Final Report for the Literacy and Numeracy Secretariat:

Niagara Catholic District School Board's Junior Interventions Project

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EXECUTIVE SUMMARY

Background

Teachers are in the unique position to create opportunities for students to learn with each other and co-construct knowledge. For example, research has found (Mercer & Sams, 2006) that teachers can support students in their use of talk as a tool for mathematical reasoning and problem solving. Yet, it is clear that teachers hold distinct beliefs about the autonomy of students to construct mathematics knowledge through language and their own autonomy to make instructional decisions. This highlights a need to support teachers' professional learning in mathematics problem-solving teaching methods while attending to their beliefs about mathematics instruction, as well as honouring their content knowledge and experience. When teachers engage in professional learning that focuses on how to pose effective mathematics problems, teachers' beliefs shift toward recognizing the impact of their mathematics instruction (Barlow & Cates, 2006). It is commonly held that supporting the practice and confidence of teachers to instruct mathematics through problem solving takes time and personnel.

In its second year of implementation, the Niagara Catholic District School Board (NCDSB) *Junior Math Interventions Project* focused on developing teachers' effective use of diagnostic assessment to identify student misconceptions and drive their instruction of mathematics. Using the principles of collaborative inquiry, this program of professional learning sought to build on junior level teachers' mathematics content and pedagogical knowledge while bearing in mind their beliefs and attitudes about mathematics instruction and how students learn mathematics.

Methodology

The NCSDB's intervention design drew on aspects of the "Seven Foundational Principles for Improvement in Mathematics K-12" document. Operationally, the intervention design included three key components: facilitated teacher professional learning sessions, collegial teacher professional learning, and student intervention tutoring. A facilitator led all professional learning sessions and worked with two math coaches to offer ongoing support for the individual needs of teachers throughout the project. There were two, full day plenary sessions that were attended by all teacher participants and were co-facilitated by the two math coaches and facilitator. There were four, half day sessions that were guided by one of the facilitators at each of the school sites and included the grade 3-6 teachers and their administrator. Each of the participating teachers was granted eight half days to engage in collegial professional learning with their same-grade/division colleagues. An interventionist was assigned to each school and was devoted to providing one-on-one mathematics tutoring in number sense and numeration for students targeted by their classroom teachers.

This research was an evaluative case study with the purpose to inquire into an educational program in order to determine its effectiveness. There were six research questions that related to teachers' practices and beliefs, a comparison between teachers participating for the first or second year, and students' achievement. Quantitative and qualitative data (surveys, interviews, fieldnotes, journals, report card scores) were collected from five sets of participants: teachers, facilitators, principals, interventionists and students. There were 21 teachers (grades 3 to 6) at five schools that participated in the program and their students indirectly participated as recipients of the teachers' professional learning and intervention tutoring. All participants (teachers, principals, interventionists facilitators, parents/guardians of students) signed informed consent forms.

Findings

The findings from this research indicate that teacher participants who engaged in collaborative inquiry focused on enhancing their math instruction by teaching through problem solving, and experienced positive professional learning and growth. At each site, junior division and grade 3 teacher participants joined to create a collaborative inquiry question to focus their instruction. These questions reflected their experience in the JMI project and readiness to alter and hone their practices. All of the teachers perceived that their students` learning was significantly impacted by their co-planning and co-teaching. Some of the co-planning activities included curriculum mapping which elucidated mathematics skills across the grade levels. Teachers in their second year of the project also acted as effective models of instruction for those in their first year.

As teacher participants negotiated their relationship with the math content and their students' learning, they recognized that the entire dynamic of their classrooms and the roles within it were changing. Communication and collaboration became key indicators of productivity in the math problem solving environment. Teachers were challenged to pose provocative, open-ended and open-routed questions and students were challenged to express their thinking and critically analyze the thinking of their peers. Teachers worked to create a math-talk culture in their classrooms; here was the place where students became leaders of their mathematics learning and teachers learned alongside of them. As a result, the teachers were less likely to contend that their role is to transmit and verify mathematical knowledge. The teachers now appreciate the key role that students have in their own learning and that students are capable of much higher levels of mathematical thought.

Within the classrooms, teachers encouraged peer collaboration and consequently witnessed students working through problems together. A math-talk culture was founded on respect while listening to your peers and communicating your thinking in a variety of different ways. Teachers remarked on the need for their students to continue to hone the necessary skills to work in such collaborative groups and feel confident taking risks to express their thinking.

Using language and communication skills has taken on heightened importance in mathematics lessons that are based on problem solving and collaborative inquiry. The teachers are no longer relying on published textbooks as an instructional resource, rather, they are promoting students' understanding of math content with authentic, relevant problems. Many of the teachers expressed how they used the numeracy nets for differentiating instruction to support the learning of students with similar misconceptions in mathematics and to identify students that required additional intervention.

Intensive remedial instruction with an interventionist was among the various approaches employed in this second year to provide mathematics support for students. Since this was a new initiative, the interventionists had to define their role and delineate how to work with students. Unequivocally, teachers stated that the interventionists were providing integral support as targeted students were displaying more confidence in mathematics and participating actively in whole group mathematics activities.

Growth in students` achievement was evident in all strands of mathematics based on analyses of report card grades (Term 1 and Term 2) and for students who received tutoring. Statistically significant student achievement has been summarized for each school site and interpreted in a series of tables. Influential factors such as gender, grade, school and tutoring were calculated.

Implications

Based on the findings, implications for practice and future research are offered. It is apparent that teachers derive great benefit from release time for co-planning and co-teaching and two years of participation in this professional learning. Refinements might include beginning of the school year support in curriculum mapping, numeracy nets and building a math-talk culture. The continued deployment of mathematics interventionists and refinement of their role is integral.

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Background

Mathematics Achievement in Niagara Catholic District School Board (2007-2012)

The mathematics achievement of students in Niagara Catholic District School Board (NCDSB) has been solid over the period from 2007-2012. **Figure 1.** shows the five-year data trend for NCDSB Grade 6 students who consistently perform above the provincial standard on EQAO.

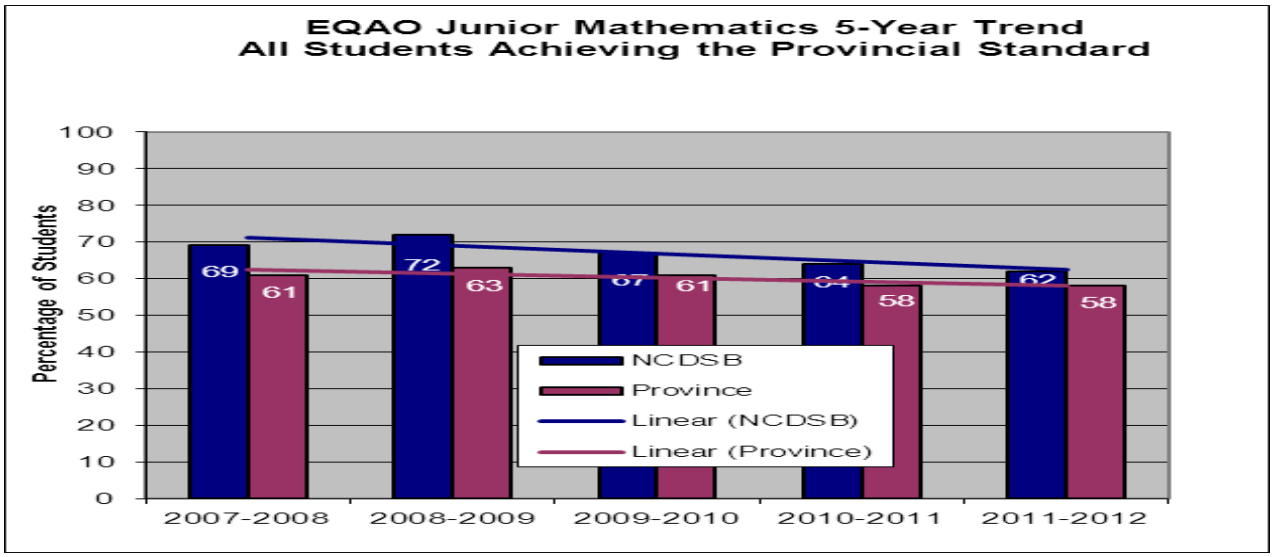

Figure 1. Grade 6 EQAO Mathematics Achievement – NCDSB and Ontario

The sub-set of schools that comprised the cohort for this project exhibited a consistent 8-10% drop in the number of students performing at levels 3 and 4 from Grade 3 EQAO to Grade 6 EQAO in Mathematics (see **Figure 2.**). This drop is consistent with provincial cohort data.

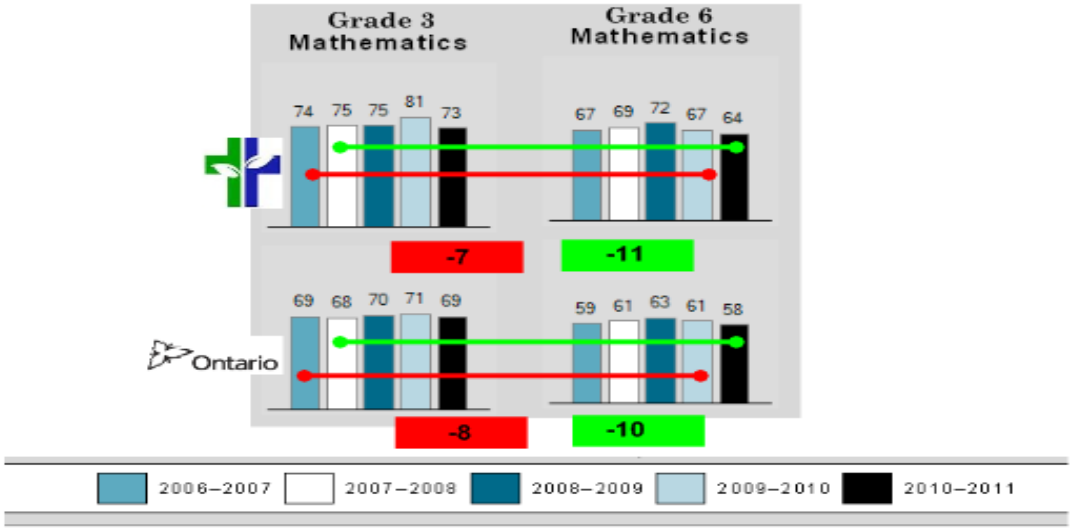

Figure 2. Grades 3 and 6 EQAO Mathematics Achievement – NCDSB Cohort and Ontario

Over the past five years NCDSB has gradually expanded its focus on mathematics instruction through problem solving (K-10). Our CIL-M model of co-planning and co-teaching has been the guiding framework in this endeavour.

Identified Areas of Need

Using Assessment to Drive Instruction and Re-structure the Project

With the release of *Growing Success Assessment, Evaluation & Reporting (2010)*, it has been NCDSB`s vision to find ways to integrate effective assessment strategies into collaborative inquiry networks. It has become evident that although teachers may embrace teaching through problem solving strategies, such as the three-part lesson, questions are always raised about: (1) how they can effectively assess student learning, and (2) when they should use problem solving strategies over the course of a unit of study.

NCDSB is currently introducing *Numeracy Nets*, an assessment for learning resource that helps teachers identify student misconceptions about the big ideas in mathematics. A pilot project revealed that teachers changed what and how they taught mathematics as a result of knowing the students' misconceptions. Based on this finding, it was concluded that if teachers know what the specific student needs are in their classroom, they can use three-part lessons to target those needs and guide their instruction.

