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MODESTUM

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Mathematics teacher specialization in elementary schools

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ABSTRACT

This study explores elementary teacher and administrator perspectives related to mathematics specialty teachers in elementary schools, in a jurisdiction, where such roles were known by researchers to not be used. Mathematics specialty teachers are those teachers that have specialized training in both mathematics content and pedagogy. Online surveys were administered and completed by teachers and administrators in one school district in Ontario, Canada. The surveys included open- and closed-ended questions. The results of both the teacher and the administrator survey show that most participants were in favor of a mathematics teacher specialization model in elementary schools. Our findings contribute to the ongoing debate on the need for mathematics specialist teachers. While our findings are small and preliminary in nature, they represent a great interest amongst teachers and administrators on this school board in implementing such a model. These findings will have implications for policy makers both in the province of Ontario, but also in other regions looking to understand international models of mathematics education.

Keywords: mathematics specialty teacher, teacher specialization, mathematics education, professional development

INTRODUCTION

A mathematics teacher specialization model is a model, wherein a teacher with special qualifications in mathematics instruction has the primary responsibility for teaching mathematics to students (National Council of Teachers of Mathematics [NCTM], 2000; Reys & Fennell, 2003). These teachers may have an undergraduate degree in mathematics and qualifications through a teacher education program (Boscariol & Neden, 2008), but in other cases may have taken a basic mathematics certification program (McGatha et al., 2017). It is important to note that though typically accompanied by undergraduate mathematics courses, the ability to effectively teach mathematics can also be developed through teacher education courses that instruct on mathematics content and pedagogy (Woolcott et al., 2017). Internationally, the mathematics specialist teacher model is not uncommon. Regions such as South Korea, the United Kingdom, and the United States have all implemented variations on the mathematics specialist teacher model (Hill et al., 2004; Kim & Albert, 2015). While a relatively common model internationally, this model is still not widely used in Canada, nor in the context of the Province of Ontario in which the researchers are operating.

As teacher subject specialists, those with the content knowledge and training in the field they are teaching in, are primarily utilized in secondary or high school education in Ontario, calls for implementation of a mathematics specialist model have persisted for decades. For example, NCTM (2000) suggests that the teacher specialization model is especially needed in elementary schools. International studies have demonstrated that utilizing the teacher specialization model in elementary education improved teaching practices, increased teacher knowledge and confidence, and increased student achievement (Freiberg, 2014; Markworth et al., 2016; Pollock & Mindzak, 2015; Reys & Fennell, 2003).

This study takes place in a school board that does not use a mathematics teacher specialization model in elementary schools. In Ontario, Canada more broadly, use of a mathematics teacher specialist model is an anomaly but not impossible. This study was motivated by standardized testing results for this school board. The Education Quality Accountability Office (EQAO) is an autonomous agency of the Government of Ontario that administers large-scale assessments in reading, writing and mathematics. Students complete standardized testing in mathematics in grades 3, 6, and 9. These standardized tests have demonstrated that in our school board, there has been a stagnation or decrease in the percentage of students that meet the provincial standards in mathematics, categorized as achieving a mark above 70.0%. The percentage of students achieving the provincial standard in mathematics over the past several years ranges from 50.0-60.0% for grade 6 students and from 60.0-65.0% for grade 3 students (EQAO, 2019). It is important to note the inherent issues such as equity issues in student preparation, low student motivation and teachers teaching to the test that come with using standardized tests as benchmarks for student success (Fast et al., 2010).

Nevertheless, EQAO tests in our province serve as important benchmarks for schoolboards, teachers, parents, and government, which results in decisions related to funding and policy. Therefore, while we are not intending to say that these tests give a holistic understanding of student learning, their importance to various stakeholders makes the declining achievement of the provincial standard important to note.

As a result, this study explores the following question: *How do teachers and administrators in this school board in Ontario perceive the possibility of and need for mathematics teacher specialization in elementary schools?* Though research has examined teachers' perceptions of specialist systems that have already been implemented or pre-service teachers' preferences (Junqueira & Nolan, 2016), less is known about how teachers and administrators perceive such a model, particularly in a context, where such models are not used (Pollock & Mindzak, 2018). We explore implications for teacher efficacy in mathematics education as well as possible responses to addressing these concerns in teacher training at the pre- and in-service stages.

Consequently, we prioritize understanding the perspectives of the members of this school district to enhance potential discussions within the district but also contributes to the literature in important ways, through providing an international understanding of how educators understand the potential of mathematics specialist teachers and their benefits on students' learning. The purpose of this study is not to argue that a mathematics specialist model is favorable, but rather to explore the perceptions of teachers experience with mathematics. We present our research as preliminary findings, setting the stage for future research to explore larger samples of teacher and administrator perspectives, and to provide comparisons of perspectives across regions, which have implemented and have not implemented the specialist model. This research will be of interest to scholars and practitioners both in favor of and opposed to implementing a mathematics specialist model, as it demonstrates a high level of support for this practice amongst teachers and administrators.

THEORETICAL FRAMEWORK

We base our study on the theory of specialized content knowledge (SCK) (Ball et al., 2008). This begins with the theory that teaching mathematics is about more than simply understanding the content that is to be delivered. It is about understanding how students learn the content and how to teach new content in ways that it can be understood. As Hill and Ball (2004) point out, "how teachers hold knowledge may matter more than how much knowledge they hold" (p. 35). This is called pedagogical content knowledge (PCK) (Flint et al., 2011; Shulman, 1986).

The two components of PCK are common content knowledge (CCK), which is knowledge of curriculum content required to complete the work, which students are doing and SCK, which is defined, as follows:

> Mathematical knowledge beyond that expected of any well-educated adult but not yet requiring knowledge of students or knowledge of teaching. Many of the common tasks of teaching require significant mathematical resources, but do not yet necessarily require knowing about students or teaching (Ball et al., 2008, p. 398).

Teachers of mathematics need to present mathematical ideas and respond to students' questions of *why* a certain strategy is used (Ball et al., 2008). This requires a much greater understanding of mathematics than most teachers will ever actually teach to students. As a result, in order to be a successful mathematics teacher, a deep understanding of mathematics SCK is required for student success (Ball et al., 2008). We base our research on the concept that though CCK is required for teachers to teach mathematics, SCK is required for students to learn mathematics effectively, and this SCK is not held by all teachers (Ball et al., 2008). This combination of CCK and SCK may be more evident in mathematics teacher specialists.

In exploring teacher and administrator perceptions of their capabilities to teach mathematics, we will explore perceptions about the quality of mathematics education students are receiving, and the perceived need for mathematics specialist teachers (Riggs et al., 2018). As the survey was administered via email to participants, appropriate explanation of PCK, CCK, and SCK to participants was not possible. Further, such an explanation was thought to potentially lead participants to certain conclusions regarding the necessity for mathematics specialist teachers. Regardless, the framing of PCK, CCK, and SCK provides an important foundation on which to evaluate teachers' responses, and their own comfort level supporting students' mathematical learning.

LITERATURE REVIEW

Mathematics Teacher Knowledge

The struggles of teachers with mathematics education are well documented and come from a variety of sources. There has been widespread acknowledgement that mathematics educators need advanced training and continued development to be effective mathematics instructors (Holm & Kajander, 2011; Kim & Albert, 2015; Wright, 2017), however many post-secondary mathematics students do not go into education as they can find jobs in other fields (Kim & Albert, 2015). This means that the availability of qualified mathematics teachers is limited. International studies from areas such as Australia and the United States focused on comparing across regions have supported the fact that teachers report high levels of comfort with personal numeracy and awareness of curriculum, but confidence drops as teachers are asked to consider how students learn (Beswick, 2012; Hill et al., 2004). Additionally, even teachers with a strong mathematics background may struggle to teach well. It is widely recognized that teachers must need to have a more advanced understanding of mathematics than they are responsible for teaching (Hill et al., 2008; Holm & Kajander, 2011; Strand & Mills, 2014), case study research with pre-service teacher demonstrates that a strong conceptual understanding of how to teach the content is a necessity (Kahan et al., 2003). National data has supported the fact that

even high mathematics knowledge may be insufficient to support student learning when teachers themselves experience severe math anxiety (Ramirez et al., 2018).

