery faster, and may be unable to explain how they obtain the answer (Diezmann, 2004; Rotigel & Fello, 2004).

Ayebo (2010) studied teachers’ perspectives on mathematically gifted students through online surveys collected from 98 teachers. The survey included both open-ended questions and 5-point likert scale, and the teachers surveyed asserted that gifted students were eager to solve challenging mathematics problems, understood new mathematics concepts more easily than other students, and attained very high test scores. Gucyeter (2015) conducted a similar study using surveys sent to 161 teacher participants. The teachers reported that gifted students were good at memorizing, thinking creatively, and producing new methods for problem solving. Sheffield (2003) grouped the characteristics of mathematically talented students into four categories:

1. Mathematical Frame of Mind—has a deep understanding of mathematical concepts, sees mathematics and structures in a variety of forms
2. Mathematical Formalization and Generalization—generalizes the structure of a problem from only a few examples, thinks logically and symbolically
3. Mathematical Creativity—processes information flexibly, reverses processes and has original approaches to problem solving
4. Mathematical Curiosity and Perseverance—asks why and what if, has energy and persistence in solving difficult problems

Within a problem-based learning context, mathematically gifted students exhibited all four characteristics (Trinter, Moon & Brighton, 2015).
In sum, many definitions of mathematical giftedness exist in the literature. There is no unique way to identify mathematically gifted students but they usually exhibit some of the characteristics listed above.

2.2 Interventions and Instructional Strategies

A variety of interventions and instructional strategies for mathematically gifted students are suggested in the literature, such as enrichment, acceleration, differentiation, grouping, curriculum design and extra-curricular activities. Each of them is discussed in greater detail below. However, there is no single approach for all mathematically gifted students, since they also vary in terms of their mathematical ability. It is suggested that based on the degree of their talent, a combination of interventions would be most appropriate (Stambaugh & Benbow, 2010). For example, the top 1% to 5% students should participate in accelerated individualized mathematics, extracurricular math competitions, mentorships, and clubs (Stambaugh & Benbow, 2010).

2.2.1 Enrichment and acceleration

Enrichment and acceleration are closely related, but they are not exactly the same. Enrichment is usually enriching and extending the official curriculum by elaborating on the topic and requiring deeper understanding (Koshy, Ernest & Casey, 2009; Lupkowski-Shoplik, 2010). On the other hand, acceleration means moving students more quickly than is typical through the math curriculum (i.e., studying math at a higher grade level). Most programs offered to mathematically gifted students entail both enrichment and/or acceleration.

To further address the learning needs of mathematically gifted students, a pyramid of educational options was suggested by Lupkowski-Shoplik (2010). The pyramid classified math talent into moderate, high and exceptional, and recommends different types of programs
according to the level of math talent. In general, accelerative programs are suggested for exceptionally talented students and enrichment programs are suggested for moderately talented students. For example exceptionally talented students are recommended to take fast-paced summer classes, be accelerated in mathematics and even enter university early, while moderately talented students are recommended to participate in enrichment classes and have enrichment in the regular classroom.

Acceleration can take many other forms, such as skipping a grade, taking a university-based program during the school year, or taking an individualized, accelerative program. Although grade skipping as a form of acceleration is inexpensive and requires no curriculum adaptation or differentiation, it does not guarantee that students will receive quality teaching (Kim, 2006). Subject acceleration, on the other hand, brought positive experiences to most students (Kim, 2006).

Many tasks offered to mathematically gifted children included both enrichment and acceleration in the sense that when pupils were motivated to carry out a complex and in-depth investigation, they often sought new and more advanced knowledge. There are varying opinions as to which option is more effective. Koshy, Ernest, and Casey (2009) suggested favoring enrichment over acceleration since it gave student more motivation. However, Lupkowski-Shoplik (2010) asserted that good accelerative and enrichment activities should work together. A number of researchers have looked into the effectiveness of acceleration and enrichment programs. Most demonstrated that both acceleration and enrichment programs produce many positive effects, and virtually neither has been found to have any harmful effects on the students (Kim, 2006; Lupkowski-Shoplik, 2010; Sowell, 1993). Sowell (1993) conducted a meta-analysis of the research on programs for mathematically gifted children in 1970s and 1980s. He found
that the acceleration programs produced dramatic changes in achievement when those students had opportunities to learn at a faster pace. The only study in Sowell’s (1993) meta-analysis that focused on enrichment in the elementary grades found significant gains in achievement and attitude for students who were in the enrichment program compared to those in the regular program. McAllister and Plourde (2008) designed an inquiry-based enrichment program and discovered that using higher-level math concepts engaged students and kept them excited about learning.

2.2.2 Differentiation and grouping

Pierce et al. (2011) suggest that “[d]ifferentiation involves finding multiple ways to structure a lesson so that each student has an opportunity to work at a moderately challenging level” (p. 572). Differentiation of instruction provides multiple ways for students to succeed academically without lowering the standards and allows teachers to support not only gifted students, but also all learners in general. Instructional strategies to differentiate instruction include manipulatives, games, small group instruction, learning contracts, pretesting and compacting the curriculum. However, effective differentiated instruction for gifted students should not just involve giving them more problems to solve; this approach has been found to cause a loss of motivation (Diezmann, 2004; Jordan, 2007; Kim, 2006; Rotigel & Fello, 2004).

Differentiation of instruction is crucial to the education of gifted students since gifted students have varying abilities (Dimitriadis, 2013). Hekimoglu (2004) found that gifted students could benefit from a differentiated curriculum which provides greater depth and open-ended problems. Similarly, Dimitriadis (2013) suggests differentiating work and instruction for mathematically gifted students by adding depth, complexity and extension to address their needs. Nonetheless, this is not always true in practice. Ayebo (2010) discovered that teachers who
taught math to gifted students in the United States did not differentiate instruction for gifted students due to lack of training, large class sizes, and inadequate time to plan.

A closely related strategy to differentiation is grouping. Grouping can be done homogeneously, where students are grouped according to their ability, or heterogeneously, where students are not grouped based on their ability. The literature does not agree on which is better for students in general. Rogers (as cited in Stambaugh & Benbow, 2010) conducted a meta-analysis on grouping. She analyzed the pros and cons of homogeneous grouping and found that “homogeneous groups are more beneficial academically for students of all abilities than heterogeneous grouping” and that “low-ability students benefit academically when paired with a high-ability partner, but this may not be true for the high-ability partner” (p. 19). The latter finding was echoed by Winebrenner (2001), stating that although the use of gifted students as peer tutors was a common teaching strategy, it was inappropriate.

Regarding grouping strategies for mathematically gifted students, most studies tend to agree that homogeneous grouping suits them best. In Sowell’s (1993) meta-analysis on programs for the mathematically gifted stated that mathematically gifted students worked better when they work with other mathematically gifted students. Mingus and Grassl (1999) found that mathematically gifted students preferred to work alone or peers at the same intellectual level, since they challenged them to strive for excellence, allowed them to interact at a quicker pace and higher level, and were sources of emotional support. More recently, Pierce et al. (2011) discovered that putting gifted students together allows them to explore content at deeper levels, and allowed more efficient differentiation. They noted that teachers in those classrooms were naturally driven to differentiate, which helped all learners.