Year 1 research in this project concluded that attempting to identify and target misconceptions across all five strands of mathematics was too broad. Interventionist work with students reduced but did not close gaps. It also did not allow time for students to fully entrench the new learning.

Year 2 of this project narrowed the scope of mathematics intervention to number sense and numeration. Feedback from a wide range NCDSB teachers noted a need with students' understanding of this mathematics strand. This need is also cited by the Ministry of Education through their development of resources like *Gap Closing* which focuses entirely on number sense and numeration. To better inform the interventionists in their work, each teacher created a 'numerate picture' of the students targeted for intervention. This numerate picture was created by administering several grade-specific *Numeracy Net* checkpoints that were foundational to number sense development. In addition, teachers reviewed student work, classroom assessments and anecdotal notes.

Building "Math Content for Teaching" Knowledge

Over the past four years of Collaborative Inquiry for Learning Mathematics (CIL-M) implementation, NCDSB has noted that a common barrier to teaching through problem solving is a teacher's own confidence in his/her depth of understanding mathematics content and concepts. According to the *Junior Math Interventions Initiative* (Ministry of Education, 2011) one of the consistent components of success with previous intervention projects is teachers' application of mathematics content and pedagogical expertise to support the embedding of understanding of mathematics content for teaching and learning. Although NCDSB has consistently embedded content-knowledge-building pieces into professional learning sessions, there is still a call for the effective facilitation of job-embedded, inquiry-based learning that both informs instructional practice and impacts teacher depth of knowledge in mathematics-for-teaching.

Strategic Direction for Student Achievement (NCDSB - BIPSA 2012-2013)

It is the goal of NCDSB to continue to advance student achievement with Ministry of Education, Board and school initiatives on Provincial EQAO Primary and Junior assessments, and the EQAO Secondary Mathematics assessment by June 2013. Implementation of these priorities involve network learning sessions for administrators and teachers that deepen understanding of instructional and assessment practices. This year the JMI initiative targeted two elementary schools identified as SIM (System Implementation & Monitoring).

Theoretical and Practical Foundations

Academic Research

Social constructivist theory purports that when learners interact with each other, knowledge, attitudes and values develop and learning occurs. Accordingly, learning takes place in social contexts where strategies and knowledge are mutually constructed. Teachers should create opportunities for students to learn with the teacher and peers while co-constructing knowledge. In the social constructivist view, language and communication are essential to mediate learning.

Teachers are beginning to value the utility of language and talk as integral to the dynamic of teaching mathematics (Hye & Reifel, 2011). However, extended use of talk in mathematics instruction is somewhat non-traditional and may contradict teachers' entrenched beliefs about how students learn mathematics. Is there a relationship between teachers' beliefs about mathematics instruction and students' beliefs about mathematics learning?

Yes, teachers hold distinct beliefs about how the relationship between the teacher, the student and the content affects the instructional core (Elmore, 2009). In particular, beliefs about their role as the teacher-as-director are salient. Not all teachers embrace the belief that students can self-direct their own mathematics learning. In a study of elementary teachers who focused their professional learning on how to enhance students' problem-solving strategies, only about half of the teachers involved the students in inquiry into their peers' strategies (Warfield, Wood & Lehman, 2005). Moreover, when teachers believe that they command a strong understanding of mathematics concepts, their students believe that they can generate ideas and solutions to mathematics problems and that math knowledge does not originate from external sources (Beghetto & Baxter, 2012). It is clear that teachers hold different beliefs about the autonomy of students to construct mathematics knowledge through language and their own autonomy to make instructional decisions – this impacts students' learning in mathematics.

It is also clear that students need to be engaged in communication with their peers while their teacher poses questions and allows them to explore potential solutions to mathematics problems. Teachers can elicit math-talk that actively engages students as they interact and explain their thinking. A math-talk learning community is defined as one in which students assist each other by engaging in meaningful mathematical discourse. Within this community students engage in questioning, explain their mathematical thinking, describe sources of mathematical ideas, and assume responsibility for their own learning (Hufferd-Ackles, Fuson, & Sherin, 2004). Teachers can effectively support even primary level students to engage in math-talk that includes interrogation, explanations of their thinking processes and argument (Bruce & Flynn, 2011). Specifically, research has found that primary teachers can support students in their use of talk as a tool for mathematical reasoning and problem solving (Mercer & Sams, 2006).

In a math-talk community, teachers should pose open-ended or open-routed questions. To do so effectively, teachers need to have experience in devising pedagogically meaningful questions and

supporting students' responses that exemplify their efforts to make meaning and articulate their thinking. Teachers need to give pedagogically sound explanations that bridge mathematical content to students' thinking (Inoue & Buczynski, 2011). When teachers become active participants listening and talking during student conversations, they are able to help students express their thinking, assess students' understanding, and determine misconceptions (Vanderhye & Demers, 2008). Further, encouraging students to be persistent with their questioning enhances their understanding provided that teachers have laid the groundwork for respectful communication (Piccolo, Harbaugh, Carter, Capraro, & Capraro, 2008) in a safe classroom environment (Vanderhye & Demers, 2008). It has been found that establishing a democratic environment with full participation from all students, is a prerequisite to a math-talk culture in the classroom (Knott, 2010). Teachers are also reminded that implicit questioning demands a command of language that may challenge some students who are English language learners or have learning disabilities (e.g., communications) (Parks, 2010).

The academic research points to the need to support teachers' professional learning with respect to the role of language in mathematics problem-solving teaching, while attending to their beliefs and attitudes about mathematics instruction and their content knowledge. Since beliefs, attitudes, and content knowledge are all related to teachers' mathematics instructional practice (Wilkins, 2008), a program of professional learning should address all of these components. In particular, attention must be paid to teachers' beliefs as these mediate the effects of content knowledge and instructional practice attitudes (Wilkins, 2008). Specifically, how do these factors interact with respect to inquiry-based mathematics instruction?

Teachers' use of inquiry-based instruction is influenced by their beliefs in its effectiveness. Not surprisingly, teachers with positive attitudes toward mathematics are more likely to believe in the effectiveness of inquiry-based instruction and use it more frequently in their classroom. Interestingly, a recent study by Wilkins (2008) found that early primary teachers (grades K-2) tend to naturally use inquiry-based instructional methods more often than junior teachers (grades 3-5). These findings underscore the need for professional learning in inquiry-based mathematics instruction methods for the junior division teachers.

The design of a professional learning program in mathematics is essential. In particular, when the program of professional learning focuses on how to incorporate and pose effective mathematics problems, teachers' beliefs shift toward recognizing the impact of their mathematics instruction (Barlow & Cates, 2006). A successful program for elementary teachers found that modelling self-questioning during mathematical problem solving combined with systematic reflective support from colleagues contributes to teachers' pedagogical-content knowledge and contributes to their metacognitive knowledge of mathematics (Kramarski, 2009). The program of professional learning evaluated here sought to build on junior level teachers' mathematics content and pedagogical knowledge while bearing in mind their beliefs and attitudes about mathematics instruction and how students learn mathematics.

Supporting the practice and confidence of teachers to instruct mathematics through problem solving takes time and personnel (e.g., facilitators, consultants, coaches). Research (Obara & Sloan, 2009) on the role of a mathematics coach has found that teachers benefit from a site-based, long-term professional learning that targets content and pedagogical knowledge. The mathematics coach should support teachers as they explore pedagogies, mathematics concepts, and work in collaborative groups. Teachers also need opportunities to personally engage and practice problem solving together. This type of collaboration contributes to teachers becoming more comfortable with the mathematics and recognizing the importance of group work while problem solving. For most teachers, this transfers to how they then support their students' collaborative problem solving (Sakshaug & Wohlhuter, 2010).

Reflection is also an important component in teacher professional learning in mathematics. It has been found that teachers' individual reflection facilitates the reflexive relationships within a school's community of practice. Reflection enables teachers to improve their skills, beliefs and perceptions of

mathematics teaching and is an overall facilitator of teacher development (Turner, 2009). The *Junior Math Interventions Project* in NCDSB was conceived with these professional learning design components in mind.

Ministry of Education and Literacy and Numeracy Secretariat Resources

The Junior Math Interventions Initiative *(Ministry of Education, 2011)*

The *Junior Math Interventions Initiative* (Ministry of Education, 2011) cites two factors that contribute to successful intervention projects. These two factors were integrated into *NCDSB's Junior Math Interventions Project*:

1. collaboration and learning that includes ***teacher professional development meetings and classroom*** **experiences** for students and teachers;

2. use of mathematics content and pedagogical expertise that can ***support the embedding of understanding of mathematics*** content for teaching and learning within the ongoing work of teachers.

School Effectiveness Framework *(2010)*

Key components of NCDSB's *Junior Math Interventions Project* are the effective practices of *assessment for, as, and of learning* as well as *School and Classroom Leadership*. The following indicators from the *School Effectiveness Framework (2010)* were instrumental factors within this Project:

Indicator 1.5:

A variety of valid and reliable assessment data is used by students and teachers to continuously monitor learning, to inform instruction and assessment to determine next steps.

Specifically:

- Collaborative processes are in place to guide problem-solving and decision making in relation to preventions and interventions that may be required where data indicate students are not demonstrating the intended learning expectations
- Instructional decisions are made and actions are taken to respond to what student demonstrations reveal

Indicator 2.4:

Job-embedded and inquiry-based professional learning builds capacity, informs instructional practice and contributes to a culture of learning.

Specifically:

- Evidence of student learning is shared as a catalyst for professional dialogue.
- Knowledge and effective instructional practices are shared (through co-planning, co-teaching, mentoring and coaching)

Growing Success: Assessment, Evaluation & Reporting *(2010)*

The *Junior Math Interventions Project* focused on developing teachers' effective use of diagnostic assessment to drive their instruction of mathematics. According to *Growing Success (2010),* diagnostic assessment, "occurs before instruction begins so teachers can determine students' readiness to learn new knowledge and skills …" (p.31). It is NCDSB's intention that as a result of the *Junior Math*

Interventions Project, teachers will use diagnostic assessments, "to determine what students already know and can do," as well as to, "plan instruction and assessment that are differentiated" (p.31).

Professional Resources used in NCDSB's Junior Math Interventions Project

Instructional Rounds in Education *(Elmore, 2009)*

At the heart of the *Junior Math Interventions Project* is what Richard Elmore (2009) describes as Cohen and Ball's instructional core: *the relationship between the teacher, the student and the content*. Based on this instructional core, Elmore's first principle challenges facilitators to:

1) *increase the level of knowledge and skill that the teacher brings to the instructional process*;
2) *increase the level of complexity of the content the students are asked to learn*;
3) *change the role of the student in the instructional process*.

In addition to these challenges, Elmore also outlines his considerations for effective professional development, noting its quality depends on:

1) what teachers are being asked to learn;
2) how they are learning it;
3) whether they can make the practices they are being asked to try, work in theirclassrooms.

Throughout the planning process, the *Junior Math Interventions Project* Facilitators frequently cross-referenced these six guidelines with the goals that were set for the professional learning sessions to ensure the cohesiveness of the project.

Ontario Numeracy Nets: Grades 3-6 *(Bauman, 2009)*

A core resource for the *Junior Math Interventions Project* was *Ontario Numeracy Nets: Grades 3-6* that provides classroom teachers with a diagnostic tool that is rooted in research. *Ontario Numeracy Nets: Grades 3-6* espouses the belief that "all students can learn mathematics and that struggles with mathematics are not due to some inherent deficit, but to undetected misconceptions that hinder or even halt student progress" (p.2). It was the intention of the *Project* that through the use of Numeracy Nets, teachers will begin to utilize powerful diagnostic questions and ultimately enhance their instruction as a whole. The moderated marking of diagnostic tasks was a key component of facilitated sessions and the co-planning process within the project.