There has been growing recognition that even what 'strong' teachers know about curriculum content let alone students' mathematical learning is incredibly limited and does not correlate with increased student learning (Hill et al., 2008). Multi-year studies of teacher training programs have noted that teachers, specifically of mathematics, often have continued to teach in the way they were taught, especially if they do not adequately understand the content (McNeal & Simon, 2000). Additionally, teachers without mathematic specific training do not tend to engage in pedagogies, which may be more effective for mathematics such as inquiry-based learning (Harlen, 2013) or use assessments, which require a demonstration of full content understanding (Hill et al., 2008).

This ultimately points to the fact that teacher's mathematical knowledge of content and pedagogy is a critical element to student success in mathematics as highlighted by a recent study of teacher researchers in the UK (Wright, 2017). While such content knowledge can be developed in non-specialist teachers, longitudinal research on mathematical knowledge has shown that the maintenance of such knowledge is costly and time consuming (Sani & Burghes, 2022). This ability to specialize is not always going to be the case for teachers, and points to the potential for another model of mathematics education.

Models of Teacher Specialization

Nations around the world such as China, France, South Korea, the United Kingdom, and the United States have implemented a mathematic specialist teacher model in limited capacities (Hill et al., 2004; Kim & Albert, 2015) and it takes a variety of forms. The most basic form is the mathematics specialist teacher model, where one mathematics teacher teaches mathematics to all students, and has the qualifications to do so. Other models include an intervention specialist teacher who supports students struggling with content, or the mathematics coach model, where a specialist teacher serves to provide professional development to teachers, which research reviews have consistently noted to be effective (McGatha, 2009; McGatha & Rigelman, 2017). The specialist model can also include team teaching options (Hilton & Houssart, 2014) or a model, where specialist mathematics teachers provide support to classroom teachers (Markworth et al., 2016). Additionally, a department model of multiple teachers in a single school can allow for team teaching or providing professional development to teachers (Fennell, 2017; McGatha et al., 2017).

Each model has shown varying degrees of success and requires numerous different resources to implement as well as their own set of logistical challenges. For the purpose of our study, we will focus on the implementation of a mathematics specialist teacher model, where one teacher who has advanced qualifications in mathematics teaches all students in the school. Research in this area is frequently concentrated in the United States, given the prevalence and inter-state variation in models used. While much of the research is positive on the effects of a specialist teacher, even the most positive studies note potential drawbacks to the implementation of such a model.

Strengths of Teacher Specialization

The strengths of the mathematics teacher specialist model come in terms of logistical benefits for individual teachers, improved quality of instruction, as well as learning benefits for students. In terms of logistical benefits, Markworth et al. (2016) explained because of their matched comparison study with specialist and control teachers across seven school districts in the United States that the teacher specialist model has affordances related to planning time, professional development, and instructional time. This study also notes that there can be benefits for students interacting with more teachers to improve their learning. Importantly for logistics, this model not only allows a school district to plan and deliver focused professional development for fewer teachers, but in-depth case study research has also found that such a model allows teachers the opportunities to focus on improving mathematics lessons with increased reflection time (Reys & Fennell, 2003; Webel et al., 2017).

In schools and districts around the world utilizing the specialization model, teachers tend to use more effective pedagogical tools for instruction after working with a specialist coach (Beswick, 2012; Ellington et al., 2017; Webel et al., 2017). Longitudinal research has found that teachers also report feeling better prepared, more knowledgeable, and more effective in mathematics instruction (Freiberg, 2014). Strohl et al.'s (2014) case study research also supports these findings noting that teachers experienced higher morale, lighter workload, and increased overall job satisfaction.

The most significant benefit of a mathematics specialist teacher education model is seen in terms of student achievement. Though the research on the mathematics specialist teacher model specifically is limited, the limited research including past literature reviews have shown that such an approach can benefit student test scores (Markworth, 2017; McGatha, 2009; McGatha et al., 2017). Additionally, a multi-year study across five school districts on the use of a school-based mathematics specialist has shown that student test scores can increase over the course of a prolonged specialist intervention (Campbell & Malkus, 2013). This is supported by other research that shows a positive correlation between the improvement in student performance and the introduction of subject specialization in elementary schools (Hood, 2009). Even research, which shows minimal results on student achievement in the context of state level standardized tests in primary grades still finds that by the time students enter upper secondary, there is a preference among students for the departmentalized model requiring specialized teachers (Kent, 2010).

Drawbacks & Critiques of Teacher Specialization

A teacher specialization model is not without its challenges, however, often focused on student learning and logistical constraints. Such a model runs the risk of creating the view that mathematics is a unique separate subject, thereby increasing mathematical anxiety surrounding the subject by further segregating it from other subjects. Longitudinal and large multi-site studies have noted constraints related to the teacher specialization models include limitations on flexibility and the difficulties in

collaborating with other teachers around content and student learning (Freiberg, 2014; Markworth et al., 2016). The loss of such pillars of primary education, which are increasingly focused on cross-curricular and integrated learning could serve as a major hindrance if mathematics is removed from the purview of the homeroom teacher. Other research has noted that, regardless of the model used, be it the traditional or specialist model the teacher was the most impactful factor on student achievement, suggesting that a specialist model does not necessarily impact student learning so much as having good quality teachers (Lee et al., 2016). In another study of the implementation of the mathematics specialist model in one school district, researchers found that teachers who were working as mathematics specialists noted that their relationship with students was not as deep as if they were teaching one class all day (Lee et al., 2016). These more recent findings corroborate research from Chang et al. (2008) who found in their American based study of one school district that such a model can also limit the creation of routines for students, which are particularly important for younger students. These findings have important implications for the success of students given the role of relationships with teachers and the necessity of routines in student learning and should be considered in any implementation of the specialist model.

Aside from challenges related to student learning, logistical challenges are also present in the implementation of such a model. Most obviously, for this model to work, there needs to be enough mathematics teachers to be hired (Reys & Fennell, 2003). Past survey data from a study conducted in one American school board also notes difficulties for principals in scheduling teaching blocks and planning time given the role of rotary teachers, the time allocated to mathematics and the need for homeroom teachers to receive adequate prep time (Gerretson et al., 2008).

Summary & Next Steps

With the above literature review in mind, our study recognizes that even a model with as much potential as the teacher specialist model comes with substantial challenges for implementation. While such a model provides benefits for logistics such as planning time, as well as benefits surrounding teacher comfort and overall student achievement, the potential pitfalls must be considered in any implementation of such a model. Challenges surrounding the quality of relationships between teachers and students and lack of collaboration on mathematics could pose issues for the success of such a model, and the logistical headaches of scheduling and teacher availability may render certain regions unable to implement these changes. Importantly then, for the purpose of our paper, we seek to explore teachers and administrators' perceptions of mathematics teaching and a teacher specialist model. While surveys have been conducted on this area in the past (Gerretson et al., 2008) this research explores perceptions in a region, which does not currently use the mathematics specialist model. Our preliminary research aims to provide an international comparative perspective to provide a jumping off point for researchers and other policy makers around discussions of implementation of a specialist model. We aim to include discussion of both the strengths and drawbacks of a mathematics specialist model, and note that, while our aim is not to argue in favor of this model, much of the responses show that, at least in this school board studied, there would be support for such a model.

METHODOLOGY

Jurisdictional Context

Our study takes place in the context of Ontario, where EQAO scores in mathematics had been declining, with fewer students meeting provincial expectations across the province, as well as in the school district in which our study takes place. Currently, in many school districts across the province of Ontario, including the one in which this study takes place, elementary classroom teachers in kindergarten to grade 8 are responsible for the delivery of the curriculum in all subjects except for French. In Ontario, there are a variety of mathematics teacher specialization designations differentiated by grade level. Approximately 10.0% of teachers in the province in 2019 have this qualification (Ontario College of Teachers, 2019a, 2019b). It is important to note that, though some teachers may have mathematics teacher specialization qualifications, it is not a requirement in all school boards to have this to teach mathematics at the elementary grades.