2.2.3 Curriculum design and other teaching strategies
In general, mathematics curricula use a spiral approach of going through different strands in the same year and build up on them in the years which follow. However, the spiral approach may not suit mathematically gifted students since they often want to know more about a specific topic before moving on to the next. A linear approach in the curriculum, which goes through everything in a topic before moving on to the next, has been found to better address the needs of mathematically gifted students since it is less repetitive (Deal & Wismer, 2010; Kim, 2006). Gavin & Sheffield (2010) proposed that an advanced, in-depth curriculum for mathematically talented students should include the following four components:

1. Creative and complex problem solving
2. Connections within and across mathematical and other content areas and across a wide range of contexts
3. An inquiry-based approach that focuses on processes used by mathematicians
4. Appropriate pacing (p.58)

They suggest that this type of curriculum could provide appropriate challenge, rigor and enjoyment for mathematically talented students. It could also allow students to use thought processes similar to those of practicing mathematicians. John Benson, a teacher who has taught gifted middle school students using a curriculum emphasizing creative and complex problem solving for more than twenty years, reported anecdotally that many of his students benefited from the program (Benson, 2010). Some examples of complex problem solving include tasks requiring proofs and tasks yielding multiple solutions (Leikin, 2010).

Technology can also be integrated into the curriculum since it assists mathematically gifted students in learning problem-solving skills, and can allow students to advance on their own rate, and become more autonomous learners (Freiman, 2011). The use of calculators,
computers and online learning systems can reach higher depth and breadth of the curriculum (Kim, 2006). Some online learning systems can even adapt interactively by adjusting the problems that they offer to students based on their success on previous problems (Rusczyk, 2010). Freiman et al. (as cited in Freiman, 2011) also identified that teachers using laptops in their classes can cover curriculum faster. They further suggested using the remaining time on in-depth study of some topics, as well as going beyond the curriculum.

Since some schools do not have a sufficient number of mathematically gifted children that they can offer a special curriculum, Rusczyk (2010) suggests implementing school-sponsored math clubs and teams to challenge those who are not challenged in the regular school curriculum. He found that math clubs and teams allow students to learn mathematics outside the curriculum, indicating the importance of mathematics and providing the value of social groups in which mathematics is highly valued. Math competitions, meanwhile, can provide a focus for the club, act as a yardstick for the top students, allow exposure to a wide array of mathematical topics including those which are underrepresented in most curricula, and be a form of mental recreation. In order to engage students, math clubs can offer math games such as Blokus, SET, etc., math contests, exploration of new subjects and math projects (Rusczyk, 2010).

2.3 Teacher Perceptions of Teaching Mathematically Gifted Students

A lot of teachers recognize the needs of mathematically gifted students. However, they think that they are unable to meet their needs due to insufficient time to plan, not knowing how to manage differentiation in the classroom, having too many students and not having an assistant to help with differentiated instruction (Ayebo, 2010; Jordan, 2005). They also perceive that it is not an easy task to work with mathematically gifted children since they have special insights as problem solvers, for example by arriving at correct answers through nontraditional
methodologies or asking questions beyond the scope of the lessons. Some teachers, particularly those with limited mathematical background, would feel challenged and threatened, possibly due to their lack of mathematical background (Mingus & Grassl, 1999; Rotigel & Fello, 2004).

In Karp’s (2010) study on twelve experienced Russian teachers who worked with mathematically gifted students, they reported that during their first years of teaching, it was an enormous effort to prepare for lessons since students learned too quickly and they needed to learn new areas of mathematics and ways to present them. Karp (2013) also found that a crucial role in teaching mathematically gifted students was collective research, in which teachers and students conducted research together on an equal footing. In another study on a teacher’s perspectives on teaching mathematically gifted students, Leikin (2011) reported that the teacher was proud of his students’ discoveries since he had profound mathematical knowledge and was able to improvise.

Leikin and Stanger (2011) studied teachers’ perceptions of gifted students through semi-structured interviews with three elementary classrooms and ethnographic observations of their classes. They found that teachers conceived mathematically gifted students as catalyst, scaffold, or springboard for class discussion. They also reported that teachers admitted that they focused their attention on teaching mid-level students in their classes.

In a training to prepare teachers to teach the mathematically gifted, teachers reported that teaching mathematics to gifted children to be a particularly complex and challenging activity. Nevertheless, the training, which included mathematics investigation, allowed them to be more confident and more positive (Koshy, Ernest & Casey, 2009). In another training program, Levenson and Gal (2013) reported that a teacher who perceived mathematically talented students hardly made any arithmetical mistakes and rarely have learning disabilities changed her view
after participating in a professional development program. Dimitriadis’s (2013) findings agreed with the above results. He discovered a strong correlation among teachers’ training background, subject knowledge, experience, and their confidence level in teaching mathematically gifted students.

2.4 Conclusion

In this literature review I examined research related to mathematically gifted students, interventions and instructional strategies for those students, and teacher perceptions of teaching them. A main focus of the review was on interventions and instructional strategies for mathematically gifted students, since many have been studied but they may not suit all mathematically gifted students. It is also interesting to note that teacher perceptions may affect how the needs of mathematically gifted students are addressed.

Among all the studies reviewed in this literature review, virtually none was conducted in Ontario, or in Canada. This study therefore explored mathematically gifted students in the Ontario context with a focus on how teachers can specifically address their needs. This study was conducted using semi-structured interviews with middle school teachers who have experience working with mathematically gifted children in Ontario. It addresses identification of mathematically gifted students, instructional strategies for mathematically gifted students, barriers and supports teachers face when teaching them, and how teachers feel about teaching them. It is my hope that this study will contribute on supporting mathematically gifted students in existing research by providing a case in Ontario, and from there help teachers to be more confident in supporting and teaching them. A further hope is that this study will inform teacher training and policy development so that the needs of mathematically gifted students can be fully addressed.
Chapter Three: Research Methodology

3.0 Introduction

In this chapter I describe and explain the research methodology. I begin by reviewing the general approach, procedures, and data collection instruments before elaborating more specifically on participants sampling and recruitment, and some information on the participants. I then explain the data analysis procedures and review the ethical considerations pertinent to my study. Relatedly, I identify a range of methodological limitations but I also speak to the strengths of the methodology. Finally, I conclude the chapter with a brief summary of key methodological decisions and my rationale for these decisions given the research purpose and questions.

3.1 Research Approach and Procedures

This research study was conducted using a qualitative research approach involving a literature review and semi-structured, face-to-face interviews with three teachers. Qualitative research is an exploration of human experience more concerned with validity (the degree to which the data and interpretation fit a situation) than absolute truth (Donalek & Soldwisch, 2004; Schensul, 2004). It has a focus on individual meaning, and has an inductive style (Creswell, 2014). This enables researchers to explore in detail social and organizational characteristics and individual behaviors and their meanings (Schensul, 2012). However, the results are usually not generalizable unlike those of many quantitative studies (Lapan, Quartaroli, & Riemer, 2012).

Contrary to quantitative research, in which researchers consider themselves to be objective, separate and detached from the experiment and subject(s) under investigation, researchers conducting qualitative studies assume that each person has an understanding of reality from an individual perspective (Erlingsson & Brysiewicz, 2013). Moreover, qualitative approaches provide not only answers to the researcher’s questions, but also explore the
participants’ feelings, perceptions, experiences and thoughts (Ivey, 2012). This approach preserves the context for the data, which cannot be otherwise preserved in a quantitative study. Given my research purpose and questions, since a qualitative research study permits me to enquire into the lived experiences of a small sample of teachers who have taught mathematically gifted students, a qualitative research approach was chosen.