Big Ideas from Dr. Small *(Small, 2009)*

A supporting resource for teachers' content-knowledge-building was Marian Small's, *Big Ideas from Dr. Small*. The strength of this resource is its structure, based on central "big" ideas, that effectively map out how, "new ideas connect to what we already know. *"* Ultimately, like Marian Small, it was a goal of the project that NCDSB teachers will grow to appreciate, "the power in being comfortable with the math we teach." (p. xi). All teacher participants were provided with personal copies of this professional resource.

Teaching Student-Centred Mathematics *(Van de Walle & Lovin, 2006)*

Van de Walle and Lovin's *Teaching Student-Centred Mathematics* provides NCDSB schools with a source for further content-knowledge-building and ideas for group-learning tasks. The fact that this

resource is directly cross-linked to *Numeracy Nets* allows teachers to quickly and efficiently locate relevant information and activities to help plan for targeting student misconceptions. All teacher participants were provided with an additional school set of this professional resource. Each of the six interventionists were provided with personal copies to use in their work with students.

Research Questions

Research questions were adapted from the Final Report for the Literacy and Numeracy Secretariat: Niagara Catholic District School Board's Junior Mathematics Intervention Project (2011). The chief difference between the research questions for the first and second year of the project is a pair of questions that compares the practices and beliefs of teachers who participated in both years of the project to teachers who participated in only one year of the project. The six research questions that were identified relate to teachers' practices and beliefs, and students' achievement. The following are these research questions and sub-questions that guided the evaluation of this initiative:

Teachers' Practices

1. Are teachers (Grades 3-6) using evidence-based intervention practices in their mathematics instruction?
    a. Are teachers focusing on the relationship between the teacher, the student and the content?
    b. Are teachers identifying curriculum connections and using curriculum mapping?
    c. Are teachers promoting students' understanding of math content?
    d. Are teachers using instructional strategies such as: collaborative inquiry, BANSHO, open-ended problem solving, open questions and parallel tasks and *Numeracy Nets*?
    e. Are teachers using intervention resources for whole class instruction AND for struggling math learners?

Teachers' Beliefs and Attitudes

2. Do teachers perceive growth in their knowledge of mathematics content and mathematics instructional methods?
3. Has the recent project in professional learning in mathematics instruction increased teachers' self-efficacy in mathematics instruction?
4. Has the recent project in professional learning in mathematics instruction made an impact on teachers' intentions for their future practice?

Comparing Teachers' Practices and Beliefs: Years 1 and 2

5. What are the differences in practices and beliefs between the teachers who have had two years of professional learning and those teachers who have had one year?

Students' Achievement

6. Were there gains in students' (Grades 3-6) mathematics achievement as a function of the evidence-based intervention practices?

Research Design

Intervention Design

The intervention design has overlapping layers of implementation for both teacher professional learning and students' learning in mathematics. Two schools (Schools 1 and 2) participated for the first time and focused on implementing and supporting successful intervention practices in order to close the gap in students' mathematics achievement in the Junior division (Grades 3-6). In order to address this intention, these schools were introduced to the document, *Paying Attention to Mathematics Education* (Ministry of Education, 2011) and the "Seven Foundational Principles for Improvement in Mathematics K-12." This document was also referenced in the first year of the project (2011-2012) and was the design impetus for the *Junior Mathematics Intervention Project*. Three schools (Schools 3/4 and 5) were participating in this project for a second year and acting concurrently as implementarion support for Schools 1 and 2. The teacher professional learning in these schools focused on identifying students' misconceptions in mathematics on a broad landscape of conceptual learning and then providing responsive instruction.

Operationally, the intervention design included three key components: facilitated teacher professional learning sessions, collegial teacher professional learning, and student support from an interventionist (tutor). The project focused on providing teachers with professional learning and support in the use of the instructional methods of collaborative inquiry and teaching through problem solving. This was accomplished through professional learning sessions that sought to clarify mathematics content and enhance teachers' pedagogical expertise. It was also the intention of this initiative to increase teachers' efficacy by building their self-confidence in their abilities to develop appropriate interventions to remedy the misconceptions they've uncovered in students' conceptual understanding of mathematics. The intention of providing targeted student interventionist tutoring in small groups was to assist struggling students in the foundations of number sense and numeration. Taken together, this intervention project sought to improve student achievement and make a measureable difference in the learning gap with the intentional planning of the 3-part lessons and collaborative student inquiry.

Facilitated Teacher|Interventionist Professional Learning Sessions

The teacher professional learning initiative was facilitated in five NCDSB elementary schools. Teachers in grades 3-6 participated in the project from November 2012 – May 2013. Three facilitators from NCDSB provided the teacher professional learning sessions to support:

- teaching through problem solving with strategies (e.g. co-teaching, co-planning and 3-part lessons)
- strategies to target misconceptions identified through a diagnostic resources (e.g., Numeracy Nets)
- use of formative assessment to drive teacher instruction
- improve teacher efficacy through development of mathematics content knowledge and curriculum mapping
- focused lesson for small groups of struggling students through the use of intervention resources and interventionists

The facilitators led all professional learning sessions and offered ongoing support for the individual needs of teachers throughout the project. The schedule of facilitated professional learning sessions included one full plenary day, followed by four half days (approximately one per month), and then finished with one half day plenary. All participating teachers had release time for these sessions.

The two plenary sessions were attended by all teacher participants and were co-facilitated by the three facilitators. The first session in November, 2012 was an Introductory Session and the agenda included the following:

- overview of the research project
- key constructs: collaboration, inquiry, and problem solving
- project vision and goals
- Year 2 schools sharing their experiences with Year 1 schools
- marker students and the role of the interventionist
- differentiating the focus for Year 1 and Year 2 schools
- student voice and clarifying misconceptions
- for Year 1 schools: progression from diagnostic (numeracy nets) to planning lesson problem to implementing lesson problem in 3 part lesson structure (sample lesson plan provided; video illustration shown)
- mathematics scope and sequence of expectations

The four, half day sessions were facilitated by one (or two) of the facilitators at each of the school sites and included the grade 3-6 teachers and their administrator. These three sessions followed an identical agenda at each site (for each of Year 1 or Year 2 schools) which included guided activities for enhancing teachers' mathematics content knowledge and then group discussion. This discussion varied from session to session, however, the focus in the Year 1 schools was typically on some of the following: role of the interventionist, school-site inquiry question, administration and analysis of *Numeracy Nets to* identify student misconceptions; three-part lessons; collaborative inquiry methods; teaching through problem solving. The focus in the Year 2 schools was on some of the following: managing *Numeracy Nets*; open-ended/open-routed questions; indicators of successful collaboration; curriculum mapping; math talk culture; instructional strategies such as grouping students. There was time devoted during each of these sessions for teacher participants to share their experiences and successes with their colleagues and write in their learning logs.

The interventionists participated in two facilitated professional learning sessions that covered *Numeracy Net* training, math instructional strategies (e.g., open number line, base ten array), resources, administrative tasks. Since the focus of their tutoring would be in number sense and numeration, they defined big ideas in addition/subtraction (e.g., compensation) and multiplication/division (e.g., distributive property).

The final plenary session in May, 2013, was a consolidation and debriefing session for all teachers, principals and interventionists. The discussion focused on:

- same grade teacher discussion groups (planning; problem solving lessons; consolidation; next steps)
- sharing of grade-specific findings based on authentic student work samples
- teachers from the Year 2 schools presenting their recent collaborative inquiry experience and lessons learned
- school site discussions related to BIPSA planning for next year

The three facilitators were also available for each school to provide the teachers with on-going support in coaching, planning, modelling strategies, and/or providing co-instruction.

Collegial Teacher Professional Learning

Each of the participating teachers was granted eight half days to engage in collegial professional learning with their same-grade/division colleagues. Teachers booked these half days in advance and

were given release time. During these half days the teachers self-determined their activities which included: explore mathematical content, moderation of student work, class observations, co-planning, co-teaching, conferencing with students. Detailed descriptions of their tasks were self-reported and verified by the principal and to the facilitators.

Student Interventionist Tutoring

An interventionist was designated to each of the schools to provide one-on-one focused mathematics instruction in number sense and numeration for students targeted by their classroom teachers. These struggling mathematics learners were given skill-specific weekly instruction for approximately 20 minutes (individual students) or 40 minutes (small groups). The interventionists designed activities and tracked progress to meet the individual needs of targeted students. The interventionists were all certified teachers who volunteered approximately one day per week to each of the five schools.

Methodology

Case study is an exploration or study of a bounded system which may consist of multiple sites within the same study. Identical to Year 1, this research is an evaluative case study with the purpose of inquiry into an educational program in order to determine its effectiveness as judged by the researcher (Merriam, 2001; Stake, 1995, 2006; Yin, 2004, 2009). This case study has been informed by both qualitative and quantitative data and in this vein employs mixed methods of data collection. Ethical clearance to conduct data collection was granted by both Brock University Research Ethics Board and Niagara Catholic District School Board's research ethics boards. All participants (teacher participants, interventionists, facilitators, parents/guardians of students) signed informed consent forms.

School Sites, Teachers and Students

In sum, five elementary schools participated in this program. Two schools (Schools 1 and 2) partcipated for the first time and were chosen based on their proven inconsistencies in recent numeracy EQAO scores as well as, staff readiness to incorporate inquiry-based professional learning in order to build capacity, inform instructional practice, and contribute to a culture of learning. The administrators at these schools cited goals related to improving mathematics achievement in their school improvement plans. Three schools (Schools 3/4 and 5) were participating in this project for a second year and continuing their professional learning. Schools 3 and 4 are twinned divisionally (i.e., primary AND junior/intermediate) and it should be noted that these schools experienced significant staff attrition from Year 1 to Year 2. School 5 also acted as a demonstration site and teachers frequently collaborated with others involved in the project. There were 21 teachers (grades 3 to 6) that participated in the program and their students indirectly participated as recipients of the teachers' professional learning and interventionists' tutoring. In total, there were 487 students in these 21 classrooms; of this total, there were 107 students that were the recipients of intervention. The following **Table 1.** offers a profile of each of these school sites, the teachers, their students, the interventionists, principals, and the facilitators:

School	Teacher	Grade	Number of Students	Number of Intervention Students	Interventionist	Principal	Facilitator/Coach
1	1A	3	22	4	1MI	1P	Jasmine (Junior Division Consultant)
	1B	4	24	8			
	1C	4/5	22	10			
	1D	5/6	28	5			
2	2E	3	14	6	2MIa 2MIb	2P	Jasmine
	2F	3	16	2			
	2G	4	27	3			
	2H	5	20	0			
	2I	5/6	26	8			
	2J	6	17	4			
3*	3K	3	21	5	3MI	3P	Jasmine & Luciana (Math Coach)
	3L	3	21	4			
4*	4M	4	24	5	4MI	4P	Jasmine & Luciana
	4N	4/5	25	5			
	4O	5/6	27	7			
	4P	6	28	11			
5	5Q	3	19	3	5MI	5P	Jasmine & Carlo (Numeracy Facilitator)
	5R	3	18	4			
	5T	4	25	6			
	5U	5	31	4			
	5V	6	32	3			

Table 1. Summary of Sample: Schools, Teachers, Grades, Students, Interventionists and Facilitators

NOTE: * Schools 3 and 4 are twinned as School 3 is primary division only and School 4 is junior/intermediate division only

Data Collection

There were five sets of participants that data were collected from: teachers, principals, interventionists, facilitators and students. Within each participant set, multiple forms of data were collected. This practice contributed to the triangulation of the data and the rigour of the findings.