Across the province of Ontario there have been numerous attempts to increase the mathematical background of teachers and increase the number of mathematics teacher specialists. The Ontario Government has allocated funds for elementary teachers to take additional mathematics courses and to hire mathematics specialist support teachers at each school, though with low numbers of mathematics teacher specialists available, this has not been realized (CBC News, 2014). All these efforts point to the government's acknowledgement that having adequately trained mathematics teachers is important and that a shortage of qualified teachers could lead to further declining student performance.

Participants

This research took place in one school district, located in a city in Ontario, Canada of approximately 300,000 people. All procedures performed in studies involving human participants were in accordance with national research ethics standards in Canada. The school district approved the administration of this survey by the first author (an employee of the school board). The survey was administered in January 2020, and was open for a total of two weeks. Our decision to administer the survey in only one district was based on access to the school board, where the first author was able to have the survey administered through existing connections. Due to access constraints in other school boards and individual research requirements, additional sampling was not possible. While experiments of convenience samples using surveys have found that such samples produce results comparable to representative population-based samples (see for example Mullinix et al., 2015), we note that our findings are limited by their relatively small size and are not able to be widely abstracted. As a result of the limited sample size, this convenience sample does

Table 1. Teacher demographics (n=87)

Variables	Values		
Age (no respondents under 30)	30-39	40-49	50-59
	16.1%	62.1%	21.8%
Years of experience	Less than 16	16-20	21+
	26.0%	50.0%	24.0%
Highest education achieved	Bachelor's		Master's
	88.4%		10.5%
University major field	Mathematics	Science & technology	Other (arts, social sciences, & business)
	5.7%	26.3%	68.0%
Current teaching assignment	Primary (grades K-grade 3)	Junior (grade 4-grade 6)	Intermediate (grade 7-grade 8
	20.6%	29.9%	26.4%
Mathematics qualifications	Mathematics major	Mathematics teacher specialization	Additional qualifications mathematics
	5.7%	11.5%	13.8%

Table 2. Administrator demographics (n=17)

Variables	Values		
Age (no respondents under 30)	30-39	40-49	50-59
	17.6%	29.4%	52.9%
Years of experience	1-5	6-10	10+
	29.4%	41.2%	29.4%
Highest education achieved	Bachelor's		Master's
	58.8%		41.2%
University major field	Mathematics	Science & technology	Other (arts, social sciences, & business)
	5.9%	35.3%	58.8%
Role currently held	Principal		Vice-principal
	56.3%		43.8%
Mathematics qualifications	Mathematics major	Mathematics teacher specialization	Additional qualifications mathematics
	0.0%	5.9%	5.9%

limit the broader applicability and generalizability of our findings. The data collected from participants, however, does provide important preliminary context and information for mathematics specialist teachers to prompt further discussion.

The first author and lead researcher in this study is an administrator in this school district. All elementary teachers and administrators in this school district were invited to participate in this study. The historical response rate for surveys conducted in this school district for both teachers and administrators were approximately 5.0-10.0%. The potential sample pool of teachers was 767. The teacher response rate for this study was 11.3% (n=87). Teacher demographics are shown in **Table 1**.

Teachers' self-reported content knowledge of mathematics curriculum is shown in **Figures 1** to **4**.

The potential sample pool of administrators was 56. The response rate for administrators was 30.3% (n=17). Administrator demographics are shown in **Table 2**.

Given this relatively small sample size, our study reports on the findings of our preliminary research, acknowledging the limitations this may be present for this data to be extrapolated broadly. Therefore, while we do not claim our sample size to be representative of the entire district or the entire province, we do present here the data from the survey as a way to provide valuable context to broader conversations around mathematics specialist teachers in the province of Ontario. We note this as a limitation at the end of our research and as an area for expansion of research in this field.

Data Collection

Two online surveys were distributed: one for teachers and one for administrators. Response to the survey was optional for all employees and were anonymous. The surveys were developed by the first author and were composed of both open-ended and closed-ended questions. The survey was founded on the principles of mathematics teacher specialization in practice by the first author, a school board administrator. Questions were developed in line with calls for research from professional bodies to explore mathematics teacher specialization (see for example NCTM, 2006) and focused on the context of mathematics content knowledge of teachers in the province of Ontario in response to calls for a renewed focus on mathematics (Ontario Ministry of Education, 2016). As a result of limited time and resources, the survey was not piloted. Questions were reviewed in light of a literature review conducted by the third author on mathematics teacher specialists to compare survey questions with key themes in the research. No questions were added after review. The survey questions are attached as an appendix. As is seen in the appendix, we defined a mathematics teacher specialist as, "a teacher that has special qualification in mathematics and is knowledgeable in both curriculum content and effective pedagogical practices". While we defined the specialist teacher as having qualifications, we did not specify the model this teacher would follow in their teaching so as not to sway participant opinions.

Surveys are widely recognized as an effective tool to gain responses from a large population in a short amount of time (August & Tuten, 2008; Minnaar & Heystek, 2013). Additionally, the use of surveys in our study of mathematics specialists is consistent with other studies of content specialists (Campbell & Malkus, 2010). Due to the logistical issues with conducting interviews with educators during school hours, for this introductory study, a survey the most efficient data collection instrument. Though this method may not have provided as deep an understanding of teacher and administrator perceptions as interviews, it allowed for a

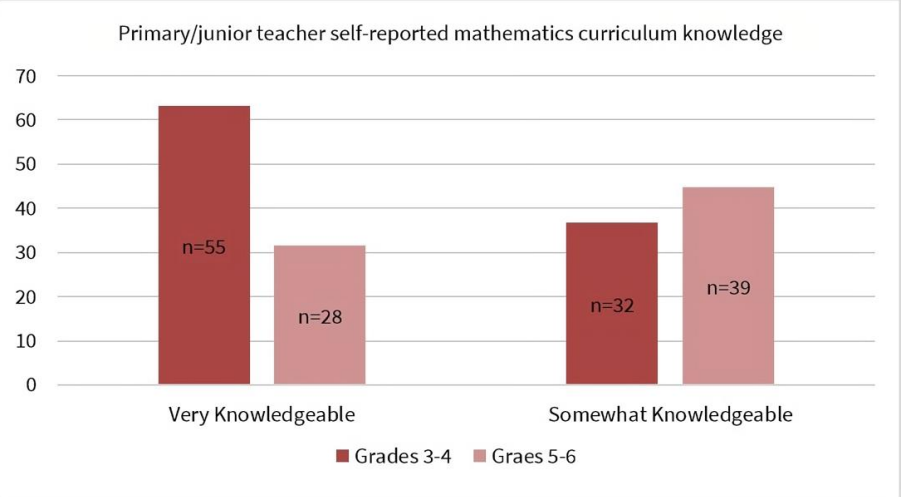

Figure 1. Teacher's self-reported content of mathematics curriculum (Source: Authors' own elaboration)

greater number of teachers to be included. Further limitations are discussed in the conclusion. All data was coded by the first author. The third author reviewed the codes for accuracy.

Data Analysis

The surveys were targeted at understanding teachers' and administrators' perceptions of the mathematics content knowledge required for educators to be successful mathematics teachers as well as the potential benefits and drawbacks that would come with a mathematics specialist teacher model. Once the data was collected, it was analyzed and the patterns and trends in both qualitative and quantitative responses were interpreted, with quantitative analysis consisting of descriptive statistics. For closed ended questions, descriptive statistics were used to examine participant responses. These tools were used particularly for questions, which included a range of options, including rating teacher comfort with mathematics content at a specific grade, where ordinal data (very knowledgeable, somewhat knowledgeable, etc.) was cross tabulated by demographic data to be compared across groups. Binary data (yes/no questions) were cross tabulated and reported as percentages. Specifically, data summaries from the survey software were downloaded and sorted by their answers.