3.2 Instruments of Data Collection

In qualitative research, one way of collecting data is by using interviews. Qualitative interviewing can be broadly classified as individual interviews, focus group interviews, and online interviews (Lichtman, 2013). Individual interviews can be further classified as structured interviews, semi-structured interviews, and unstructured interviews. Structured interviews are interviews in which the questions and format are the same for each individual, while unstructured interviews do not have a specific set of questions and resemble an informal conversation (Lichtman, 2013). Semi-structured interviews, on the other hand, are somewhere between structured interviews and unstructured interviews. They involve a general set of questions and format which is used with all participants, but the interviewer can vary the questions as the situation requires (Lichtman, 2013).

The primary instrument of data collection was the semi-structured interview protocol. I conducted face-to-face interviews with three teachers in Ontario. In a semi-structured interview, there is a general plan for the topic to be discussed but does not follow a fixed order of questions (Packer, 2011). It involves open-ended questions which encourage participants to share views and opinions, and which allow them to focus on the issues of greatest importance to them (Creswell, 2014; Rosaline, 2008). Jacob and Furgerson (2012) elaborate that an interview protocol is more than a list of interview questions. It should include an opening and closing
script, prompts to remind the interviewer the information he is interested in collecting.

Furthermore, in a semi-structured interview, participants can provide historical information and the researcher can control the line of questioning (Creswell, 2014). Given my research purpose and questions, semi-structured interviews could allow me to explore participants’ feelings, perceptions, experiences, and thoughts about the questions. Thus, semi-structured interviews were used for data collection.

3.3 Participants

In this section, I review the sampling criteria I established for participant recruitment. I will also review the methods used to recruit participants as well as information regarding the participants.

3.3.1 Sampling criteria

The following criteria were applied to teacher participants:

1. Teachers will have at least five years of teaching experience (including teaching mathematics) between Grades 4 and 8
2. Teachers will have taught in Ontario for at least two years
3. Teachers will have taught at least three mathematically gifted students in their career

First, teachers ought to have a minimum of five years of experience in teaching mathematics so that they are familiar with the various instructional strategies. Gifted programs in Ontario generally start at Grade 4, so it would be more relevant to look at that grade onwards. Furthermore, this research aims to provide an understanding of the research questions in the Ontario context, so it is imperative that teachers have some Ontario teaching experience. Finally, teachers should have taught at least three mathematically gifted students so that teachers can
generalize their experience in terms of the characteristics of mathematically gifted students, instructional strategies used to accommodate mathematically gifted students, and their feelings towards teaching mathematically gifted students.

### 3.3.2 Sampling procedures

In qualitative research, sample sizes tend to be smaller, but the information gathered from each participant tends to be more extensive (Springer, 2010). Some of the commonly used approaches include typical case sampling, maximum variation sampling, critical case sampling and snowball sampling (Springer, 2010). These approaches are described as purposeful since the goal is to deliberately identify individuals that are informative (Springer, 2010).

Purposeful sampling is a strategy in which particular settings or persons are selected deliberately to provide important information which cannot be obtained from other choices (Maxwell, 1996). In larger studies, it can also achieve representativeness or typicality of the settings and individuals selected. Creswell (2014) suggested purposefully selecting participants who will best help the researcher understand the problem and the research question. A subset of purposeful sampling is convenience sampling, where participants are selected based on their convenient accessibility and proximity to the researcher.

My study aimed at studying how teachers address the needs of mathematically gifted children, so the participants in my study were recruited purposefully based on the criteria listed above. Moreover, I recruited participants conveniently based on existing contacts and networks in the teachers college and mentor teachers. The research was conducted outside of the school building and three teachers were interviewed.

### 3.3.3 Participant bios
Elaine is a middle school teacher in Toronto. She has 25 years of teaching experience and she has taught Grades 7 and 8 exclusively in a core classroom. In the recent 5 years, she teaches in a gifted class. She does not have a mathematical background, but her recent focus on professional development is around STEM projects. She has also completed the special education part 1 additional qualification.

Ivan teaches a Grade 7/8 class in the east end of Toronto. He has 26 years of teaching experience and 16 years at his current school. He teaches in a regular class, but he is interested in mathematics and he likes to challenge his students in math. He learned math mainly through the help of his mentors, who are experts in the field of math education. He also enjoys solving math problems.

Sarah has 10 years of teaching experience and she has mainly taught Grade 7 and 8 students. She is the only participant who has a mathematical background in postsecondary education and she is a math specialist. She taught rotary math for a few years in the past, and she trained the students to participate in math competitions. She is currently teaching core in a gifted class.

### 3.4 Data Analysis

After transcribing the interviews, the first step is to write notes about categories and relationships while reading the transcripts (Maxwell, 1996). The data are then analyzed by coding. Coding is the process of organizing the data by bracketing chunks (Creswell, 2014). The goal of coding is to fracture the data and rearrange it into categories which facilitates the comparison of data within and between these categories. During coding, interviews are analyzed line by line and notes are made about what the research thinks might be a theme (Ivey, 2012).
Packer (2011) suggested looking for commonalities in the data and dividing the data into parts before categorizing the data and rewriting in objective language.

I coded my interview transcripts multiple times to look for categories of data and identify common themes related to my research questions after transcribing the interviews. I also looked at null data, which is what participants did not speak to.

3.5 Ethical Review Procedures

Ethical issues pervade all of qualitative research (Shank, 2002). Ethical principles such as doing no harm, being open to what you are doing and being honest are therefore crucial to minimize the risks. A consent form is always used to mitigate these issues. The form will include the purpose of the study, level and type of participant involvement, risks to the participant, guarantee of confidentiality and assurance that the participant can withdraw at any time (Creswell, 2014).

For my study, I have taken the following measures. First and foremost, participants were asked to sign a consent letter (Appendix A) giving their consent to be interviewed as well as audio-recorded. This consent letter provides an overview of the study, addresses ethical implications, and specifies expectations of participation (one 60-75 minute semi-structured interview). Second, all participants were assigned a pseudonym and participants identities would remain confidential and any identifying elements related to their schools or students were excluded. Furthermore, all data will be stored on my password protected computer and will be destroyed after five years.

Finally, there are no known risks to participation in this study.

3.6 Methodological Limitations and Strengths
There are a few limitations with regards to this research approach. One shortcoming is the key informant bias, which states that there is no guarantee that the participants’ views are typical, even when they are purposefully selected and the data seem valid (Maxwell, 1996). Furthermore, the results cannot be generalized to the experience of teachers. Another issue is that the interviews provide indirect information filtered through the views of interviewees, and not all people are equally articulate and perceptive (Creswell, 2014).

On the other hand, there are a number of strengths related to this research approach. Qualitative research provides an understanding into the meaning of participants’ lives and experiences through a participants’ perspective, as well as an understanding on the particular context of the events (Maxwell, 1996). It also allows more flexibility since questions may change and individuals studied may be modified. Furthermore, semi-structured interviews allow face-to-face interaction in a relatively natural setting. Participants can also provide historical information and researchers can control the order of questioning in semi-structured interviews (Creswell, 2014).

Regarding my research, as noted above, semi-structured interviews allow me to gather in-depth information from the participants’ experiences and the context of the events. They also permit me to tweak my questions depending on the participants. However, since the sample size is small, the data gathered may not be representative of teachers in general.