Teacher Data

1. Surveys

In November, 2012 at the first, full day plenary session, teachers were surveyed to capture their current practices and beliefs related to mathematics instruction. At the end of the final, half day plenary session in May, 2013, the teachers were again surveyed to capture changes in their practices and beliefs as a function of the professional learning project. The surveys consisted of questions on a 5-point Likert scale (Strongly Disagree, Disagree, Undecided, Agree, Strongly Agree). Question items included statements summarizing contemporary approaches to teaching mathematics and commonly espoused teachers' beliefs about mathematics. The surveys were adapted from previously administered instruments (Foong & Perry, 1998; Perry, Howard, & Tracey, 1999; Perry et al., 2002; Perry, Wong, &

Howard, 2006; Quillen, 2005; White, Way, Perry & Southwell, 2005). The surveys were coded for each of the teacher participants and 10 questions matched for the November and May administration dates.

2. Anecdotal Notes during Professional Learning Meetings

Anecdotal notes were taken by the researcher during the two plenary sessions (1 ½ days) and one of each of the four, half day plenary sessions. During these sessions, the researcher was an unobtrusive observer taking fieldnotes of the professional dialogue and collecting artifacts. Both the teacher participants and the facilitator were observed.

3. Interviews

Teachers from each of the five schools were interviewed (n=12) in late May, 2012. These teachers volunteered for this interview and were given release time. The purpose of the interview was to garner an elaboration of the teachers' practices and beliefs with examples and illustrations from the classroom. Teachers were asked 10 questions about instructional strategies and evidence-based intervention practices in mathematics. They were asked about curriculum connections and mapping. They were asked about their perceptions of students' mathematics achievement and improvement in the learning gap, especially as it relates to the role of the interventionist. Finally, they were asked about their own professional learning growth and self-efficacy in mathematics instruction. The 30 minute interviews were transcribed by a transcriber.

4. Learning Logs

Teachers completed learning logs at the end of the two, full-day plenary sessions, after each of the four, half-day sessions and at the end of their collegial professional learning half-day sessions. Time was allocated for completing the logs during the sessions and prompts were provided. The intent of the learning logs was to track teachers' experiences and reflections throughout the project.

The first log entry was guided to direct the teacher participants to deconstruct a video recording of a mathematics lesson. This activity was meant to bring awareness to exemplary instructional practices. Subsequent learning log entries were prompted by the facilitators at the end of the sessions. The prompts were topically connected to the focus of the facilitated professional learning sessions and included questions such as: "What are my personal barriers to our collaborative inquiry question?" "What is the impact of the interventionist?" "What have you seen shift in the students that you have been sending to the interventionists? What kind of change is this? "

The final log entry was intended to be a comprehensive reflection on the project and what the teachers believed that they had derived from it. The following questions were asked for this final log entry:

a. What have been the milestones or pivotal moments along your learning journey?
b. What did you see from the sharing session and/or the video that you could use in your practice?
c. What are your personal next steps and what are the supports that you need?

The confidentially coded learning logs were collected by the researcher at the end of the final session. Facilitators did not have access to view the learning logs at all.

Interventionist Data

1. Focus Group and Interviews

At the final half day plenary session, an interventionist focus group discussion was conducted by facilitators (Jasmine and Luciana). The discussion queried their thoughts on: their role, the effectiveness of the classroom teachers' diagnostic (numerate picture), resources, and student self-efficacy. Each of the six interventionists were interviewed. One interventionist (5MI) was interviewed in March, 2013 prior to her maternity leave. At her school, she was replaced by another interventionist. The remaining interventionists were interviewed in May, 2013. The purpose of their 7 question interview was to garner an elaboration on their evaluation of their students' progress and achievement in mathematics.

2. Interventionist Tracking Sheets

Using diagnostic assessments, classroom teachers created a profile or "numerate picture" of their targeted students identifying students' strengths and areas of need (specific misconceptions). Evidence of intervention provided to the targeted students was tracked by the interventionists. Each time that he/she worked with each student the following data were recorded: area of focus/learning goal; activities/strategies used; observations; next steps. These data provided a trace of the skills and concepts that the interventionists targeted, subsequent instruction and impressions of the students' learning. There was on-going, informal communication between the classroom teachers and the interventionists.

Principal Data

1. Interviews

Two of the participating principals volunteered to be interviewed in May, 2013. The purpose of their interview was to document their supportive role as an administrator for this project and their staffs' professional learning. They also offered an evaluation of the project and suggestions for future implementation.

Facilitator Data

1. Anecdotal Notes during Professional Learning Meetings

As noted above, anecdotal notes were taken by the researcher during the two plenary sessions (1 ½ days) and one of each of the four, half day plenary sessions observing the facilitators and the teachers.

2. Interviews

Each of the three facilitators were interviewed in May, 2013. The purpose of their interview was to garner an elaboration on their evaluation of the project and changes in teachers' practices and beliefs.

3. Learning Logs

The facilitators also completed learning logs after each of the Facilitated Teacher Professional Learning Sessions. The learning logs tracked their experiences throughout the project as leaders.

Student Data

1. Term 1 and Term 2 Report Card Grades

For confidentially, the student data were coded by: school/teacher/grade/student code/gender/tutored. Student participants' report card grades (Term 1: January and Term 2: June) for all five of the mathematics strands were converted from alpha grades into numeric grades: A+= 95; A = 88; A- = 82; B+ = 78; B = 75; B- = 72; C+ = 68; C = 65; C- = 62. Grades for targeted students who received tutoring were identified as a sub-set of the student sample.

2. Surveys

In February and June, 2013, students at School 5 completed a 14 question survey. Survey questions were clustered into 5 categories: collaborative problem solving (q1, 5, 6, 11), mathematics rules (q2, 3, 4, 8), intrinsic motivation (q9, 12, 14), talk (q7), grades (q10), parents (q13). The surveys were teacher constructed from previously administered instruments. The survey responses were on a 5-point Likert scale (Strongly Disagree, Disagree, Undecided, Agree, Strongly Agree) and completed electronically by students on *Survey Monkey*. This electronic polling site, calculated descriptive statistics (frequencies) for each of the response categories for the two administration dates. Paired samples t-tests were also run.

Data Analysis

The interviews (teachers, interventionists, principals, facilitators) were transcribed by a transcriber and the researcher then conducted qualitative data analysis including coding and collapsing data into themes. These subsequent themes were derived in response to the research questions. The learning logs, interventionist tracking sheets and anecdotal notes were similarly coding using the same themes that evolved from the interview data. Interpretations of the themes were made and illustrative quotes were selected from all of the participants. These qualitative findings are mapped back to the seven research questions in the following section.

The quantitative data (teachers' and students' surveys, students' report card data) were entered and analyzed using SPSS 19.0 (SPSS Software, 2011). The teacher survey data (November and May, 2013) and student survey data (February and June, 2013) were compared using Paired Sample t-Tests with Cohen's d effect sizes calculated. The students' report card data for Term 1 and Term 2 were compared for all five strands using Repeated Measures Analysis of Variance (ANOVA). Both within subjects ANOVA and between subjects ANOVA were run, the latter used to ascertain interaction effects that might be attributed to factors such as the students' school, teacher, grade, gender, and/or tutoring.

Findings

The following section is a presentation of the findings based on the data analyses. These findings respond to the clusters of research questions related to: "Teachers' Practices," "Teachers' Beliefs and Attitudes," "Comparing Year 1 and 2 Schools" and "Students' Achievement." Within these four clusters, the findings will describe how the teachers: focussed on the relationship between the teacher, student and the content; identified curriculum connections; promoted students` understanding of mathematics content, and; used instructional strategies and intervention resources. Teachers' beliefs about growth in their knowledge, self-efficacy and intentions for future practice are summarized. Findings also discuss the differences in practices and beliefs between the teachers who have had two years of professional learning and those teachers who have had one year. Finally, the results of the analyses of students` achievement as a function of the evidence-based intervention practices are offered.

Teachers' Practices

Are Teachers Focusing on the Relationship between the Teacher, the Student and the Content?

Early entries in the teachers' learning logs expressed their tensions with respect to adjusting relationships between teacher and students and finding roles within the mathematics classroom. As all members engaged in the mathematics content, teachers came to realize that they were co-constructing mathematics knowledge and skills with their students. Accordingly, roles within the classroom shifted and teachers came to acknowledge that their students were leading the lessons and in fact were the facilitators. Over the course of the project, this role reversal was also echoed by the interventionists. The net result was that students were assuming ownership for their own learning.

> I also learned that sometimes students move the lesson into a different realm than where the teacher intended the lesson to go (Journal, Teacher 2F, May 23/13).

> Now I see that there is more to teaching math. I look at it through different lenses. I do it completely differently and see the variety of ways to get there. I listen to the kids and they guide the next steps. I am not just the teacher, the kids are (Interview, Grade 4 Teacher 4M).

> I've always been very structured about how I've approached teaching math in the past but this has really taught me to let go and let the students direct me. I let them take me where they're willing to go and it might take longer, but if that's the route they need to take in order to get there then I'll do that (Interview, Interventionist 2MIb)

> It is about the learning of the students and not so much about getting through the curriculum. It is more interesting to teach this way. This is the ownership of the students' learning and it is amazing to see them lead their own learning (Interview, Grade 6 Teacher 5V).

> There were a lot of conversations that the kids had with each other. I was more of a facilitator, they were having conversations and learning from each other (Interview, Interventionist 4MI).

There still was a need for direct instruction as teachers remarked on the need for them to explicitly teach students the necessary skills to work in collaborative groups. These social and communication skills and how to assume roles in discussion groups needed to be taught as pre-requisites to collaborative inquiry.

> One teacher stated that she spent the Fall just doing generic cooperative learning strategies and strategies for social and conversation skills. A teacher impresses that the students need to be taught how to talk with each other. She had to model this and create anchor charts…A male teacher says that he uses, "Looks like, sounds like, feels like" for a reference of what the collaborative talk looks like. Jasmine adds that another strategy is called, "Fishbowl" when all students watch while one student provides a model and then they deconstruct this. A teacher states that she does this and some of the strong students reference anchor charts during this and become confident in doing so. She also assigns roles within the groups to help keep students accountable. Teacher 5V states that he has to nurture group caring as they are accountable as a group for their response. Jasmine terms this as, "interdependence" and then asks him how he can track individual accountability too. Teacher 5V replies that he does observations and exit cards to address this (Fieldnotes, School 5, Session 4).

> Where do I need to go with 3-part math lesson? I need to make up groups with different number of students and same levels in each group based on student needs. I need to take a step back during presentation - let the learning come from other students, not teacher during presentation piece (Journal, Teacher 1A, Feb. 20/13).

As relationships matured among the teacher, the students and the mathematics content, teachers came to realize the integral need for organized and instrumental communication in the classroom. In particular, teachers came to appreciate the value of communication as a means to elucidate misconceptions that their students might hold. During the Facilitated Professional Learning Sessions, both Jasmine and Luciana helped teachers make connections between the mathematics content in the curriculum document and instructional practices that would encourage communication and justification. Some teachers embraced these recommendations and witnessed their students connecting with the content and their peers.