For open-ended questions, a content analysis approach was used to develop codes, which we report as major themes in the data. This research takes an emergent coding approach, layering on a thematic analysis, whereby codes are drawn out of the text based on frequent references to understand key themes on the minds of respondents (Braun & Clarke, 2006; Stemler, 2001). Specifically, we looked for responses, which were common across respondents to reveal themes that were routinely of interest to highlight commonalities. When similarities were noticed across multiple responses, a code was created, and any related responses were then assigned accordingly. Responses could be assigned to various groups or 'codes' depending on the content and complexity of their response. Codes included such themes as professional development, understanding students' needs and time constraints. While we report them as frequencies similar to the closed-ended responses, these responses provide unique insights as teachers and administrators were free to respond however they like to the questions, meaning that similarities in their responses provide natural insight into the thinking and concerns of teachers and administrators to bolster the pre-made responses. These responses also provided rich illustrative examples in the form of quotes, which we correlated with the various codes to demonstrate the way various codes were understood by respondents and the research team. The results reported below are based on both teacher and administrator responses to the survey questions. Additionally, results were compared, and similarities and differences are reported below in the administrator response section.

RESULTS

For readability purposes, the results are reported here organized by themes according to teacher and administrator responses under the headings of mathematics content knowledge, special qualifications to teach mathematics, what challenges are mathematics teachers facing?, teachers specialization model in mathematics for elementary school, the teachers specialization model: What grades?, and advantages and disadvantages of the teacher specialization model. Discussion follows the presentation of the results.

Teachers' Content Knowledge

We first began by asking teachers to report their own level of knowledge with various levels of mathematics curriculum that they would be required to teach. **Figure 1** and **Figure 2** represent all teachers comfort level with grade 3-grade 6 curriculums.

Figure 3 and **Figure 4** only asked teachers about mathematics in grade 3-grade 8 due to the increasing nature of difficulty of content and pedagogy beyond grade 2. Although this group of teachers do not currently have Intermediate qualifications, it is important to note that obtaining this qualification as an additional qualification course would permit them to teach grade 7 and grade 8, including mathematics without having a mathematics teaching specialization.

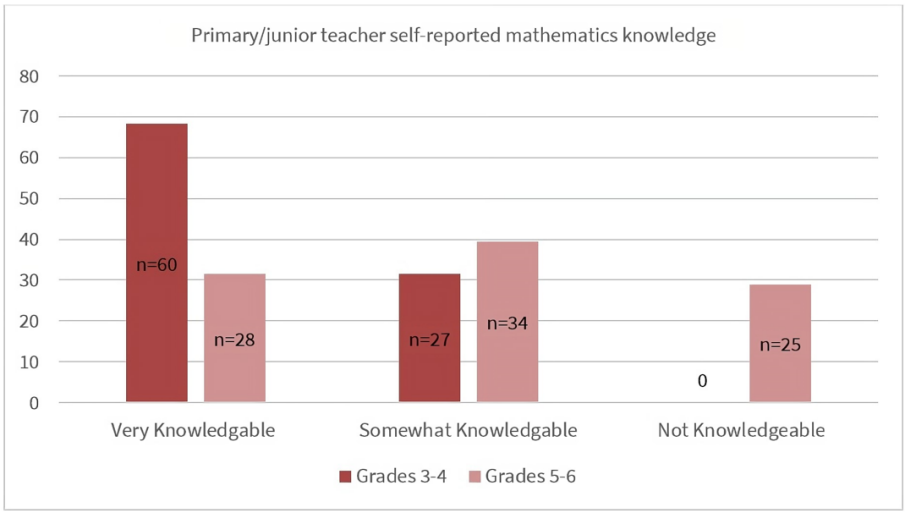

Figure 2. Primary/junior teacher self-reported mathematics knowledge (Source: Authors' own elaboration)

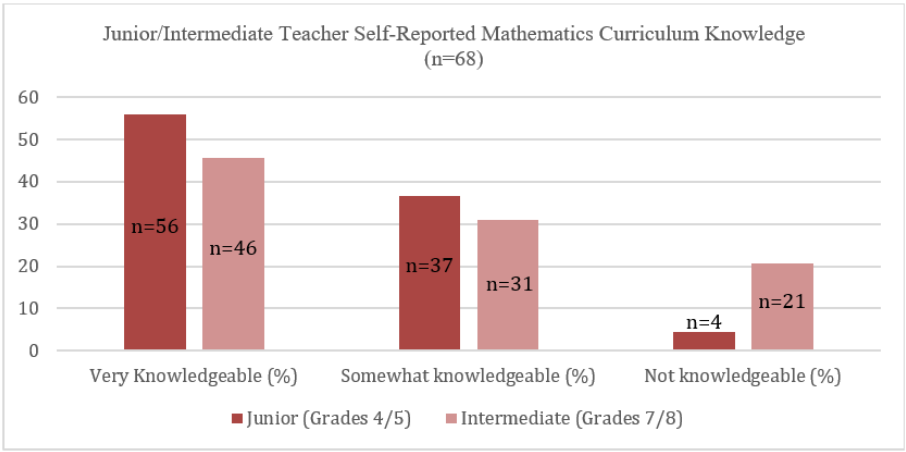

Figure 3. Junior teacher self-reported mathematics knowledge (Source: Authors' own elaboration)

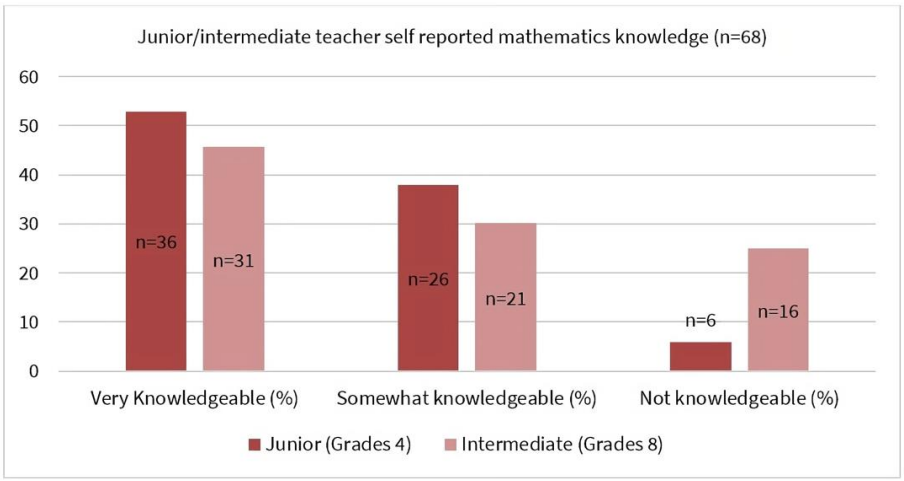

Figure 4. Junior teacher self-reported mathematics knowledge (Source: Authors' own elaboration)

When administrators were asked to rate the mathematics content knowledge of teachers in the school, 49.0% (n=8) thought their teachers were somewhat knowledgeable and 41.2% (n=7) thought they were very knowledgeable. When asked about their teachers' pedagogical knowledge, 58.8% (n=10) thought their teachers were somewhat knowledgeable and 41.2% (n=7) thought they were very knowledgeable.

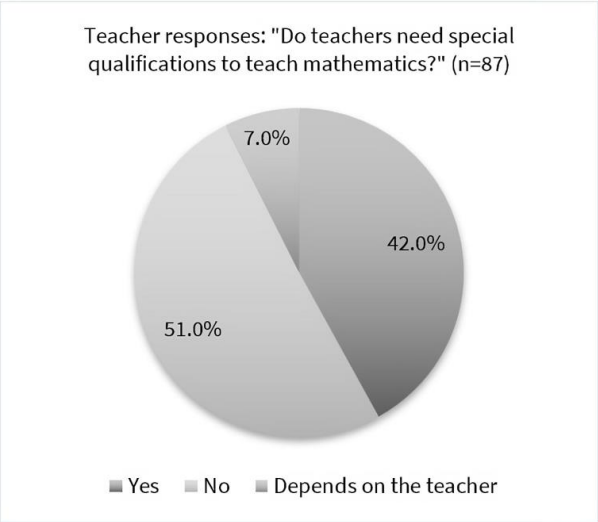

Figure 5. Teacher response to special mathematics qualifications (Source: Authors' own elaboration)

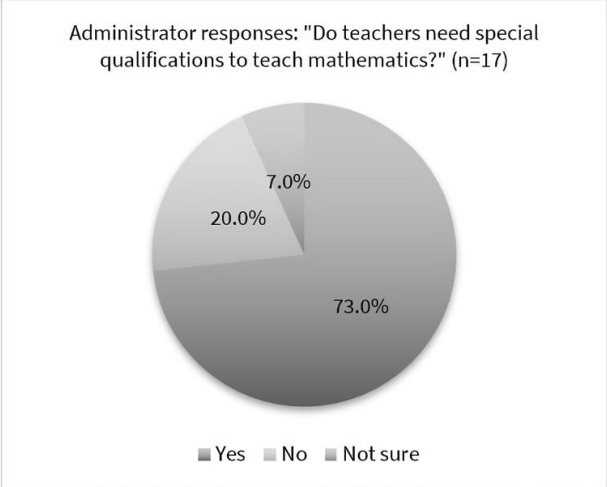

Figure 6. Administrator responses to specialist mathematics qualifications (Source: Authors' own elaboration)

Special Qualifications to Teach Mathematics

When asked whether teachers should have special qualifications such as additional mathematics courses or certifications in order to teach mathematics, teacher participants were split in their responses (**Figure 5** and **Figure 6**).