3.7 Conclusion

In this chapter I explained the research methodology. I started with a discussion of the research approach and procedures, comparing quantitative research with qualitative research and explained why I chose a qualitative approach. I then described the instruments of data collection, identifying semi-structured interviews as the primary source of data. I explored the
characteristics of semi-structured interviews and their strengths. I later identified the participants of the study, listing the criteria applied to the interviewees, and providing the rationale for the criteria. I also described the sampling procedures which entailed purposive sampling and convenience sampling. I proceeded to how I analyzed the data by coding. Ethical issues including consent, risks of participation, right to withdraw, and data storage were also considered. Finally, I examined the methodological limitations and strengths of this research study. In the next chapter, I will report research findings.
Chapter 4: Research Findings

4.0 Introduction to the Chapter

In Chapter One, I have explained the research problem and my research questions. In Chapter Two, I have reviewed relevant literature. In Chapter Three, I have elucidated my research methodology. In this chapter, I present and discuss the findings that emerged through the analysis of data from my research interviews. The interviews were conducted with three teachers working in the Toronto District School Board in June and July. Throughout the analysis, I remained constantly guided by my research question: how are Ontario middle school teachers currently addressing the needs of mathematically gifted children? The research subquestions (How do teachers reportedly identify mathematically gifted students? What instructional strategies do teachers reportedly employ to teach mathematically gifted students? What barriers and supports are teachers experiencing when teaching and supporting mathematically gifted students? How do teachers feel about teaching mathematically gifted students?) guided me to find themes that emerged from the data. In the discussion, connections are drawn between participants’ experiences and the literature reviewed in Chapter 2. Findings are organized into four main themes:

1. Identifying mathematically gifted students
2. Instructional strategies to accommodate mathematically gifted students
3. Barriers and supports
4. Teacher attitudes towards teaching mathematically gifted students

For each theme, I will first describe it, then report on the data, and discuss the significance of each theme within the context of the existing literature. Finally, I summarize my findings.

4.1 Identifying Mathematically Gifted Students
According to these teachers, identification of mathematically gifted students is not straightforward because there is no fixed set of characteristics that mathematically gifted students exhibit. Thus, these teachers struggle in determining if a student is mathematically gifted. In this section, I will first discuss the wide range of characteristics of mathematically gifted students. Then, I will touch briefly on the definition of mathematical giftedness, before concluding with the challenges teachers face when identifying mathematically gifted students.

The participants reported a wide range of characteristics of mathematically gifted students, such as mathematical creativity, higher level thinking, absorbing new information quickly, and struggling to express their thinking. Diezmann (2004), Rotigel and Fello (2004) and Sheffield (2003) also reported similar characteristics. Among them, higher level thinking, or divergent thinking, appears to be a major characteristic of mathematically gifted students in the research literature. Elaine described divergent thinking as thinking outside of the box or a new way of solving a problem, while Ivan described it as the ability to extrapolate. Freimann (2003) used the term “mathematical cast of mind” to describe this idea and defined it as a combination of traits that enable children to think in structures, to formalize and to generalize. Participant responses confirmed that having a mathematical cast of mind is an important characteristic for identifying mathematically gifted students.

When asked to describe the characteristics of mathematically gifted students, Elaine explained that “[t]hey are very hard to describe… and they present differently from person to person.” She also described that “[t]he fact that they persevere through problems, they take on new concepts quickly, sometimes they can see problems in creative ways. All these things are what make students academically successful.” Thus, teachers think that higher level thinking is probably the characteristic which separates mathematically gifted students from students who are
simply high achievers. Elaine further noted that “[t]he students who are mathematically gifted don’t always perform with the test results academically.” This can happen when students just show the answers but do not show all process work. Even if their answers are correct, they may not receive full credit. Her response highlighted the difficulty of generalizing the characteristics that define mathematically gifted students. This is also reflected in Gavin, Firmender and Casa’s (2013) findings, where they noted that math talent is hard to describe since children manifest mathematical talent in different ways.

Relationally, when asked for a personal definition of mathematical giftedness, all three participants struggled to provide one. Sarah bluntly stated that it was a very complicated question, while Ivan noted that the definition is evolving over time. On the other hand, Elaine simply repeated the definition of giftedness set by the Toronto District School Board, and was reluctant to provide a personal definition, saying “[i]t’s not up to you to have a definition because the board does that for me.” This shows that may just resort to the school board’s definition instead of coming up with their own definition.

In some rare cases, teachers believe that they can be certain that a student is mathematically gifted. Sarah mentioned a few of those students who were high achievers, had excellent mathematical communication and could solve problems way ahead of their grade level. She described, “I would say … I definitely know [they] were mathematically gifted because on all the competitions that they participated, they would always come on top.” Apparently, competition results are an unambiguous indicator that a student is mathematically gifted since they are rather objective and competitions compare students to their peers. However, most of the time, these teachers struggled to tell if a student is mathematically gifted. Sarah explained her difficulty in judging if a student is mathematically gifted as follows:
There is no definition… There are no points to put a check mark beside it. Student might be mathematically inclined but may not be gifted. Where is the line where you say he is gifted or he is [just] a hardwork[ing] [student]? I had many hardworking students who would achieve very well in class, but as soon as you give [them] more complicated [problems], they would be anxious […] and back off.

This goes back to the complexity of defining giftedness. There is no fixed set of characteristics that mathematically gifted students exhibit and this is why teachers struggle to determine if their students are mathematically gifted. She further explained the difficulty through an example of a student whose parents arranged her to do extra math outside of school:

She understood everything in class, but her work would always have some mistakes. She was bored during class time […] but] when I suggest her to do some extra math work, she would complain saying ‘I already have so much math there. I don’t want to do anything complicated.’ Is she mathematically gifted? I really don’t know.

A student who achieves well in math but lacks motivation to do more or explore more is another difficult situation. The student may lack motivation because she is too busy with other work and just want a break, or she may not really like math at all. Once again it is hard to say.

Koshy, Ernest & Casey (2009) also noted that identification of mathematically gifted students is not a simple process because the concept of giftedness is complicated. They also found that teachers in the UK found the process of identifying mathematically gifted students challenging. This is especially the case when students exhibit mixed characteristics, for example students who learn new ideas quickly but lack motivation to work at a higher level.

In sum, identifying mathematically gifted students is challenging for teachers because there is no clear definition. In addition, mathematically gifted students do not all exhibit the same
set of characteristics. When they exhibit only some of the characteristics, which are in most cases, teachers struggle to make a decision.

4.2 Instructional Strategies

Teachers employ a variety of instructional strategies to support mathematically gifted students to keep them challenged. In this section, I will discuss the instructional strategies the participants reportedly used in their classroom. I will begin with enrichment and acceleration, before discussing differentiation and grouping.

Enrichment is a main strategy which the participants reportedly use in their classroom. It is usually enriching and extending the official curriculum by elaborating on the topic and requiring deeper understanding (Koshy, Ernest & Casey, 2009). When asked about how she modified her instruction for mathematically gifted students, Elaine replied, “[w]hat I do to accommodate them is give them lots of enrichment opportunities [such as] problem of the week.” For the same question, Sarah responded, “[t]o make sure that my mathematically … gifted students are challenged, I always have a set of problems on the side.” It is evident that more problems, more difficult problems are given to mathematically gifted students is what the teachers considered accommodations for those students. The question then becomes what those problems are and what they look like.