> Teachers noted that their intervention students were disorganized. When I was in the classroom I asked the kids about what was on their chart paper. Their answers were all over the place. I told the teachers that as the novelty of writing on chart paper wears off, they will structure their answers better and they need to communicate their knowledge better. With the teachers then I take back the task of how can you work with your students to communicate better? How can we create an anchor chart to help them do this? This is what I take forward and discuss with the teachers to structure their subsequent lessons (Interview, Facilitator Jasmine).

> As stated in the math document, communication is not always in words. Process is important and an emphasis on justification is needed. Jasmine asks the teachers, "What is justification and what does it look like?" A teacher states that you can model it but it is hard to break it down into components. Luciana links justification back to the achievement chart categories such as reasoning and communication. When students offer justification and it is not right then this points to a misconception that the teacher must then target with further questioning (Fieldnotes, School 4, Session 2).

> The Gallery Walk has been the best to teach the kids how to ask questions of their peers. I tell them that if they aren't sure what a student is trying to express, then they need to go and ask questions. They are now more at ease using the math language. They are comparing their own strategies and make connections with their peers. They see that they are all arriving at the same place. This is a valuable tool and key to get to their understanding. I highlight a few strategies that I want them to walk away with and I show them why it is a good strategy. These highlights are in the consolidation and it is student driven. For the most part, I stand back as it needs to be a chance to express their understanding. Students catch on to their peers' understanding much better than to my explanation (Interview, Grade 3 Teacher 5Q).

During the Facilitated Professional Learning Sessions, the facilitators elicited discussion among the teachers about how a well-constructed open-ended and open-routed question can set the stage for

math talk. The facilitators began to deeply question the use of questions to enhance students' reasoning and justification.

> At School 4, teachers agree that students must have a question that is open enough to elicit general discussion. Luciana clarifies that students` knowledge can then be applied in the question. She explains that open–routed means that students all end up with the same answer in the end. There is value in this for some students who need a target. She further clarifies that, open-ended requires students to really justify their thinking and offers opportunity for a higher level of discourse. It allows the teacher to see the potential of the creative thinking that the students are capable of (Fieldnotes, School 4, Session 2).

> The teachers felt using open-ended and/or open-routed questions might give students greater opportunity to explain and prove their thinking. This really made me think about whether students develop reasoning skills and if justification is something we can "teach." What does it look like? Sound like? How do we get students to want to explain their thinking? How much of their justification is for themselves and how much is to appease the teachers or some other "authority" (Journal, Facilitator Jasmine, Nov.26/12)?

A few teachers initially expressed frustration with respect to their students' challenges to communicate in mathematics. These barriers were also discussed during the Facilitated Professional Learning Sessions.

> The Grade 5 teacher shares that her students don't see the value in communicating their understanding in math. They need prompting from the teacher to communicate. Some of them are too lazy to write an explanation. Jasmine suggests lessons should be retaught focusing only on communication: explicitly looking for "math vocabulary" and an explicit proof of their thinking. The teacher states that she makes her groups so that they do have success on the computation so that this is not an issue and then she can emphasize the communication. She is constantly reminding them to 'prove their work.' Jasmine points out that in the curriculum document the 'Communication Processes' can be easily converted into success criteria. Students need to explain their thinking in pictures, numbers or words. The consolidation of the lesson needs to be emphasized and this is often in words. It is important to present and chart their learning. This could be solidified with an anchor chart (Fieldnotes, School 1, Session 4).

As the project progressed, discussions during the Facilitated Professional Learning Sessions turned to how teachers might continue to facilitate and sustain the math talk culture in their classrooms. This includes a command of the mathematics nomenclature, a physically conducive environment, and a safe, respectful space for students to engage in critical talk. The interventionists also recognized the importance of math language.

> When working in pairs they give feedback to each other. They struggle with the math talk and they are missing some of the math key words especially the Level 1 and 2 learners. I paired them with someone who could explain it well to them. I would also do an exit ticket to have them reflect on what they learned (Interview, Grade 6 Teacher 2J).

> The culture of my classroom includes group work, collaborative talking and student-lead problems to solve. The desks have just been moved in groups to allow for easier discussion with their peers (Journal, Teacher 5U, Feb.7/13).

> One teacher notes that her students need some guidance around the culture of "critical talk" – students seem to be good at positive comments but offering suggestions to improve are more difficult. Jasmine notes that the teacher can model this and even use speech bubbles to prompt this. When a student does offer a good critical statement it could be posted as an example. The notion is that we can all learn from each other. They are all supportive of each other already and the space is safe already so disagreeing politely is okay (Fieldnotes, School 4, Session 2).

> I saw students using the language of math. This is important because if a grade 3 teacher is always using a math word and a student moves on to grade 4 and now there's the word, 'product' or 'sum' they need to

know what it means. For me it was important that School 1 has this language that crosses from the primary into the junior grades (Interview, Interventionist 1MI).

Are Teachers identifying Curriculum Connections and using Curriculum Mapping?

During the Facilitated Teacher Professional Learning Sessions, the facilitators introduced the activity of tracking curriculum expectations within a strand across the elementary grades. Teachers focused on identifying the "big learnings" within each of the grades. As follow up, most of the teachers involved in the project then dedicated some of their release time to delving into the mathematics curriculum expectations and mapping additional skill progressions across the grades. They worked with same grade and adjacent grade teachers and identified distinctions that they then focused on in their planning. Same grade teachers partnered to co-plan using the curriculum document as the basic resource. This activity left teachers feeling responsible for a set of math concepts that spanned the grades instead of simply feeling accountable for a grade`s expectations. Comments from the facilitators' and teachers' journals and their interviews documented this process:

> We started by taking a looking the trajectory of learning in light of the curriculum expectations. At some of the schools we had teachers working in split grades so they had to work together on this continuum of expectations and plan together. They carved out the landscape and discovered where a concept is coming from and what it might look like when the students represent it. So the teachers know what the big ideas are that the students are constructing. I worked with teachers to identify this and solidify it in the consolidation phase (Interview, Facilitator, Luciana).

> We work together as a division and one of our teachers was on the scope and sequence panel so we use this as part of our planning. We are using the curriculum as our guide and a backward approach to find a problem to teach the concepts (Interview, Grade 3 Teacher 5Q).

> Curriculum mapping – I found this to be incredibly valuable and a rich source of discussion as teachers explored the changes from grade to grade and across the trajectory of learning (Journal, Facilitator Luciana, Feb.4/13).

The administrators who actively participated in the JMI program recognized the utility of the professional learning that came out of the curriculum mapping activity. One administrator noted how teachers' awareness of the curriculum expectations refined teachers' observation and assessment skills.

> The landscape introduced as part of the JMI in-servicing has become a valuable tool for the teachers. In a full inquiry stance, the curriculum expectations become more of a checklist for teachers to use when observing students and to guide their facilitation of student activities. The strand very much determines the ease with which classroom teacher can guide inquiry to include certain expectations (Interview, Principal 1P).

Additionally, another administrator attributed the curriculum mapping exercise as helping her to recognize teachers` instructional compatibility with respect to mathematics concepts/skills at certain grade levels.

> We experienced curriculum mapping for the first time this year. We took a math strand from grade 1-6 and we noticed the curriculum expectations in grade 1-3 were small and then in grade 4 it was a page full of content. This means that you need to get it right in the primary grades and then when you hit that grade 4 mark you are ready to run. It helped me make my decision for teaching assignment for next year. This makes you think: who is a match to teach these expectations? This is powerful information to make a decision as an administer (Interview, Principal 2P).

Are Teachers Promoting Students' Understanding of Math Content?

Of paramount importance was the role of communication to promote students' understanding of math content. In his interview, an administrator drew together evidence of how students are demonstrating their understanding of math content through language. A grade 4/5 teacher also echoed that this was the case for many of her struggling math students. Teachers in their second year of the project had had the experience of promoting students' understanding of math content through various strategies that accentuated the role of communication.

> The idea of one correct method or answer in math is losing favor with classroom teachers and students alike. Students have a growing confidence and are taking greater risks in putting forth strategies and solutions. They are being given the vocabulary and opportunity to explain their thinking and are beginning to appropriately challenge each others' thinking (Interview, Principal 1P).

> Students have had to focus on how to explain their thinking. Those that have language challenges are still working on this. This is a work in progress. I will start this earlier next year. It is vocabulary and conceptual understanding… I took for granted that kids could communicate. When I put kids together in a group they did not know how to communicate with each other as they don't do this with technology. They don't know how to talk to each other; this has been lost (Interview, Grade 4/5 Teacher 1C).

> The understanding comes through in a gallery walk and turn and talk. Students are constructive about their peers' work without being critical. They are positive when collaborating. I tried the strategy, "3 Stay and 1 Stray" in which three students stay at their problem solution work and one student strays to spy and find out what others are doing and bring back the ideas. There is accountability and they need to be responsible for their own learning. They have to be knowledgeable and on task as they don't know who will be presenting and who will straying (Interview, Grade 3 Teacher 5R).

To promote students' understanding of math content, some teachers called on relevant circumstances that students could relate to. A key to teaching through problem solving and the three part lesson was finding the best problem – one that generates discussion and multiple solution pathways. Teachers also noted that it was essential that a problem was relevant to junior learners. The teachers came to realize that relevancy adds authenticity and value to the learning activity. Teachers nurtured mathematics problems to organically come from relevant circumstances.

> I had a hands-on problem solving activity in which the school was saving money for a charity project to help to build a home. It started with bringing in pennies. The money grew and we moved on to several containers. This became our money unit and they realized that if there were not just pennies there would be more money in value... We rolled all the money and did the calculations of the values. They came up with questions such as, 'How much more money do you need to equal another classes' amount collected?' They worked in pairs and they formulated these questions and a solution. Some students realized that they did not have enough information in the question so they learned a valuable lesson (Interview, Grade 3 Teacher 3K).

It was obvious that to promote students' understanding of math content, teachers needed rich and engaging resources. Many of the teachers expressed that they drew from a variety of professional and teaching resources when planning their mathematics lessons. This is a departure for them from sole reliance on a mathematics textbook as the primary resource.

> We are using the resources and trying everything. I used the *Super Source* heavily to help figure out what they need to work in groups on. Now I use the work of Cathy Fosnot as it is based on visuals and the students can use them to form their answers. This gives them a pathway to get there without an algorithm. The kids like the more open-ended questions in this resource. In the *Math Expressions* I tried a place mat activity and it was great for getting the kids to blend their best ideas. We still use *Math Makes*

> *Sense* but only for the problem solving questions. I use these resources for the whole class and the Interventionist uses them for the struggling learners (Interview, Grade 3 Teacher 5R).
>
> The text doesn't address the need for the word problems and I am fine with the book being taken away. You can't script problems based on what the students say and do and instruction is now based on where my students are at. Texts are scripted. The text was easy to use and ignorance was bliss to follow the textbook and not at the curriculum document. I have marker students and know which ones are struggling and the text can't show you what they might do and when you see this happen then you know what to do… I don't need a math text to make this happen. I used to think it was the end all and be all. I understand the math content more than ever (Interview, Grade 6 Teacher 5V).

These teachers from a Year 2 school have grown in their recognition that the math textbook has a limited role. Last year, they came to this superficial realization: the textbook includes many topics that are not required by the Ontario mathematics curriculum – consequently, time was being wasted on unnecessary topics. Now, these Year 2 teachers hold a more rigorous realization: the quality and instrumental use of problem solving resources is the key to help promote students' understanding of math content.

Are Teachers Using Instructional Strategies?