Some of the reasons that teachers gave included "teachers who are not comfortable with the curriculum tend to play it safe and rely on the textbook" (primary teacher, January 2020) and "despite PD, teachers will only teach what they are comfortable with and the way they understand it" (junior teacher, January 2020).

When asked if teachers needed specialist qualifications, some of the reasons that administrators gave included, "not all teachers have the ability to teach mathematics" (administrator, January 2020), and "teaching mathematics requires extensive knowledge" (administrator, January 2020). One administrator that felt special qualifications are not needed claimed that "taking an additional qualification course could be helpful but not as necessary" (administrator, January 2020).

What Challenges are Mathematics Teachers Facing?

Teachers were asked what challenges those teaching mathematics are facing. The greatest number of participants (n=23, 26.4%) felt that the lack of time was a major challenge. Teachers noted that there is "not enough curriculum time during the instructional day" (intermediate teacher, January 2020), and "a great deal of time is needed to properly plan lessons and activities" (junior teacher, January 2020). The second most common response, which 24.1% (n=21) of teachers noted was the lack of knowledge of effective pedagogy. Some examples of teacher responses included "balancing fact learning with open-ended math communication and application," (prep teacher, January 2020) and "many colleagues have admitted to having math phobia and worry about stepping outside their comfort zone" (special education teacher, January 2020).

Another common response referenced was meeting the varied needs of students, which was raised by 21.8% (n=19) of teachers. One participant explained the difficulty in teachers meeting "the multitude of academic challenges that their students have in their classroom" (intermediate teacher, January 2020). Linked to this is the lack of professional development, resources, noted by 21.8% (n=19) of teachers, with one saying that teachers are facing a "lack of resources and support for multi-level learners

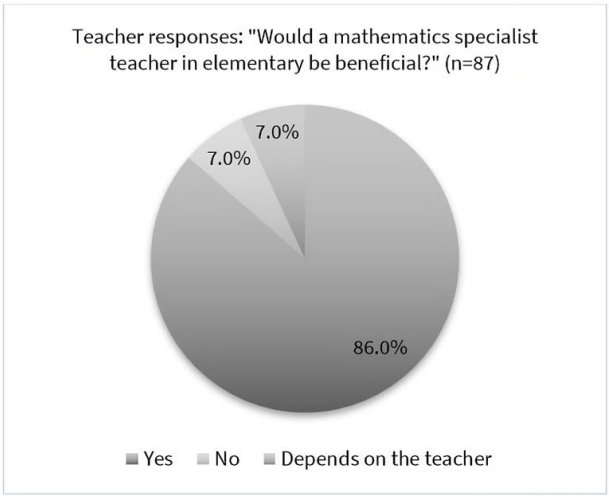

Figure 7. Teacher response to specialist mathematics teachers (Source: Authors' own elaboration)

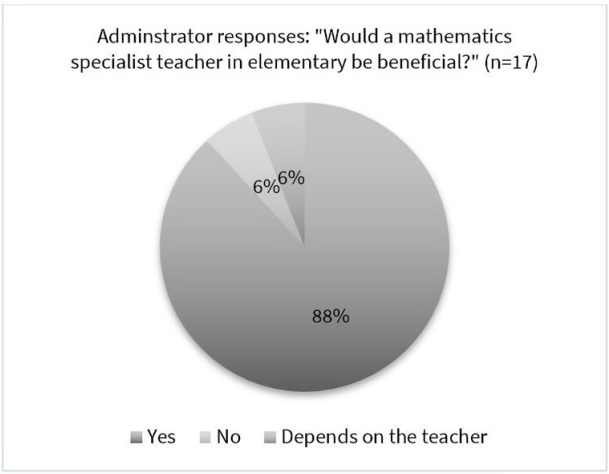

Figure 8. Administrator response to specialist mathematics teachers (Source: Authors' own elaboration)

in their classrooms" (special education teacher, January 2020). In addition to the challenges listed above, the lack of teacher content knowledge was noted by 9.2% (n=8) of teachers, with one noting that "some teachers struggle in math concepts themselves, making it difficult to teach" (special education teacher, January 2020). Other responses shared amongst teachers included the lack of home-school connection (6.9%, n=6), students' lack of basics in mathematics (6.9%, n=6), the lack of teacher confidence (5.7%, n=5), and the lack of student confidence (2.3%, n=2).

Administrator participants were asked what challenges teachers are currently facing and the majority (52.9%, n=9) cited the lack of knowledge of effective pedagogical practices. One administrator said that teachers "Are using the way they were taught math … they need to change their way of thinking and teaching" (administrator, January 2020). The second most common response to this question was the lack of teacher content knowledge with 35.3% (n=6) of administrators stating that this was a challenge. One administrator explained that teachers, "do not have the required content knowledge to teach mathematics and this causes them to lack confidence and it affects their teaching" (administrator, January 2020). This was linked to the lack of teacher confidence, which 23.5% (n=4) of administrators identified as a challenge. In addition to the challenges listed above, 11.8% (n=2) of administrators felt the lack of time and time management is a challenge, which mathematics teachers are facing.

Teachers Specialization Model in Mathematics for Elementary School

In an effort to address some of the challenges listed above, participants were asked if they thought mathematics teacher specialists would be beneficial in elementary schools, and the majority of teachers (86.4%, n=75), as well as the majority of administrators (94.1%, n=16) felt that they would be. Many of the reasons participants gave were that mathematics teacher specialists would have more passion and knowledge for the subject and would be able to better support students (**Figure 7** and **Figure 8**).

The majority (86.4%, n=75) of teachers indicated that a teacher specialization model in elementary would be beneficial. Some examples of the responses included "focusing on one topic is beneficial for students and other teachers" (intermediate teacher, January 2020), "this would ensure consistency and allow the transfer and development of knowledge from one year to the next" (Junior Teacher, January 2020), and "we should have teachers focus on subjects that they thrive in" (primary teacher, January, 2020). Of the 9.9% (n=9) of teacher respondents that were neutral as to whether they supported this model, the majority felt they would require more information about this model and the success of this model would be highly dependent on who the specialist

teacher is and what grades they are teaching. Of the 3.7% (n=3) that said no to the teacher specialization model, one teacher explained by stating “although I do not have an [Ontario specialization] in mathemtics [SIC], I love teaching it” (prep teacher, January 2020). Another participant echoed this statement saying that one AQ course is not enough and that teachers need to have “experience in teaching math” and “the confidence to teach it.”

However, most participants felt that the teacher specialization model would indeed be beneficial. Many respondents felt that the advantages to utilizing a teacher specialization model in elementary school were that the model allows teachers to focus on one subject, which will improve their practice. This is consistent with Freiberg’s (2014) view that the teacher specialization model allows teachers to be more knowledgeable and more effective in their practice.

The respondents who were uncertain as to whether they agreed with this specialist model highlighted that the success of this model would be highly dependent on who the specialist teacher is and what grades they are teaching. When looking at the potential challenges of utilizing the teacher specialization model in elementary schools, many participants stated concerns about scheduling or that this model could negatively impact the teacher’s ability to know their students and so it is important to use this model for appropriate ages (e.g., grade 7 and grade 8). Our research adds though, that many of the teachers who noted such concerns still felt as though the potential positives outweighed the negatives in a specialist model.