All of the teachers interviewed reported a good source of problems is from the Centre for Education in Mathematics and Computing (CEMC), University of Waterloo. More details will be provided on this in my discussion of barriers and supports below. Elaine finds that open-ended problems and real life problems are particularly good for mathematically gifted students because open-ended problems require them to answer the question in different ways and real life problems provide an “extra depth and breadth” for them. This confirms Rotigel and Fello’s
(2004) recommendation on addressing the needs of mathematically gifted children. The following is an example of such real life problem from Grade 8 Geometry provided by Elaine:

When I taught them Pythagorean Theorem, the next step was we looked around our school. Our school is not accessible to people with wheelchairs. We don’t have any ramps and we have stairs everywhere. So I said to them what are we going to do? […] So they are tasked with making ramps, and to plan and make a ramp they need to use Pythagorean Theorem, in order to make sure that their ramp satisfies the building code. […] They needed to use what they learned in ratio and Pythagorean Theorem, [and] apply it to the building of these ramps.

This real life problem requires students to apply what they have learned into real life, so they are being challenged at a higher level. This is a form of enrichment for mathematically gifted students as this is not a typical textbook problem.

Acceleration means moving students more quickly than is typical through the math curriculum (Lupkowski-Shoplik, 2010; Stambaugh & Benbow, 2010). Only one participant explicitly referred to such accommodations. In Sarah’s school, Grade 8 students had the opportunity to go through Grade 9 math in her math club, and if they scored 75 or higher on a Grade 9 math test, they could go to Grade 10 math directly. However, although this is a wonderful acceleration opportunity, it is not common for high schools to collaborate with their feeder middle schools to allow for such opportunity.

As opposed to enrichment, these teachers seemed to have a less clear understanding of what acceleration is. For example, Ivan talked about a problem which he used to ‘enrich’ student understanding on the topic of addition of fractions. Through the use of hands on activities, he attempted to guide his Grade 7 and 8 students to understand that $\frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \cdots = 1$. This is
called a geometric series and it is in the Grade 11 math curriculum. Although he called this ‘enrichment,’ what he did was actually acceleration by exploring concepts and ideas in higher grades. Teachers not knowing the precise meaning of acceleration is a possible reason why it was seldom mentioned by the participants.

In this section, I am going to discuss differentiation and grouping as an accommodation strategy for mathematically gifted students. Ivan, the only participant who worked in a regular classroom, explained differentiation of instruction as his main strategy. His approach was to first create a low floor by bringing everything down to the very basic. Then he would work at the grade level, and keep going on to a higher and higher level. He referred his approach as “low floor, high ceiling”. He also noted that this approach allowed him to keep pushing students higher and higher. Often teachers understand differentiation as an accommodation for students who are not achieving grade level expectations, as Ivan cautioned in the interview:

So this is going to be completely different than what you have seen. You know what differentiation is right? So differentiation you start with … the grade level … [and] create things that are less for the other kids to do.

However, differentiation can go both ways. Teachers can differentiate their instruction by providing more advanced materials.

Having students work in groups is a common strategy among all the interviewees. One rationale is the peer learning opportunities group work provides. For example, Elaine mentioned:

Another strategy is having students teach one another in small groups. They are each responsible for learning something. They ask questions of one another. All that peer stuff is much more effective than listening to me.

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The reason why the participant found peer learning more effective is probably because it allows the students to explore content at deeper levels (Pierce et al., 2011).

When asked how he grouped his students, Ivan replied “[h]eterogeneously, because there’s always a time when the … low[er] [ability] kid will actually discover something before the … high[er] [ability] kid.” He further explained that this would “boost [students with lower abilities] up”. However, this contradicts with the findings of Rogers (as cited in Stambaugh and Benbow, 2010), who in a study of homogeneous groups and heterogeneous groups for students of different abilities found that homogenous groups are more beneficial academically for students of all abilities than heterogeneous groupings. Sowell (1993), Mingus and Grassl (1999), and Pierce et al. (2011) also favored homogeneous grouping for gifted students.

### 4.3 Barriers and Supports

Teachers face more barriers than supports when it comes to addressing the needs of mathematically gifted children. In this section, I will first discuss the barriers teachers face and how teachers manage them. Then, I will discuss the supports that teachers have. Finally, I will talk about if teachers feel supported overall.

One of the major barriers in teaching mathematically gifted students is that they know too much ahead of the curriculum. Often those students will learn extra math outside of school and will find math at their current grade level uninteresting. Elaine referred to it as “[y]ou [students] are not coming with a blank slate.” She elaborated:

> [When] [the students] know the formula already, they are less apt to want to go back and investigate why, because they have already learned what it is. For instance I am teaching the area of a circle and I want them to learn why it is $\pi r^2$. I want them to […] figure it out […] and see what the relationship is […], but they already just know, $\pi r^2$. 


When asked how she managed this barrier, Elaine referred back to her instructional strategies, which include providing students with a problem of the week and real-life problems, asking open-ended questions, and asking students to explain their answers. She further explained that “[i]t’s the why question that brings everybody to the same level, because the student who didn’t already study Grade 12 math still has really good ideas about why.” Apparently, asking students to explain their work can mitigate their differences in terms of mathematical knowledge.

Similarly, Sarah reported that when she told her students to look at different ways of representing the addition and subtraction of positive and negative numbers, the students would respond, “But we know this”, or “I know it like this, why do I need that?” The way she managed the barrier is that she insisted her students should listen to what she had to say first, and then when they saw new ideas or new perspectives appear, she said, “They would appreciate it […] and they would still be engaged.” Therefore, presenting new perspectives on math content that students already know may alleviate the barrier that students know too much ahead.

Another major barrier emerged from the interviews is the lack of administrative support. For instance Elaine, who did not have a math background, noted that she did not have enough time or money to take some courses to learn more techniques. On the other hand, Sarah, who had a master degree in mathematics, indicated that her administrators did not allow her to use her strength as a math specialist. She explained that the new principal took her out of the rotary math program and put her in a core classroom, forcing her to shift her focus away from math. She was quite upset as she said, “I was told that I also cannot teach anything that is from Grade 9. I am forbidden to touch anything that is from Grade 9.” This is terrible for her mathematically gifted students, but she had no choice but to listen to her administrators.
The participants spent significantly less time on talking about supports. This is probably because they have more barriers than supports when it comes to addressing the needs of mathematically gifted children. One of the major supports which the participants found to be helpful is the problem of the week and math contest problems (like the Gauss contest, a Grade 7/8 math contest, in particular) from the Centre for Education in Mathematics and Computing (CEMC), University of Waterloo. Elaine explained how it works:

They [CEMC] send [problem of the week] to me. I like those ones because they are always fresh. The nice thing about the University of Waterloo is that they’re very good at sending [problem of the week] to you and then sending you the answers, and they also have a great search tool. So if I want to specifically give a problem related to a specific skill, I can look it up.

The resources from the University of Waterloo are perfect for Ontario teachers since the problems are based on the Ontario curriculum. This can allow teachers to easily enrich their math lessons. Ivan mentioned a similar website called “nrich”, which has a number of problems based on different areas of math. However, since it is developed in the UK, the problems there do not necessarily correspond to the Ontario curriculum, and so they may not be as easily adapted in the Ontario math classroom.