Teachers wrote in their learning logs about the paradox of using the *Numeracy Nets*: there is great value in what the *Nets* reveal about students' misconceptions, yet completing the *Nets* is a great investment of time. The teachers used the *Numeracy Nets* as an illuminating diagnostic assessment to provide programming information for the interventionists and for grouping students within the classroom. The student misconceptions that were brought to light by the *Numeracy Nets* guided subsequent instruction. During the Facilitated Professional Learning Sessions, facilitators impressed upon the teachers how assessment data identifies students' needs and then drives intentional planning. Taking anecdotal notes in addition to the *Numeracy Nets* is helpful to inform the planning.

> Numeracy Nets: There is an ease of use but these are time consuming when doing one-on-one - but it can be managed. If the net has a lot of questions, then you have to break it down. I then group kids who have like misconceptions to then fill the gaps (Journal, Teacher 1C, Jan.11/13).
>
> I found the nets very valuable as a whole class assessment tool to determine students' misconceptions. Next time, I will conference with students concerning their responses to try to understand their thinking if it was not evident on paper (Journal, Teacher 2G, Jan. 11/13).
>
> During the numeracy nets, I was thinking of taping the children as they explain their work and transcribing later. This might speed things up especially when trying to test the whole class. This would be very informative when accompanied by the explanation by the children. It is certainly more useful than just giving a test alone (Journal, Teacher 3K, Jan. 11/13).

The interventionists offered suggestions for refining the use of the *Numeracy Nets*. Their perspective informs use of this diagnostic resource for the purpose of individualized, focused instruction in number sense and numeration. This is a slightly different purpose than what the teachers were using the *Numeracy Nets* for in the classroom. Future use of this instructional strategy might demand modifications as it is re-purposed as an intervention resource for a specific mathematics strand.

> Teachers completed *Numeracy Nets* in varying degrees of generalization using such comments as, 'trouble with multiplication' or 'place value and base 10.' Other teachers were almost too specific citing weakness related to a specific task and less generalized to conceptual understanding…Interventionists recommended that they should co-create numerate picture with teachers using a set of checkpoints that represents a numerate picture for their grade (Fieldnotes, Interventionist Focus Group).

Teachers gained knowledge and experience of a repertoire of instructional strategies for getting students to share their work and discuss their solutions. Another teacher explained her practice of asking questions in such a way that students strive continue to elaborate on their responses. These strategies were reviewed during the Facilitated Professional Learning sessions.

> A teacher and her teaching partner share some samples of students' work. She acknowledges that this is conducive to 3-part problem solving and sharing whereas, when they work on problems in their notebooks, it is more independent. Jasmine notes that the BANSHO, congress, and gallery walk are all ways to encourage sharing. During these sharing strategies, students might post their work beside someone elses' that is similar to theirs. She states that her students respond well to "you be the teacher" to encourage them taking ownership (Fieldnotes, School 2, Session 4).

> I have learned how to do a poker face so I don't give away the fact that they are on the right track and I have to keep asking them questions to get them to express their understanding. She further states, "I need to have the same reaction to their responses regardless of whether they are right or wrong. Now they expect that of me (Fieldnotes, School 5, Session 2).

Other teachers combined high-yield instructional strategies such as student reflection, halving/doubling strings and K-W-L charts within problem solving activities. Employing these additional strategies offered additional scaffolding for those students who needed it.

> This morning at the final plenary session, we had the opportunity to share student work with other schools in JMI. Some key tips I learned are that I could have students journal about their learning to explain how they knows. This allows students to hopefully solidify their understandings. Students could also do a walk about and put sticky noted on the works of others highlighting points of learning and areas of confusion. This in turn would allow me to guide my teaching to correct misconceptions (Journal, Teacher 1B, May 23/13).

> Each day students are given an EQAO-type problem and work through it. They use a graphic organizer, "KWH – Know, Want to Know, How it will be done." Jasmine validates what they are doing and provides further recommendations for the teachers to spend more time allowing the students to share the ways that they have solved the problems. This makes them accountable and helps them to understand that it is important to focus attention on the actual problem solving (Fieldnotes, School 2, Session 4).

Are Teachers Using Intervention Resources for Whole Class Instruction AND for Struggling Math Learners??

Intensive remedial instruction with an interventionist was among the various approaches employed in Year 2 of this project to provide mathematics support for students. Since this was a new initiative, the interventionists had to define their role and delineate how to work with students.

> My goal for each session was to do a short mini lesson, an activity to practice the mini lesson concept, an EQAO style word problem (for grade 3 and 6 students), a facts game (usually with cards) (Journal, Interventionist 1M1, May 22/13).

> I printed a question out and then blew it up to 11 x 17 so that when we presented each solution all the students could see the work. I also use markers instead of their pencils so it is easier to see. I will often have the students explain their solutions so that the group can see and comment on it (Journal, Interventionist 4M1, Feb.20/13).

> I'm finding that if my group is larger than 4 students at a time then the day's lesson is not very successful (Journal, Interventionist 2MIa).

> I pretend that I don't know a lot so I can let my students 'teach' me and we can discover math concepts together. This appears to help one girl in particular – she has developed a better self-concept of her math

abilities. She is easily discouraged, and I feel that her attitude holds her back more so than her ability; she only wants to do well and doesn't understand that making mistakes is part of learning and getting better (Journal, Interventionist 2MIb, Feb. 21/13).

I promised myself that I would never allow the students to come to the junior math intervention session with a paper and pencil... When I had them work on problem solving, I always gave them a big piece of paper and a marker and they always hated when I gave them markers because they couldn't erase their mistakes but I said you know what, it's not a mistake it's a learning experience. They would try to cross out when they made a mistake and I would tell them not to erase that because that's not a mistake, that's growth. I told them that it's growth within the two minutes that it took them to think about having to do it another way. I saw that growth because they couldn't erase or cross out (Interview, Interventionist 1MI).

In their learning logs, the teachers were prompted to reflect on the role of the interventionist and how their students were responding to this support. Unequivocally, teachers stated that the interventionists were providing integral support and keeping in communication with them about students' progress. Targeted students were displaying more confidence in mathematics and participating actively in whole group mathematics activities. This evaluation was echoed by the interventionists as well.

The interventionist's support has provided my students with the confidence they need to dialogue in the classroom in group discussions and activities. These students are less hesitant when doing math – they are willing to take risks (Journal, Teacher 1B, Mar. 20/13).

The interventionist role has given my students confidence. Students that would "hide" during math instruction now actively participate during lessons and positively contribute during group situations (Journal, Teacher 1D, Mar. 20/13).

Students are excited to work with the interventionists and I have noticed that the students are more confident and participate more during whole class and with partners in math class. Specifically, students' number sense is improving (Journal, Teacher 2E, Apr.3/13).

I see growth in all the students. Looking at my early tracking sheets I see improvement in their sense of what the answer could be and they're using strategies they previously could not understand (Journal, Interventionist 1M1, Apr. 17/13).

Some of the interventionists and the classroom teachers that they worked with developed a complementary relationship; they were synchronized in the way that they worked together. This was ideal for all including the students that they supported.

We also have an interventionist come in and have the first two periods on a Monday with him and he supports me and we do some co-teaching. He feels comfortable with me and I give him carte blanche. The two of us work well together. He will work with one or two students and support them. I still need support too and he has been really helpful and this is has been appreciated. There is a great dynamic with him and the students. I love the approach that he takes with the kids (Interview, Grade 3 Teacher 3K).

The teachers at School 1 decided to follow the scope and sequence so I knew pretty much where they were throughout the school year and what they were working on. I could approximately tell what strand they were on and I looked through that strand to find where's the number sense in that strand and where can I help students to see a connection when they are with me and when they're in the classroom (Interview, Interventionist 1MI).

There was a distinction in the intervention support between the first year and the second year of this project. The math coach employed in Year 1, supported students in an itinerant-type role, whereas in Year 2 the interventionists were dedicated to a site and supported students on a regular weekly

basis. Teachers in Year 2 remarked on this difference citing intervention consistency as a positive change.

> As for as the difference between 1st and 2nd year goes with the interventionist, I find that this year is more seamless because there is more of a consistency week to week with the students I am sending. This allows the interventionist to become more in tune with their needs (Journal, Teacher 4M, Apr. 19/13).
>
> For the students there was accountability to the interventionist and they established a bond with her because of their consistent weekly contact with the interventionist (Journal, Teacher 4O, Apr. 19/13).

During the interventionists' focus group discussion, the interventionists offered specific suggestions to enhance their role and further impact students' learning. The interventionists expressed a desire to build rapport in the classroom with students and develop a holistic impression of targeted students' learning strengths, needs and interests. It was also suggested by the facilitators that the classroom teachers continue to work collaboratively with the interventionists to identify students' needs.

> I needed a more holistic picture of the student - information beyond 'numerate picture' (e.g., language deficits, behaviour triggers)... Relationship building would be on firmer ground if the interventionist began in the classroom as 'teacher support' before targeted intervention (Fieldnotes, Interventionist Focus Group).
>
> The interventionists mentioned that they needed observation time to get to know students in the classroom and get to know their interests as whole children. The children could get to know them as well. They could be part of the community and create the numerate picture of the child with the teacher. They can have the professional dialogue with the teacher. Moving forward we would focus on number sense again and providing the opportunities to dialogue with the classroom teacher and be in the classroom to help and observe student thinking (Interview, Facilitator Luciana).
>
> I hope for next year they could start the program at the beginning of the year so the interventionist could know what the class and teacher have done and at what point of the year (Journal, Interventionist 1M1, Apr. 10/13).
>
> To close the gaps teachers need to take the time to identify the specific needs of a student to get the most of tutoring. Specificity will net achievement gain. The numerate picture needs to be even tighter and the role of the interventionist needs to be defined and put in place. They need to continue to dialogue with the classroom teacher (Interview, Facilitator Jasmine).
>
> I really wish there was more feedback from the teachers to us and us to the teachers. At this school especially, there's a lot more needs than just academic; you're dealing with kids that are hungry and don't even have proper clothing…we should really get a whole picture of the child because sometimes there's also a language component and they have a hard time picking out what's important in a question and I think it's really because they're not understanding what they're reading. Sometimes there are triggers for behaviour issues (Interview, Interventionist 2MIa).

Finally, there was also value added when the interventionists and teachers engaged in professional learning together – messages were consistent. The interventionists appreciated this time to meet and share best practices. For future implementation, the interventionists requested more of this professional dialogue and learning time.

> Today Jasmine came in and demonstrated a multiplication string with the grade 5/6s. I learned a lot from seeing that and made it a lot easier to see examples of what to say and at what point of the string to activate certain thoughts and ideas (Journal, Interventionist 1M1, Mar.5/13).

The opportunity should be built into the schedule for interventionists to meet monthly and there should be some professional development and sharing practice within the group (Fieldnotes, Interventionist Focus Group).

Teachers' Beliefs and Attitudes

Is there Growth in Teachers' Knowledge of Mathematics Content and Instructional Practices?

At the end of the project, five questions on the teachers' survey, *Beliefs about Mathematics, Mathematics Learning and Mathematics Teaching*, had significantly changed response patterns. This survey of their beliefs was on a Likert-scale (1=Strongly Disagree; 2=Disagree; 3= Undecided; 4=Agree; 5=Strongly Agree) and consequently the means (M) reflect these values. **Table 2.** is a summary of these significant survey questions, statistics, and interpretations.