When administrators were asked if a teacher specialization model in mathematics would be beneficial to elementary schools, 88.2%, (n=15) said yes, 5.9% (n=1) said no and 5.9% (n=1) said it depends as there are pros and cons to both. An example of the responses received from the administrators that said yes is “many teachers are not comfortable with all math concepts … a specialized teacher would have the knowledge and confidence to really get students excited about math” (administrator, January 2020).

Teachers Specialization Model: What Grades?

The majority of teachers felt a teacher specialization model would be successful (72.3%, n=63), with their thoughts for the best grades to implement the teacher specialist being: grade 7-grade 8 (20.3%, n=13), grades 6-grade 8 (19.0%, n=12), grade 1-grade 8 (16.5%, n=10), or grade 4-grade 8 (16.5%, n=10). A teacher who thought this model would benefit all grades explained: “Building mathematical learners early will reap the benefits throughout elementary” (primary teacher, January 2020) and starting in the younger grades is important in order to “build a solid foundation” (primary teacher, January 2020). The teachers that believed this model should start with the older students (e.g., grade 7 and grade 8) said, “the greatest benefit would be at the older levels, where some teachers become less comfortable as the curriculum becomes increasingly difficult” (junior teacher, January 2020), and that starting with the older students would “get them ready for high school” (junior teacher, January 2020).

The majority of administrators felt as though a teacher specialization model would be beneficial in at least some grades with 41.2% (n=7) saying it would be effective for students in grades 4-8 and 17.6% (n=3) saying it would be effective for students in grade 1-grade 8. An example of a response for utilizing this model with all grades is that “primary learning is based on certain fundamentals, which need to be taught in a specific way” (administrator, January 2020). One administrator pointed out that utilizing this model in the older grades is best as students are “old enough to handle the amount of shifting between teachers.”

Advantages & Disadvantages of Teacher Specialization Model

Many teachers listed several advantages for the teacher specialization model. Some examples of responses included “more planning time when you only have to focus on certain areas” (intermediate teacher, January 2020), and “allowing teachers to focus on one subject provides for a greater level of expertise and deeper understanding” (junior teacher, January 2020). Teachers also said that this model would expect to see them to be more knowledgeable with expertise in the area (n=19), confident and passionate (n=9), and comfortable with the subject matter (n=8), which will allow them to become experts in one subject area.

In addition, teachers mentioned that this model would be beneficial for those that are not confident with mathematics instruction as they would not have to teach it. One teacher explained, “I would be able to focus on the subjects I am more confident in, the students would be getting the proper math instruction from teachers who are good at teaching math” (intermediate teacher, January 2020). In terms of student benefits, teachers noted that the improved instruction would allow students to gain a strong understanding of mathematical concepts, which would increase student achievement and EQAO scores (n=19). Respondents stated other benefits to be “teachers would be familiar with the curriculum through all grades and would be able to move back and forward as students need it” (primary teacher, January 2020), and “more learning opportunities and differentiate instruction because teachers would be more familiar with the topics” (intermediate teacher, January 2020). Two teachers also pointed out that this model would prepare students for this type of departmentalized format in high school and allow for consistency throughout the school and school board.

Some disadvantages listed by teachers included not having enough specialists that are knowledgeable in both curriculum and pedagogical practices with one teacher saying, “a school would really need to monitor who is teaching and how they teach mathematics–are they using current pedagogical approaches” (junior teacher, January 2020). With that being said, some teachers were concerned that an effective mathematics teacher would not be allowed to teach mathematics because he/she does not have the right credentials: “Some teachers may enjoy teaching their own math and want to continue or learn strategies to become better” (junior teacher, January 2020). Many teachers pointed out disadvantages related to scheduling conflicts (n=18), needing to use this model for other subjects (n=5) and the loss of cross-curricular teaching moments (n=8).

In terms of disadvantages for students, some teachers pointed out that through this model it would take longer for specialty teachers to get to know their students as they are only together for a short block, which might result in difficulties accommodating (n=8). Teachers also indicated that this model may be difficult for students that struggle with transitions, and that it may lead to a lack of support for students on individual education plans (n=2).

Some of the disadvantages listed by administrators were related to scheduling conflicts (n=6) and unequal balance of workload for teachers (n=2). Administrators also pointed out the dilemma of who would choose the mathematics specialty teachers and the concern of not having enough qualified specialists (n=2). Some other disadvantages noted by individual participants included the loss of cross-curricular tasks, lack of knowledge development among all teachers at all levels, and teachers not knowing their students well enough. Despite these issues raised, there was still consensus among administrators that a mathematics specialty model has great potential for both teacher success and student learning. These issues raised by administrators however provide cautionary discussion for the potential implementation of such a model.

Elementary school teachers and administrators in this study emphasized some of the benefits of the teacher specialization model in mathematics to be improved teaching practices, increase in teacher knowledge and confidence, increase in planning time, consistency in mathematics instruction, and a potential increase in student achievement.

DISCUSSION

We now move to discuss the results elaborating on key findings and connecting the work to past literature in regions, which have implemented a mathematics specialist model to show how our findings corroborate and expand on this research in a region exploring option for mathematics education.

Mathematics Content Knowledge

The results above shoed that, overall, the percentage of teachers that felt they were very knowledgeable of curriculum content and pedagogical practices decreased as the grade level increased; and the percentage of teachers that felt they were not knowledgeable increased along with the grade level increase. Although the majority of Junior/Intermediate (grade 4-grade 8) qualified teachers either felt they were very knowledgeable or somewhat knowledgeable, the percentages declined as the grade level increased. This was also the trend for primary/junior (grade K-grade 6) qualified teachers. Although the majority of the primary/junior qualified teachers felt either very knowledgeable or somewhat knowledgeable for grade 3-grade 5 mathematics content and pedagogy, when it came to the grade 6 level, approximately one third of these teachers felt they were not knowledgeable. While a smaller sample size, the fact that principals noted that only about half of teachers who were in charge of teaching mathematics were very knowledgeable, which shows a gap in education, which could harm student learning in mathematics (Wright, 2017). This limited sense of knowledge of mathematics echoes the findings of Freiberg's (2014) study in which teachers felt less knowledgeable when teaching mathematics when they were responsible for the instruction of every subject. It is also consistent with the fact that a small minority of teachers focused their university studies on mathematics and had limited training or additional qualification in mathematics and therefore they may be predisposed to a level of discomfort with the subject matter.

This is significant in that, in Ontario, teachers do not require mathematics qualifications to teach mathematics and as such any teacher could teach mathematics from Grades K-8. The concern is that teachers could have a grade level assignment in which they have no experience or knowledge of the mathematics curriculum for that grade. This is consistent with other research, which argues it is unrealistic to expect teachers to have detailed knowledge of mathematics and all the other subject areas at the elementary level (Reys & Fennell, 2003).

Special Qualifications to Teach Mathematics

Of teacher respondents, 20.7% (n=18) had either mathematics as a teaching specialization or had taken additional courses in mathematics education content and pedagogy. Of those 18 participants, their response to whether special qualifications in mathematics were needed were split with 10 of them feeling that they are needed and eight feeling they are not. Their ratings of their own curriculum knowledge level were also split with eight of them feeling they were very knowledgeable in the curriculum content level of most grades and 10 of them feeling they were either somewhat knowledgeable or not knowledgeable when it came to the curriculum content of grade 7 and grade 8.

Interestingly just over half of the teachers felt that they do not need special qualifications to teach mathematics. These teachers explained that "continued PD sessions in mathematics" (special education teacher, January 2020) and "having pedagogical expertise" (junior teacher, January 2020) are more important than having qualifications. Teachers also stated that having confidence and willingness to implement best practices are more important than qualifications. These perceptions support the research on PCK in how teachers recognize that implementing appropriate tools is more important than simply having a high level of mathematical understanding (Harlen, 2013; Strand & Mills, 2014). Importantly as teachers highlighted pedagogical expertise and continuous PD to support teacher comfort and student learning, such a route can be overlooked by school boards due to its time consuming and costly nature (Sani & Burghes, 2022). These findings also point to the fact that teachers may reject additional certification required to teach mathematics if implemented.