When asked if they feel supported in teaching mathematically gifted students, none of the participants feel that they are adequately supported. Sarah in particular talked about her success as a rotary math teacher, in which she took her gifted students to math competitions and won numerous prizes. However, the new principal made her teach a core classroom instead, ignoring her talents in teaching gifted students. Ivan, on the other hand, said that he was lucky because he
was supported by his mentor massively. His mentor was a professor in mathematics education, and Ivan said his mentor always gave him new ideas.

It appears that teachers experience more barriers than supports when addressing the needs of mathematically gifted children. Ayebo (2010) also had similar findings. He reported a number of barriers that teachers face in a survey to teachers who taught mathematics to gifted students, but not much in relation to supports. This is probably because a lot of attention in mathematics education focuses on students who are not achieving with less attention is paid to those who are gifted and talented. In sum, teachers face a lot of barriers when addressing the needs of mathematically gifted students while receiving little support.

4.4 Teacher Attitudes Towards Teaching Mathematically Gifted Students

Teachers who position themselves as facilitators often enjoy the process of working with mathematically gifted students. When teachers consider themselves as facilitators, they will feel less challenged or intimidated by the knowledge of their mathematically gifted students, which may be well above their level, especially if they do not have a strong mathematical background. Those teachers will feel more comfortable guiding the learning of their students and may even learn something new in math on their own. I would argue that this process of learning together with the students brings teachers positive feelings towards teaching them. In this section, I will first present teacher perceptions on mathematically gifted students. Then I will discuss how and why these teachers position themselves as a facilitator in the classroom. Finally, I will talk about how teachers experience enjoyment in teaching mathematically gifted students.

First of all, I found that the participants perceived that mathematically gifted students need challenges. Ivan commented on the importance of challenging them, “You have to make sure that they are challenged. Otherwise they will be bored. And if you’re lucky, they will go to
sleep. If you are unlucky, they will start misbehaving.” Sarah further noted that mathematically gifted students appreciated her efforts to prove something to them, or explain why something worked. When asked to compare teaching regular students with gifted students, Elaine said,

In a regular […] classroom, if I was teaching data management, I could just teach them how to calculate the average, and we’d be finished. But my gifted students require me to come up with a reason to calculate the average. They require me to come up with challenges for them that are interesting.

This shows that mathematically gifted students need to be challenged by their teachers. I will suggest how this ties in with teacher enjoyment in teaching mathematically gifted students below.

All the participants reported that they positioned themselves as a facilitator in the classroom, especially if they did not have a solid mathematical background. Elaine explained that in her classroom, “There are many, many days, I am not going to say probably most days, where a student have an understanding of math … [which] well surpasses my own.” Instead of shutting it down, she would reportedly have the students explain something to her. She considered herself as a facilitator who guided her students through the curriculum, while being a learner at the same time. Her reason is, “For every teacher, you’re never going to know everything.” In other words, Elaine is suggesting that even if you have a strong mathematical background, it will still be impossible to know everything about mathematics.

Ivan, who did not have a strong mathematical background, shared a similar mindset. When his student’s knowledge of math exceeded his, he would be happy to learn from them and then he could know more math. He then said excitedly that this would allow him to teach more math.
Some teachers, particularly those with limited mathematical background, would feel challenged by mathematically gifted students, and experience frustration when students arrive at correct answers through nontraditional methodologies (Mingus & Grassl, 1999; Rotigel & Fello, 2004). That is not the case for my interview participants. They reportedly enjoyed learning more about math from their mathematically gifted students instead of getting frustrated.

Finally, I found that all the participants enjoyed teaching mathematically gifted students. When asked how she felt about teaching mathematically gifted students, Elaine responded,

> It’s been [the] most joyous time in my teaching career. The children challenge me every day. As a teacher, they challenge me every day. I learn more every day than I ever did teaching in a regular stream. They surprise me every day with what they do, with what they know. It’s really amazing, and so it’s been an absolute pleasure. I look forward to [teaching gifted students] every day. They are fantastic. I just feel lucky that I get to teach gifted. Yeah. They’re wonderful.

Her enjoyment likely stems from how she set up her classroom and built relationship with students. Ivan responded to the same question similarly. He responded, “Love it. It’s great. It’s a challenge. It’s fun. It’s a real challenge…oh it makes me think. And each time you get to think, it’s fun. You have to get to be creative. It’s fun to be pushed.” It is interesting to note that although Ivan and Elaine are not math specialist, they like the process of working with gifted students. It is perhaps the way how gifted students push their teachers to create activities to challenge them allow teachers to acquire new knowledge at the same time, and that gives them a feeling of enjoyment.

Similarly, Sarah replied, “Oh very excited. I absolutely love it. When you’re a math specialist, you have so much to offer.” Dimitriadis (2013) conducted a similar interview study
with teachers in England and he found a strong correlation between teachers’ math knowledge and their confidence level in teaching math. This seems to contradict what I found from my interviews. Regardless of their mathematical background, all teachers reported a high degree of enjoyment in teaching mathematically gifted students. I would suggest that this is because they positioned themselves as a facilitator in the classroom, which allowed them to guide the learning of their students without worrying about being challenged by them.

4.5 Conclusion

Overall, my findings show that middle school teachers in Toronto reportedly employ enrichment as an accommodation strategy for mathematically gifted students. They often struggle to identify gifted students, and they perceive a lot more barriers and supports when it comes to addressing their needs. However, they often enjoy working with gifted students probably because they position themselves as a facilitator. The findings point to ways in which teachers are trying to accommodate mathematically gifted students even if they do not have adequate support. They also suggested being a facilitator in the classroom can increase enjoyment in teaching gifted students.

In the next and final chapter, I will explain the importance of my findings, identify broad and narrow implications, give recommendations to teachers, administrators, and policymakers, and point to potential areas of further research.
Chapter Five: Conclusion

5.0 Chapter Introduction

In Chapter 1, I have provided an overview of my research on the topic of teacher experience in addressing the needs of mathematically gifted children. In Chapter 2, I have reviewed the relevant literature. In Chapter 3, I have presented and explained my research methodology, which involves semi-structured interviews with three conveniently sampled participants. In Chapter 4, I have presented my findings from semi-structured interviews with three teachers in the Toronto District School Board. In this chapter, I will first give an overview of key findings and explain their significance. Next, I will discuss both broad implications for the educational community and narrow implications for my professional identity and practice based on my findings. Then I will provide recommendations to the educational community regarding how to address the needs of mathematically gifted children. I will also point to areas for further research before concluding this chapter.

5.1 Overview of Key Findings and Their Significance

Four key findings emerged from the semi-structured interviews conducted with three middle school teachers who have experience working with mathematically gifted children. First, teachers reported that identifying mathematically gifted students was anything but easy. Second, enrichment was reported to be the most common strategy used to accommodate mathematically gifted students. Furthermore, teachers perceive significantly more barriers than supports when it comes to addressing the needs of mathematically gifted children. Finally, teachers who reportedly positioned themselves as facilitators in the classroom often enjoy the process of working with mathematically gifted students.
First and foremost, I found that teachers reported that it was often difficult for them to identify mathematically gifted students in their classroom. The primary reason teachers perceive for this is that there is no definition on mathematical giftedness, and there exists no checklist that a teacher can use to verify if a student is mathematically gifted. A further reason is that students reportedly often exhibit mixed characteristics, for example, they may do very well on tests and exams but lack the motivation to work on harder problems, or they may have very good mathematical insights but not perform well on tests. As a result, teachers find identifying mathematically gifted students on their own challenging.