Survey Question	**Paired Samples t-Tests**	**Interpretation of Significant Results**
Mathematics problems are solved by using previously learned solutions/searching for order and pattern	$t(23)=-4.32$, $p=<.001$, CI=[-1.29, -.46]	T1 M (3.13; SD 1.04) is less than T2 M (4.00; SD 0.72), therefore they are now more likely to agree.
Using a rule or formula is more important than understanding why and how it works/right answers are more important than the ways in which you get them	$t(23)=2.88$, $p=.008$, CI=[.13, .79]	T1 M (2.00; SD 0.72) is greater than T2 M (1.54; SD 0.59), therefore they are now more likely to disagree.
Mathematics is relating different ideas/the result of the learner interpreting and organizing information gained from experience	$t(23)=2.56$, $p=.017$, CI=[.06, .60]	T1 M (4.17; SD 0.51) is less than T2 M (4.50; SD 0.48), therefore they are now more likely to agree.
Getting the right answer is the most important part of mathematics/getting the right answers quickly	$t(23)=2.60$, $p=.016$, CI=[.12, 1.05]	T1 M (2.13; SD 0.90) is greater than T2 M (1.54; SD 0.59), therefore they are now more likely to disagree.
Learning mathematics involves memorizing procedures and formulas/memorizing facts	$t(22)=-2.19$, $p=.039$, CI=[-1.10, -.03]	T1 M (3.09; SD 0.79) is greater than T2 M (2.52; SD 0.85), therefore they are now more likely to disagree.

Table 2. Summary of Significant Results of Teachers' Survey

Based on these significant survey question responses, teachers are likely to hold the belief that mathematics problems are solved by looking for a logical order/pattern or a problem solution schema. Similarly, these teachers are more likely to now believe that mathematics is a dynamic of many different ideas and learners interpret and organize this dynamic of information. In general, teachers are less likely to hold the belief that mathematics is closed, absolute, and rule-oriented. These teachers do not contend that mathematics learning is demonstrated through computations and the ability to memorize facts, procedures or formulae. In a similar vein, these teachers do not believe that students should be focused on quickly getting a correct right answer to a mathematics problem – the process of problem solving and understanding why and how one derived at a solution is of great value. The

teachers now appreciate the key role that students have in their own learning and that young learners are capable of much higher levels of mathematical thought. The teachers regard a mathematics learning context as one that is enhanced by challenging mathematics problems within a supportive environment, and activities which build upon and respect students' experiences.

Teachers expressed their perceptions of their own growth in mathematics pedagogical knowledge citing specific practices that they now appreciate, have honed, or in some cases have abandoned. The true value of their pedagogical growth is the realization that they can transfer these instructional practices into future classrooms.

> The project increased my understanding of how important talk is. I have learned about how to group kids and make sure the talk is effective and how to have them work in groups that will be effective and benefit them the most. We talked about the setting of the stage and the success criteria for working together – this is active listening…This is what is great about this – you use this at any grade level. I am an LTO and the team teaching was beneficial and some much can be carried on to wherever I go next. I learned how to group kids and this applies for any grade that you teach (Interview, Grade 3 Teacher 2E).
>
> I am constantly exploring and always asking why they don't get it? I refuse to teach algorithms and I look at them now and I realize that algorithms do not make sense. I was getting frustrated and over the last few years I have been shifting away from this. I refuse to teach them the way I was taught math. I teach math conceptually so they can solve it on their own. I won't introduce the algorithm until they understand where it came from (Interview, Grade 5 Teacher 2H).

Is there an Increase in Teachers' Self-efficacy in Mathematics Instruction?

Even after the first year in the project, teachers who did not regard themselves as strong mathematics teachers expressed burgeoning confidence in their instructional practices. Other teachers who had participated for two years in the project expressed major shifts in their practice to not only mathematics instruction but also language instruction.

> I know that I have put 100% or more into teaching math this year. I have a like for teaching math and I put more enthusiasm into teaching it now. I have always had a passion for teaching reading and writing. The kids noticed this and now they know that I excited when teaching math. I share this feeling with them (Interview, Grade 3 Teacher 3K).
>
> I am ten times the math teacher I was and I still don't feel like I am there. It is amazing to see how far I have to still to go (Interview, Grade 6 Teacher 5V).
>
> This experience has made me learn more about my own learning. I am not stale and always look for different approaches. This has shown me how many resources are out there and I need to take the time to read and get to know more about them. I am going into my 20th year of teaching. This is a new beginning for me and this is exciting. I have energy and I feel revitalized (Interview, Grade 3 Teacher 5V).
>
> When I started teaching 10 years ago I felt that I had to impart all this knowledge in a time crunch. Now I feel that I am a facilitator and the students don't want to hear from me. Now I question them and get them to talk. My eyes have been opened to this and I am now more effective as a math teacher. I also apply this to other subjects like language I think that I am doing this when I am teaching language too. Now with this model I am doing less teacher-directed teaching - this is learning curve (Interview, Grade 3 Teacher 5R).

The interventionists also evaluated their teaching experience in the JMI program as one that contributed positively to their self-efficacy in mathematics instruction. Finally, an interventionist succinctly summarized the learning derived from this initiative from multiple perspectives. As the students have demonstrated their understanding, teachers and interventionists have learned from them.

I feel more confident teaching mathematics because I can relate to what some of the students' issues are. Once you can feel how they feel, you're learning from them, they're learning from you and you are growing together as opposed to just teaching to a student (Interview, Interventionist 5MI).

I think I am a very effective teacher now, much more effective than I would have been if I hadn't been a part of this program. I am also a supply teacher and had to decide whether to take myself out of supplying for the days that I acted as an interventionist. I would not change that decision at all as it was a good investment in my future and in turn for my future students (Interview, Interventionist 2MIa).

I think that it is so important to train ourselves to view student work with the lens "Where are the students at in their learning/understanding?" as opposed to "At what level are they?" We have to be able to see what they know and relate that to the big ideas in math. Our next steps do not come from a textbook, but rather, from figuring out what their next steps are on the landscape of learning. We have to be willing to take a 'back road' rather than feel pressured to take the 'highway' to get to our final destination/goal. (Journal, Interventionist 2MIb, May 23/13)

What is the Impact on Teachers' Intentions for their Future Practice?

As teachers reflected on their JMI experience, they expressed their intentions moving forward into next year. Teachers in the project for the first year started to appreciate the use a professional resource to identify students' learning progressions and then differentiate instruction based on this trajectory. Further, another teacher anticipated how she will be able to use teaching through problem solving as she differentiates instruction for her split grade primary class next year.

The Landscape of Learning is a great resource. I need to familiarize myself with each part of the conceptual map. I will use the map to plan the next lesson especially when I am puzzled with the kids who are apparently not understanding a concept (Journal, Teacher 2H, May 23/13).

Next September, I will have a grade 2/3 split. I will use differentiated instruction and will keep them in similar groups so that they are working at their pace and ability. Depending on the class, I will give them the same math task and then just adjust the problem. It will work well in my future split class (Interview, Grade 3 Teacher 1A).

At the final plenary session, teachers wrote a reflection in their learning logs about personal goals for enhancing their mathematics instructional practices. Teachers were considering more deeply how to assess students' interactions during math talk and collaborative inquiry. The teachers were looking for assessment tools to capture "look for's" and anecdotal notes while these student interactions are taking place. The teachers were hopeful to create and display success criteria and exemplars of student responses.

During the introductory plenary I've loved shared my experiences with the Year 1 schools. The more I share, the more I realize that teaching math through 3-part problem solving has become a passion. I also recognize that I have a long way to go, especially with regards to assessment. I know that I need to specify my "look for's." I need to nail down my specific "look for's" in solid assessment forms (i.e. checklists). It's not just enough to assess after, but need to have ongoing anecdotals, information as the activity is happening (Journal, Teacher 5P, Nov. 26/12).

I need some form of template to record anecdotals of their communication while they are working in their pair/share because that is where they will be generating a lot of their rich dialogue (Journal, Teacher 4P, Feb. 4/13).

It is important that students work together interdependently to show that they are all contributing or that their voice has value. I also need to make it a point of checking kids understanding by doing more exit

cards to truly see if kids are applying math concepts and internalizing what has been learned (Journal, Teacher 5R, Apr. 4/13).

We will need a bank of open-ended and open-routed questions for students across all strands, for each age group and for all levels. We need success criteria to assess students' problem solving methods. An assessment tool for the communication of problem solving would benefit our students (Journal, Teacher 4N, Feb. 4/13).

Teachers also expressed how much they valued moderating student work with their colleagues. They also brainstormed ways to communicate with parents about student progress in mathematics by providing descriptive comments.

I hope to better develop rich tasks for my students and learn how to consistently assess my students. I am most looking forward to marking/assessing student work with my colleagues. I am curious if we can agree on a level 3/level 4 type answers in terms of the process and communication of the task. Perhaps examples will help me better assess and provide feedback to both students and parents (Journal, Teacher 4P, Dec. 4/12).

Grades don't tell the whole story and I use the report card comments differently to communicate progress to parents. I can comment on their child's misconceptions - I write this in the comments as it is next steps (Interview, Grade 4 Teacher 4M).

The teachers began to look at their parent community as a source of support for their practice in collaborative inquiry in mathematics. They expressed concern that not all parents understand why traditional algorithms are not being taught to their children. During some of the Facilitated Professional Learning Sessions, strategies for parent education are brainstormed and during the final plenary session this topic of discussion is revisited.

Today we discussed assessment practices in math and how it looks in the classroom. We also discussed the idea of accountability for our parents in explaining to them "marks" for students vs. descriptive feedback and what it looks like (Journal, Teacher 4N, Dec. 4/12).

Jasmine notes that we need to video record kids problem solving in the classroom and let parents see how they do this and how rich the discussion is (Fieldnotes, School 5, Session 2).

A professional resource is reviewed during the final plenary Facilitated Professional Learning session by Luciana. It is positioned as a reminder that students are on different paths for their learning of a particular concept. She draws an analogy to finding a path that has multiple guideposts and checkpoints. Principal 1P notes that this resource would be great to share at a parent's night to help explain some of the methods and vocabulary that students are learning. When doing math, parents need to be able to ask their child the question, "how do you know" and that they don't have to look for a standard answer or method to solve. This forces the students to constantly be inquirying (Fieldnotes, Final Plenary).

Next year, I will communicate to the parents about the problem solving process at the beginning of the school year. The kids need to know this and I will tell the parents about this. I will tell parents that in math we let them explore like they do in science and social studies. The process of inquiry has always been there in science (Interview, Grade 4/5 Teacher 1C).

My students believed that I was the one with the right answer. They would go home and their parents would confuse them by trying to help. They now appreciate different answers and teach their parents. We hosted a parent night and we had parents come in and say that they didn't understand the math that their child was learning. I told them to ask their child to simply explain the math (Interview, Grade 4 Teacher 4N).

One of the most salient and well-triangulated findings from Year 2 of this project is the recommendation that teaching mathematics through problem solving and intervening for students' misconceptions needs to begin early in the primary grades. The interventionists found it challenging to eradicate misconceptions with students in the later junior grades.

> Student misconceptions were entrenched by the older grades (grades 5 or 6) and were much harder to debunk…Grade 3 students were easier and more open to change (Fieldnotes, Interventionist Focus Group).

> I am also suggesting that intervention tutors be employed in the earlier grades, such as grade 1. The problem with these students is that it started with a misunderstanding of math concepts early on (Journal, Interventionist 2MIa).

> I find that the students in the older grades (grades 5 and 6) have similar misconceptions/gaps, whereas, there is more discrepancy between the areas of need in students in grades 3 and 4 (Journal, Interventionist 2MIb, Jan. 24/13).

> I have also noticed that the grade 6s are much more hesitant to use manipulatives or draw out their answer so I am making sure that we always talk about other ways to solve the problem (Journal, Interventionist 4MI, Apr. 8/13).