Administrators tended to disagree with this perspective, with the minority thinking that teachers do not need specialist qualifications to teach mathematics. When looking at the administrators' perceptions of the content knowledge of teachers in their schools, even though for the most part, administrators felt that teachers were either very knowledgeable or somewhat knowledgeable, the majority of administrator participants felt that teachers still needed special qualifications to teach mathematics. One of the main reasons that administrators gave for needing special qualifications was that it would help teachers feel more confident and knowledgeable in teaching mathematics. These findings reflect those of Pollock and Mindzak (2015), who explained in their research in regions using specialist teachers that specialist teachers are better equipped to understand and

deliver the curriculum. Our research goes further however to illustrate that the confidence a specialist teacher may gain would be a standout benefit for student learning.

Administrators who thought such qualifications were unnecessary posited similar reasons to teachers, noting that a teacher's confidence, passion, and willingness to participate in ongoing professional development are more important than qualifications. This finding is important to highlight given that teacher and administrator perceptions of teachers' content knowledge were relatively similar, their understanding of the implications of this on the ability to be a successful teacher were different. This might be a result of different experiences with teaching mathematics as an individual compared with overseeing the mathematical teaching of a whole school.

What Challenges are Mathematics Teachers Facing?

Both teachers and administrators agreed that the lack of knowledge of not just the pedagogical approaches, but also the lack of mathematics content knowledge was a major barrier. This is connected to the lack of SCK that faces non-specialist mathematics teachers (Ball et al., 2008). Others major barriers included the lack of time, meeting the varied needs of students, and the lack of professional development and resources. This is consistent with Gerretson et al.'s (2008) and Markworth et al.'s (2016) findings in various school districts currently using the specialist model, which identified time as a major factor for teachers preferring the teacher specialization model since this model allows for more planning time and more time for professional development. The challenges that teachers face here hint at very least to a need to redesign the way teachers are prepared to teach mathematics. Whether this involves going to a specialist model, or providing, as some teachers and administrators above noted, more PD to allow teachers to prepare for and develop their mathematics content and pedagogical skills to provide better mathematics instruction.

Teachers Specialization Model for Elementary School

Interestingly, the vast majority of both teachers and administrators thought that a mathematics specialist teacher would be beneficial in elementary schools. Participants highlighted that mathematics teacher specialists would have more passion and knowledge for the subject and would be able to better support students. This is supported by Reys and Fennell (2003), who explained the importance of students receiving instruction from teachers who understand the content and are able to utilize effective pedagogical practices to help students learn. This is also supported by Pollock and Mindzak (2015) who explained that mathematics teacher specialists inside of elementary schools are likely to positively impact student development and achievement. Our research also adds to past research in that teachers pointed to the passion a specialist might bring as having the potential to benefit students, as this moves beyond simple knowledge acquisition and into inspiring more engaged mathematics learners likely through different instructional techniques. Of the administrators that responded 'no' (n=3) to needing mathematics teacher specialists in schools, some noted that you do not need to have mathematics qualifications to be a good mathematics teacher.

The respondents who were uncertain as to whether they agreed with this specialist model highlighted that the success of this model would be highly dependent on who the specialist teacher is and what grades they are teaching. When looking at the potential challenges of utilizing the teacher specialization model in elementary schools, many participants stated concerns about scheduling, which is consistent with the research of Gerretson et al. (2008). Some participants also brought up the same concerns as teachers in Freiberg's (2014) study of a district using the specialist model, that this model could negatively impact the teacher's ability to know their students and so it is important to use this model for appropriate (e.g., grade 7 and grade 8). This is consistent with findings of Chang et al.'s (2008) that with the specialist model there is a potential for teachers to lose a sense of responsibility for their students' success. Importantly then, regions looking to implement a mathematics specialist teacher model ought not to view it as a simple solution. Instead, like any other aspect of teaching, the selection of the appropriate teacher and preparing the teacher well will be crucial. It will not be enough to just offload mathematics teaching to one teacher, but instead that teacher will need additional training to know how to engage with students in shorter periods of time, and support transition periods for students who may be struggling. Our research adds though, that many of the teachers who noted such concerns still felt as though the potential positives outweighed the negatives in a specialist model.

Teachers Specialization Model: What Grades?

Although it was difficult to find a trend in the teacher and administrator responses to what grades would benefit most from a teacher specialization model in mathematics, the majority of participants felt that this model would work best for either, all grades (K-8) or at least the Intermediate grades (grade 7 and grade 8) in specific. Many participants felt that starting right in Grade 1 would be beneficial so that students can build a solid mathematical foundation, and noted that the routine might be better instilled in students at this young age. In contrast, others felt the greater benefit would be to utilize this model for the older grades, where some teachers become less comfortable as the curriculum becomes increasingly difficult. This might allow for greater learning gains for students in higher grades, while limiting some of the adverse impacts of such a model for students who struggle with transitions in younger grades. Especially as districts in Ontario and internationally focus in on not just student mathematical learning, but also focus on improving math scores given that achievement is one of the greatest benefits of a mathematics specialist teacher (Markworth, 2017; McGatha, 2009; McGatha et al., 2017). Again, importantly, considerations around student transitions and routines (Change et al., 2008) as well as teacher student connections (Lee et al., 2016) are all important when thinking about the grade that such a method might be incorporated in and how different aged students may be impacted.

Advantages & Disadvantages of Teacher Specialization Model

Consistently, the greatest advantages that teachers noted to the mathematics specialist model was around greater content and pedagogical knowledge of teachers, with greater impacts on students. In being able to hand off a challenging subject to teachers who are experts in the content and its instruction, teachers are noting that their own limited mathematics SCK does not necessarily have to harm students' learning. Especially in the higher grades as teacher confidence declines, limited teacher confidence would then not hinder student learning. This is consistent with other research showing that low teacher confidence in mathematics can negatively impact student success (Wright, 2017). In addition to improvements in teacher knowledge and confidence with mathematics, other benefits of such a model included, increases in planning time, consistency in mathematics instruction, and a potential increase in student achievement. These views are consistent with those identified in the reviewed literature around current practice of the mathematics specialist model and corroborate past findings with the understanding of the role of specialist teachers by those currently working in education (Freiberg, 2014; Gerretson et al., 2008; Markworth et al., 2016; Reys & Fennell, 2003; Strohl et al., 2014).

In terms of disadvantages, teachers noted challenges in terms of relationships related to planning and transitions for students. Though there certainly is merit to these claims from past research on implementation of the specialist mode (Chang et al., 2008), others have found that the option of having multiple teachers supporting one student may serve as a counterbalance to these challenges (Markworth et al., 2016). The implementation of a specialist teacher model then might propose additional issues for the most vulnerable students, and while there may be improvements in mathematical understanding for students more generally, there must be special attention given to how students who need different supports might be accommodated under such a system.

While administrators in their responses were still concerned about the impact on students, their perspective on the actual implementation of the mathematics specialist teachers provided additional insights into the challenges to be considered, namely scheduling and challenges around selecting appropriate teachers for the role. Issues around scheduling have been noted by past research (Gerretson et al., 2008), however administrators added to these concerns noting that the issues in scheduling might also result in an uneven workload balance. Such issues might pose problems in terms of teacher and administrator reception to the mathematics specialist model, thereby posing problems even getting this off the ground. The other major challenge for administrators was around having enough teachers to successfully implement this model a finding, which reflects statements from past work (Reys & Fennell, 2003) but is also complicated by the overall low percentage of teachers with mathematics training and qualification in Ontario overall, and the relatively low percentage of teacher respondents in this board, which had a high level of comfort with mathematics. As such, any region considering a mathematics specialist model would require a greater overall investment in mathematics education to ensure there are an adequate number of teachers who are able to take on such a role.

The challenges that researchers as well as participants from this study listed for utilizing the teacher specialization model include scheduling conflicts, not having enough qualified specialists, and teachers not knowing their students well enough. Although these disadvantages will require thought and discussion, it is clear by the overwhelming majority of teachers and administrators that have answered yes to the teacher specialization model for a variety of grade 1-grade 8 that the benefits outweigh the challenges.