The second key finding was that teachers most commonly report accommodation through enrichment of subject content. It is the most commonly used accommodation strategy reported by teachers. Enrichment means using problems and questions which are more complicated and are based on the same curriculum expectations. The teachers reportedly provide enrichment problems to their mathematically gifted students to keep them challenged and engaged.

Another key finding is that teachers identified significantly more barriers than supports when it comes to addressing the needs of mathematically gifted students. The most significant barrier that teachers reported was that students knew too much ahead of the curriculum, resulting in boredom during class time. Another key barrier mentioned by the participants was the lack of administrative support, in terms of not allowing a rotary system. When asked about supports, teachers spent much less time talking about them, and none of the participants felt adequately supported to address the needs of mathematically gifted students.

The final key finding is that teachers who reportedly positioned themselves as facilitators in the classroom reported enjoyment when working with mathematically gifted students. This is because when teachers position themselves as facilitators, they may feel less intimidated in
instances where they are challenged by their students, which often happens with gifted students. As a teacher, it is impossible to know everything, so considering oneself as a facilitator shifts the mindset to learning and exploring together with the students. Apparently, that results in new learning for the teacher and lead to enjoyment working with those students.

5.2 Implications

In this section, I will discuss the implications of my findings. I will discuss broad implications for the educational community, speaking to the various stakeholders such as students, teachers, and school administration. I will also discuss narrow implications for my professional identity and practice.

5.2.1 Broad implications: The educational community

Based on my findings, I have several broad implications regarding addressing the needs of mathematically gifted students. These implications are for students, teachers, administrators and school boards. First, mathematically gifted students may still generally remain unchallenged in the classroom because their teachers may not know how to differentiate for them. As a result, they may appear to be bored in class, perceiving that the teacher has no new information to provide. This boredom may manifest in students sleeping during class, or being disruptive to the learning environment. Gifted students want to learn as much as other students in the classroom, but they are rarely the focus of their teachers in regular classroom settings since teachers usually perceive that they will be fine on their own.

Furthermore, a lot of generalist teachers may not have adequate mathematical background or lack the required confidence to teach math at the middle school level. It is common for middle school teachers in Ontario to teach every subject, but math appears to be a particularly weak spot for them (Colgan, 2016). Some possible reasons for this may be that they
rarely engage in opportunities to practise math (problem solving) on their own, or their math is weak. If teachers lack confidence in math, when they see mathematically gifted students in their classrooms, they may feel intimidated by how much their students know about the subject in comparison to their own understandings. In addition, they may not have enough supports and so they will be hesitant to address the needs of mathematically gifted students.

Administration may be hesitant to adopt a rotary system in middle schools in the fear of making scheduling more complicated. As a result, most students are not offered the opportunity to learn math from a specialist teacher, which may place limitations on the level of enrichment mathematically gifted students are exposed to. Finally, in Ontario there is currently an apparent lack in policies and guides specifically for gifted education, and each school board defines giftedness differently. This means that teachers may often find difficulty seeking guidance from the school board or the ministry when they need help with instructional strategies or good math problems.

5.2.2 Narrow implications: My professional identity and practice

In this section, I am going to discuss the narrow implications that affect my professional identity and my beliefs about education. First, in my own practice, I will make sure that my gifted students are challenged appropriately in the math classroom. I may not make a strong effort to try to identify mathematically gifted students in my classroom due to the complexity of the definition. However, my focus will rather be on keeping all of my students challenged. If they have already mastered a particular set of concepts, I will give them more difficult problems to work on, instead of giving them more problems at the same level. In addition, I will set up a classroom environment in which math is highly valued. I will aim to provide a combination of real life problems as well as abstract problems to my students to cater to their interests. I will
also prepare my students, especially my mathematically gifted students, for math contests by providing additional training, since contests can give those students motivation and a goal to work towards.

Next, since I have a relatively strong background in mathematics, I will offer help to other colleagues who are not as strong in mathematics. I will collaborate with them to develop interesting and challenging math problems. I will also encourage them to engage in more problem-solving on their own so that they may build strategies to support their own gifted students in their classrooms. As for families, I will inform the accommodations available both inside and outside of schools for mathematically gifted students. I will make sure that they are aware of the ways in which I am supporting their children in school and what they can do to supplement the learning at home. For example, I will keep them informed of events offered by universities, such as math circles, math contests, and other math resources. I will encourage them to participate as many activities as possible with their children.

Regarding my beliefs about the teacher’s role, I believe that I should position myself as a facilitator of knowledge in the classroom. Even though I have a degree in mathematics, I will never be able to know everything in every strand of mathematics, and I am certain that there will be students who know more than I do in my career. By positioning myself as a facilitator, I will be able to explore new ideas in mathematics together with my students, and I believe I will find this more enjoyable, as indicated by one of my research findings.

Finally, I am going to discuss my beliefs about the purpose of schooling and equity in education. I believe the purpose of schooling is to let each and every student to reach his or her potential, and I believe equity in education is achieved when every student is given the same opportunity to work at his or her highest level. Often, I see gifted students ignored in the
classroom because teachers are too focused on helping those who are falling behind; this prevents gifted students from being challenged to reach their full potential. Therefore, I believe every student in the classroom needs to be challenged, regardless of his or her academic ability.

5.3 Recommendations

Based on the implications from my research findings, I have some recommendations for the various stakeholders (schools, policymakers, administrators and teachers) in addressing the needs of mathematically gifted students. The recommendations include both short term and long term goals, and I hope by implementing these recommendations, the potential of mathematically gifted students can be fully realized.

First, in the short run, schools should provide more professional development opportunities for teachers in the field of gifted education, equipping them to better provide enrichment opportunities for mathematically gifted students. Very few teachers have received specific training on gifted education, so they may not know how to work with gifted students. Professional development, such as workshops on the characteristics of gifted students, as well as exploration of relevant research and instructional strategies can better prepare teachers to teach gifted students who may be present in their regular classrooms. Enrichment opportunities for gifted students are equally important since they need opportunities to shine, for example by participating in competitions. Schools should set up math clubs to enrich student understanding in math.

Second, in a few years’ time, policymakers should develop policies specifically for gifted students similar to the handbook for teachers on teaching students who are gifted and talented developed by Newfoundland and Labrador Department of Education (2013). Currently there is only a small section on giftedness in Special Education: A Guide for Educators (OME, 2001).
There should be a dedicated handbook for gifted education because the exceptionality of giftedness is very different from other exceptionalities. This handbook should include information on characteristics of gifted students, challenges they face, as well as instructional strategies to accommodate them. It should also provide a definition for giftedness that can be applied across all the school boards, since there appears to be a bit of variation in the current terminology.

Moreover, the teacher accreditation body (Ontario College of Teachers) should require all elementary teacher candidates to pass a mathematics test in order to graduate and obtain their teaching license. The test should cover all mathematical concepts that are taught in elementary and middle schools. This should alleviate the problem of teachers not knowing enough math or lacking confidence in teaching math, which in turn may affect the quality of instruction delivered.

Furthermore, in the long run, administrators in middle schools should adopt a rotary system so that teachers can teach the subject they specialize in, such as math. This may improve the quality of math instruction and the likelihood that the needs of gifted students are met. As for teachers who teach math, regardless of mathematical background and experience, they should do some math on their own in their spare time, just like language teachers read in their spare time. It is important that teachers practise the process of problem solving so that they can model these strategies with their students. Teachers should also participate in professional development activities and provide enrichment to mathematically gifted students to keep them challenged. The enrichment provided, however, should not be busy work. They should be problems or challenges requiring higher level thinking skills.

5.4 Areas for Further Research
After conducting this research on teachers’ experiences of addressing the needs of mathematically gifted students, I have found a number of areas where further research is needed. There have been very few studies on mathematically gifted students in Canada – whether focusing on their own experiences or those of teachers – and virtually none in Ontario. As a result, more research around mathematically gifted students is needed. This study has considered the perspectives of three middle school teachers in Toronto, but further study with more teachers is needed to verify and consolidate the findings derived from this study. Those studies could be conducted through surveys or interviews, or through ethnography. Teachers who teach other grades and in other cities should be recruited. In addition, mathematically gifted students and administrators should be recruited to participate in interviews, surveys, or participant observation.

In the literature, there is currently very limited research on accommodation strategies other than enrichment and acceleration. Further research is needed to study the effects of other accommodation strategies such as mentoring and grouping. For instance, there should be a longitudinal study which tracks mathematically gifted students, during which time a teacher mentors them. There should also be a study which looks at if there is a correlation between homogeneous grouping and student achievement and motivation.

Moreover, very few studies have looked at how teachers perceive teaching mathematically gifted students. Since knowing such teacher perceptions can inform teaching practices and teacher training, more research is needed on how teachers perceive teaching mathematically gifted students. The research should also look at teacher attitudes and believes towards mathematically gifted students. This can in turn inform how administrators can plan specific programs to accommodate them.
5.5 Concluding Comments

My research has looked at how teachers reportedly address the needs of mathematically gifted students in their classroom. As a mathematically gifted student myself, I never really feel supported at schools as a student and I was always bored in math class. This research allows me to look at the teacher perspectives on mathematically gifted students and teaching them. I believe math talent is very important and it often indicates future success in STEM careers. The goal of addressing the needs of mathematically gifted children is not to train all of them to be mathematicians, but to introduce them to abstract concepts and logical thinking, which will prepare them for success in many other careers. I hope teachers can recognize the benefits of pushing mathematically gifted students above and beyond what they are capable of doing at the grade level, and ultimately realizing their full potential.
References


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http://www.tdsb.on.ca/Portals/0/EarlyYears/docs/SpecialEducationPlan.pdf


Appendices

Appendix A: Letter of Consent for Interview

Date: ______________________________

Dear ______________________________,

My name is Brian Tsui and I am a student in the Master of Teaching (MT) program at the Ontario Institute for Studies in Education at the University of Toronto (OISE/UT). A component of this degree program involves conducting a small-scale qualitative research study. My research will focus on addressing the needs of mathematically gifted students. I am interested in interviewing teachers who have a minimum of five years teaching experience and who have taught at least three mathematically gifted students in Ontario. I think that your knowledge and experience will provide insights into this topic.

Your participation in this research will involve one roughly 60-75 minute interview, which will be transcribed and audio-recorded. I would be grateful if you would allow me to interview you at a place and time convenient for you, outside of school time. The contents of this interview will be used for my research project, which will include a final paper and informal presentations to my classmates. I may also present my research findings via conference presentations and/or through publication. You will be assigned a pseudonym to maintain your anonymity and I will not use your name or any other content that might identify you in my written work, oral presentations, or publications. This information will remain confidential. Any information that identifies your school or students will also be excluded.

The interview data will be stored on my password-protected computer and the only person who will have access to the research data will be my course instructor. You are free to change your mind about your participation at any time, and to withdraw even after you have consented to participate. You may also choose to decline to answer any specific question during the interview. I will destroy the audio recording after the paper has been presented and/or published, which may take up to a maximum of five years after the data has been collected. There are no known risks to participation.

Please sign this consent form, if you agree to be interviewed. The second copy is for your records. I am very grateful for your participation.

Sincerely,

Brian Tsui
MT Program Contact:

Dr. Angela Macdonald-Vemic, Assistant Professor – Teaching Stream
angela.macdonald@utoronto.ca
416-821-6496

Consent Form

I acknowledge that the topic of this interview has been explained to me and that any questions that I have asked have been answered to my satisfaction. I understand that I can withdraw from this research study at any time without penalty.

I have read the letter provided to me by Brian Tsui and agree to participate in an interview for the purposes described. I agree to have the interview audio-recorded.

Signature: ____________________________

Name: (printed) ________________________________

Date: ____________________________
Appendix B: Interview Protocol

Thank you for participating in my research study. I am a Master of Teaching student at OISE. The aim of this research is to learn how teachers address the needs of mathematically gifted students. This interview is going to last 60-75 minutes. The interview protocol is divided into five sections. It begins with the participant’s background information, followed by questions about identifying mathematically gifted students, then teaching practices to teach mathematically gifted students, barriers and supports for teaching mathematically gifted students, and finally questions on how the participant feels about teaching them. I would like to remind you that you can choose not to answer any question, and can remove yourself from participation at any time. Do you have any questions before we begin?

Section 1: Background Information

1. Can you walk me through your educational background? (degrees, AQs, etc.)
   a. Have you received any training in gifted education?

2. How many years have you worked as a teacher?
   a. How many years have you been teaching at this school?

3. Are you involved in any math-related extra-curricular activities such as clubs and teams?

Section 2: Identification

4. Can you give me your personal definition of mathematical giftedness?

5. What does mathematical giftedness look like, in your experience?

6. Can you give me an example of a student who, in your eyes, was obviously mathematically gifted?
   a. PROMPTS: mathematical insight, creativity, test results, perseverance in
solving difficult problems, motivation, learn quickly

7. Can you give me an example of a time that you found difficult to judge whether a student was mathematically gifted?
   a. PROMPTS: mixed characteristics, i.e. test performance vary greatly, high motivation or good insights but apparent underachievement in assessments, outstanding performance but lack of confidence

Section 3: Instructional Strategies

8. Can you walk me through a typical math lesson in your classroom?
   a. PROMPTS: routines (i.e. problem of the day/daily math), lecture, independent seatwork, group work

9. What are some ways in which you have modified your instruction to meet the needs of mathematically gifted students?
   a. PROMPTS: grouping, enrichment, acceleration
   b. Did you find your efforts to be successful? Why or why not?
   c. What did this success (or lack of) look like?

10. Can you tell me about an activity or lesson that you have found to be particularly engaging and challenging for mathematically gifted students?
    a. Math games (rummikub, sukodu, kenken puzzles, set, etc.), math trail, mathematical Olympiad, technology

Section 4: Barriers and Supports

11. What are some barriers you face when addressing the needs of mathematically gifted students in your classroom?
    a. Can you give me an example of how you have managed these barriers?
12. Do you feel supported in teaching mathematically gifted students?
   a. PROMPTS: colleagues, resources (i.e. school policy, ministry documents, University of Waterloo Centre for Education in Mathematics)

13. Are there any resources for teaching the mathematically gifted?

Section 5: Perceptions

14. How do you feel about teaching mathematically gifted students in your general education classroom?
   a. What are some positive aspects of having them there?

15. Can you give me an example of a time that you were challenged by a student about your teaching or knowledge of math?
   a. PROMPTS: pointing out your mistake, asking questions that you cannot answer, complaining that it is too easy/tedious

16. In your view, how is teaching math to mathematically gifted students different from teaching math to regular students?

17. What advice would you have to other elementary teachers who have mathematically gifted students in their classrooms?

18. Do you have any final thoughts?

Thank you for your time.