CONCLUSIONS, LIMITATIONS, & RECOMMENDATIONS

The current model used in Ontario is one in which classroom teachers from grade K to grade 8 are responsible for the delivery of the curriculum in all subjects except for French. Calls in the province of Ontario as a result of declining EQAO scores have prompted focus on how the current mathematics education model may be restructured. Our study provides insights into the perspectives of one school board on perspectives of mathematics specialist teachers with relatively favorable results. This research addresses numerous calls to conduct research on the use of full-time mathematics teachers in elementary schools (Mackworth, 2017; NCTM, 2006) and provides preliminary findings that teachers and administrators see value in having specialist teachers teach mathematics. They note both benefits and challenges, which must be considered if any adaptation of a mathematics specialist model is to be adopted. Where past research has focused on the benefits of specialist teachers for student learning and the benefit of teachers in regions, which have taken up this model already, our study contributes to the understanding of teacher and administrator perceptions of the implementation of a specialist model in a region, which does not currently use this model. Although our results are limited to one school district in Ontario, Canada, the implications have international relevance. The sampling from this district contributes an international perspective and demonstrates that even in districts, where there is likely significant support from both teachers and administrators for such a system, caution must be taken in the implementation.

The fact that this study took place in only one educational jurisdictional context in Ontario provides two related limitations. Firstly, the fact that this survey was only distributed to one school board to a limited number of teachers and administrators could lead to results that are not representative of the experience of other school boards in this area. As such, while valuable preliminary and contextual pieces, these results should be interpreted with the limitation that they are not a representative sample, but context to be built upon in future research. Secondly, the experience of infrequent specialist teachers in this jurisdiction may not be the case of every board across the province, and therefore provides a perspective on similar jurisdictions rather than all boards across the province. Further our study does not consider the perspectives of teachers from jurisdictions, which utilize a specialist model. Future research exploring the topic would benefit from incorporating the perspective of teachers with experience using this model as to how it may be better incorporated.

Our research provides a mechanism by which we can begin to understand the potential benefits and limitations as noted by education professionals of a mathematics teacher specialist model. A remaining question given our findings is: how might current attempts in the province to better prepare elementary classroom teachers in terms of content knowledge in mathematics replace the need for specialist teachers? It may be that a specialist approach is seen as necessary simply because it is a clear alternative, but that, given the related barriers, a different combination of approaches could replace the need for such a system.

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APPENDIX A

Teacher Survey Questions

1. How old are you?
2. What is the highest level of formal education you have completed?
3. During your post secondary education, what was your major or main area(s) of study?
4. If you are qualified as a junior/intermediate or intermediate/senior teacher, what subject(s) are your teachable subjects (general education subject you are qualified to teach)?
5. Please indicate whether you have any of the following mathematics qualifications:
6. What is your current teaching assignment?
7. At this end of this year, how many years of teaching experience will you have?
8. How well prepared do you feel you are to teach the following mathematics curriculum grade levels? [grade 3 mathematics curriculum]
9. How well prepared do you feel you are to teach the following mathematics curriculum grade levels? [grade 4 mathematics curriculum]
10. How well prepared do you feel you are to teach the following mathematics curriculum grade levels? [grade 5 mathematics curriculum]
11. How well prepared do you feel you are to teach the following mathematics curriculum grade levels? [grade 6 mathematics curriculum]
12. How well prepared do you feel you are to teach the following mathematics curriculum grade levels? [grade 7 mathematics curriculum]
13. How well prepared do you feel you are to teach the following mathematics curriculum grade levels? [grade 8 mathematics curriculum]
14. How would you rate you curriculum content knowledge in each grade level? [grade 3]
15. How would you rate you curriculum content knowledge in each grade level? [grade 4]
16. How would you rate you curriculum content knowledge in each grade level? [grade 5]
17. How would you rate you curriculum content knowledge in each grade level? [grade 6]
18. How would you rate you curriculum content knowledge in each grade level? [grade 7]
19. How would you rate you curriculum content knowledge in each grade level? [grade 8]
20. How would you rate your knowledge of effective mathematical pedagogical practices in each grade level? [grade 3]
21. How would you rate your knowledge of effective mathematical pedagogical practices in each grade level? [grade 4]
22. How would you rate your knowledge of effective mathematical pedagogical practices in each grade level? [grade 5]
23. How would you rate your knowledge of effective mathematical pedagogical practices in each grade level? [grade 6]
24. How would you rate your knowledge of effective mathematical pedagogical practices in each grade level? [grade 7]
25. How would you rate your knowledge of effective mathematical pedagogical practices in each grade level? [grade 8]
26. Have you ever taken a math leadership role in your school or board? If yes, please explain.
27. Is mathematics a subject area that you feel teachers need to have special qualifications to teach? Explain.
28. What challenges do you think teachers that teach mathematics are currently facing?
29. A mathematics specialist is a teacher that has special qualification in mathematics and is knowledgeable in both curriculum content and effective pedagogical practices. Do you think having mathematics specialists in elementary schools would be beneficial to teachers and/or students? Explain.
30. A teacher specialization model in mathematics is a model in which a mathematics specialist teacher would be responsible for the math instruction of two or more classes of students. Do you think using a teacher specialization model in mathematics for elementary schools would be beneficial to teachers and/or students? Explain.
31. If your answer to the previous question is yes, what grades in elementary schools would a teacher specialization model in mathematics be most beneficial? Explain.
32. What could be some potential advantages to using a teacher specialization model in mathematics for elementary schools? Explain.
33. What could be some potential challenges in using a teacher specialization model in mathematics for elementary schools? Explain.

Administrator Survey Questions

1. How old are you?
2. What is the highest level of formal education you have completed?
3. During your post secondary education, what was your major or main area(s) of study?

4. If you are qualified as a junior/intermediate or intermediate/senior teacher, what subject(s) are your teachable subjects (general education subject you are qualifies to teach)? Select all that apply.
5. Please indicate whether you have any of the following mathematics qualifications:
6. What role are you currently in?
7. At the end of this year, how many years experience will you have had in your current role?
8. How would you rate the grades 3-5 mathematics curriculum content knowledge of the teachers in each division in your school? [primary (grades 1-3)]
9. How would you rate the grades 3-5 mathematics curriculum content knowledge of the teachers in each division in your school? [junior (grades 4-6)]
10. How would you rate the grades 3-5 mathematics curriculum content knowledge of the teachers in each division in your school? [intermediate (grades 7-8)]
11. How would you rate the grades 6-8 mathematics curriculum content knowledge of the teachers in each division in your school? [primary (grades 1-3)]
12. How would you rate the grades 6-8 mathematics curriculum content knowledge of the teachers in each division in your school? [junior (grades 4-6)]
13. How would you rate the grades 6-8 mathematics curriculum content knowledge of the teachers in each division in your school? [intermediate (grades 7-8)]
14. How would you rate teachers' knowledge of effective pedagogical practices in mathematics in each division in your school? [primary (grades 1-3)]
15. How would you rate teachers' knowledge of effective pedagogical practices in mathematics in each division in your school? [junior (grades 4-6)]
16. How would you rate teachers' knowledge of effective pedagogical practices in mathematics in each division in your school? [intermediate (grades 7-8)]
17. Is mathematics a subject area that you feel teachers need to have special qualifications to teach? Explain.
18. What challenges do you think teachers that teach mathematics are currently facing?
19. A mathematics specialist is a teacher that has special qualification in mathematics and is knowledgeable in both curriculum content and effective pedagogical practices. Do you think having mathematics specialists in elementary schools would be beneficial to teachers and/or students? Explain.
20. A teacher specialization model in mathematics is a model in which a mathematics specialist teacher would be responsible for the math instruction of two or more classes of students. Do you think using a teacher specialization model in mathematics for elementary schools would be beneficial to teachers and/or students? Explain.
21. If your answer to the previous question is yes, what grades in elementary schools would a teacher specialization model in mathematics be most beneficial? Explain.
22. What could be some potential advantages to using a teacher specialization model in mathematics for elementary schools? Explain.
23. What could be some potential challenges in using a teacher specialization model in mathematics for elementary schools? Explain.