> In my experiences the younger students are more willing to try and learn concepts they are struggling with, especially if it's made into a fun activity (Journal, Interventionist 2MIa).

This recommendation was echoed by several teachers in their interviews, learning log reflections and during Facilitated Professional Learning Sessions.

> The resource teacher notes that the intervention project should begin earlier in Gr. 2 or 3 before the misconceptions are formed. Early mathematics concepts need to cited and teachers need help to recognize them when the gaps begin. Early intervention would make it easier to break misconceptions in their thinking (Fieldnotes, School 1, Session 4).

> The intervention is great but it needs to be in the primary grades - I have done primary grade teaching. These are the years when all the skills need to be set and then reinforced in the junior grades. These students have lost it somewhere along the way. The interventionists should work with the primary students (Interview, Grade 6 Teacher 2J).

> Luciana came to demonstrate how to administer a numeracy net checkpoint. Most children did not realize that the line segments must be straight! This problem should be easily rectified, however we are going to speak with teachers in SK, grade 1 and 2 to be sure that they are aware that their teaching may have to focus on this point (Journal, Teacher 3K, Nov. 29/13).

> Next year, I am pleased to be going to teach grade 4. I like the challenge of teaching this grade and this is closer to the action. I can make a difference with these younger students. I hope that we will take time as a staff and work with the primary teachers and look at what practices can be done. We have to find it a focus and there are many things that the interventionist was doing that can be done daily in the primary grades (Interview, Grade 5 Teacher 2H).

The facilitators concurred with what the interventionists and teachers saw as the benefits of early identification of students' misconceptions and gaps.

> The junior teachers feel the gaps are widening and there is a lot to target. They spend so much time undoing them. The younger primary students are not making grand generalizations yet because they are still in the stage of making conjectures and we can still undo the misconceptions. We can show them other strategies and help them evaluate what is or is not working. They need a backpack of strategies to choose

from and it does not have to be the standard algorithm. The older the students are the ones who are holding on more tightly to the algorithm (Interview, Facilitator Luciana).

Our focus in the math team next year needs to be on kindergarten to grade 2. We won't need interventionists in grade 3-6 if we stop the problems in k-2. I think of it this way: if a student comes out of grade 2 and can't blend 't' and 'h' together, there is lots of intervention taken, but if they can't count from 1 to2, nothing is really done (Interview, Facilitator Carlo).

Comparing Teachers' Practices and Beliefs: Years 1 and 2

What are the differences in practices and beliefs between the teachers who have had two years of professional learning and those teachers who have had one year?

As a function of the Facilitated Teacher Professional Learning Sessions, teachers at each school site worked together to write a collaborative inquiry question that would capture their mathematics instructional goals. This inquiry reflected the stage at which the school was at in this project – Year 1 or Year 2. The facilitators conjectured that an inquiry question is integral to pull together a staff of teachers and push them into sustaining a collaborative focus.

The focus of the session today and making our own inquiry question is very interesting! We chose a question that relates to the goals on our school improvement plain and one that the junior division teachers felt was important (Journal, Teacher 4O, Nov. 26/12).

For schools in the first year, it's basically moving through the motions and getting the mechanics down and required them to turn a light bulb on in their head. For schools in their second year, they can go deeper in to that learning. They are not just doing it to do it, they are doing it because they know that it's beneficial and moves the student learning forward. For Year 1 schools, we gave them the inquiry question, but Year 2 schools had to create it and now as schools move into Year 3, they should know what their inquiry is (Interview, Facilitator Carlo).

I knew the two Year 2 schools needed to have a solid inquiry question and I needed to work on this with them. I had to push with them to find the underlining issues that the teachers were finding and get this into the question. You have to hear all of the voices of all of the teachers and then you have something to work with. When you give a strategy like strings to a great staff they will get it. They need to realize that they have a wealth of skill in their building. But when a staff breaks up and moves then it is a true test of whether the learning can be sustained. I believe that they will sustain it. This staff has a level of collegiality. They were ripe for whatever learning could come their way. They had a focus on the learning of the students (Interview, Facilitator Jasmine).

Teachers in both years of the project expressed the value in viewing models of instruction. During Facilitated Teacher Professional Learning Sessions and the Plenary Sessions, video segments of exemplary instruction were viewed. As well, the facilitators acted as models of exemplary instruction teaching in classrooms to demonstrate high-yield practices. The Year 2 schools also served as models of instruction as teachers new to the project visited these sites, observed instruction and debriefed with their peers. Release time was given to teachers for all of these modelling and observing activities.

From our sharing session today I learned that all of us have a similar story regarding student learning –yes, I wanted to go "this direction" with a particular lesson, however due to students' misconceptions or gaps, I had to back track a bit or address them first. The video shown today reinforced how it is good to collaborate with a same grade teacher in your school and to moderate collaborative problem solving samples of student work (Journal, Teacher 2I, May23/13).

> Today I had the opportunity to observe a 3 part math lesson in a grade 3 class at School 5. I learned I could send a group member to go on a spy walk and report back to their group to help students verbalize and explain their math process (Journal, Teacher 1A, Apr. 4/13).

The teachers at the Year 2 schools were in a position to evaluate their students' performance and their own practices as a function of the second year of the project. They agreed that their second year of participation has solidified their professional learning and pedagogical practices as well as offered a consistent learning context for their students.

> We are in year 2 and have a comfort with this and the students are comfortable with having a choice to answer a question. They work well in pairs. These students were very reluctant in the first year. They actually started this when they were in grade 2 and they have familiarity, enthusiasm and comfort with the strategies. They original took only one way to solve a problem and now they take on a problem from many different angles (Interview, Grade 3 Teacher 5R).

> Since this is a Year 2 school, there has been carry over from last year. The resources were not new. I draw from all of them. Teaching through problem solving has been our focus and the success criteria that we established as a division. I do a lot of think pair share, Bansho and Gallery Walk. The advantage for me is that right away, in September, I knew what to look for and I was able to identify the student misconceptions and I targeted students. I applied the principles of JMI right from the beginning of the year. I was not confined to do it through the numeracy nets and did it through other open ended tasks and quick observations (Interview, Grade 4 Teacher 4M).

> Each teacher has different strategies as do the students. The journey is unique to all individuals but our goal is to be consistent with each other so the transition for students each year is much easier (Journal, Teacher 5U, Apr. 4/13).

An unexpected finding from the final plenary session was a reflection shared by the teachers about collaboration. Teachers expressed their appreciation and benefit of the time to collaborate and moderate with their colleagues. Interestingly, teachers from School 5 expressed that their students became aware of the collaboration among the staff and they believe that their students see their teachers as a more cohesive team. Students are viewing their teachers as a community of learners in the same way that the teachers are encouraging them to be a community of learners in math. A parallel is drawn to their Catholic community of learning as a whole.

> It was beneficial to collaborate with other teachers regarding student work. Being able to discuss student work that wasn't my own enabled me to see things in a different light. This was the same for the video that was shown. Collaboration has been the most beneficial to me within this initiative (Journal, Teacher 1E, May 23/13).

> I had forgot about my early days, putting everything into place with my students in order to develop an environment that's supportive of math talk, inquiry, problem solving, and collaborative team work. It seems so second nature today, but really, it wasn't always so. Today's session really made me appreciate how far we've come as a school and as individual educators. It made me appreciate even more my colleague. I've loved this experience. I'm excited to continue the math journey (Journal, Teacher 5P, May 15/13).

Additionally, the administrator from School 2 (Year 1) reflected on the collaborative inquiry focus of this project and positioned this in the overarching goal that she holds for her students.

> For the future and this project I would like the kids to know that they are 21st century learners and critical thinkers who can problem solving. I have said this to staff that it is not because of our students` lack of resources or the empty knapsacks or their mother's education, you can`t convince me that they will not score well or do well in this world. They come with the basic problem solving skills and let's figure out how we can pull out the problem solving skills so that they can walk away from this school with confidence and

they can be the 21st century learner in a collaborative society using technology. It is not about regurgitation of information anymore. This is a very passionate stance. My role is to ensure that everyone is here to help the kids and respect each other as professionals. I feed the staff to get them together and build a team and working together. I would like this project for a second year and we need to get the primary grades involved (Interview, Principal 2P).

Students' Achievement

Were there gains in students' (Grades 3-6) mathematics achievement as a function of the evidence-based intervention practices?

An interesting difference between the primary and junior students at School 5 (Year 2) emerged. Grade 3 teachers perceived that after two years in the program, their learners were confidently taking risks when solving problems. These students were introduced to the three part lessons when they were in grade 2. The upper junior teachers from School 5 remarked that despite the amount of time that they have devoted to developing a culture of math talk in their classrooms, their students were still cautious about taking risks when they were discussing solutions with their peers.

> All of my grade 3 students are more confident risk takers and this is reflective in their test marks. Through the open ended problems we challenge and question and now they feel free to ask questions. This is reflective in their discussions and their attitude has shifted. They don't have apprehensions now. I have notes about how much they love math and love the problems (Interview, Grade 3 Teacher 5Q).

> In some of the grade 3 classrooms that I have been in multiple times I got to know the kids and I remember greater depth of conversation and them articulating their thinking. They were confident in their thinking. What I saw was increased communication and justification for their thinking in this classroom. They have greater confidence in tackling a problem and they get an idea and go with it (Interview, Facilitator Luciana).

Students in School 5 were given a survey of their survey asking them about their math problem solving strategies, mathematics understanding, collaboration and talk in mathematics class, and mathematics self-efficacy. There was only one significant difference between males and females on their views about math talk from Time 1 (M=2.91, SD=1.25), (M=3.04, SD=1.26) to Time 2 (M=2.93, SD=1.21), (M=2.68, SD=.98), F(1, 90)=3.77, p=.055. This suggests that male students especially value math-talk in the classroom.

The student survey confirmed that the students were beginning to embrace collaboration among their peers. The following are comments from students in School 5:

> I feel comfortable asking questions because other kids listen.
> I like working in groups because you can see what other people think.
> There's more than one way to get an answer in math but they end up meaning the same thing.
> I like showing my answer to the class and explaining how I got my answer so I can help others in my class understand.
> I enjoy working in groups because I hear other peoples' ideas and hear feedback on my own ideas.
> I feel more willing to answer question in math because I'm able to use mental strategies to solve problems.
> Learning through problem solving helps me see how my classmates would answer questions in different ways.

When teachers reflected on their instructional practices they also evaluated their students` performance. They described their perceptions of their students` learning strategies, listening skills and confidence and then cited anecdotal evidence of changes.

> Being involved in this project has affirmed for me how to teach using the 3 part lessons. I am now doing more of these problems. I find that this helping the level 3 students move to a level 4… In my level 3 students and a couple of the level 2 students, I have seen a difference in their understanding of a problem and they are now pulling information from the question. I see that they have the strategies and tools and I can work with them on this (Interview, Grade 3 Teacher 3L).

> What I'm pleased about is how my students refer to the anchor charts and apply the sentence starters. My students feel more comfortable disagreeing with one another and linking ideas. My students are beginning to feel more comfortable taking risks when confronted by a problem. My students are becoming better listeners, more considerate listeners, and responding with genuine comments (Journal, Teacher 5P, Feb. 7/13).

> Gains in students' learning might not be with a paper and pencil test. The struggling students' minds sets have changed. Their attitudes have changed and I have changed the culture of math in their minds. The struggling students are more confident. I hope that this continues as they used to just give up. Now they can attempt a problem and even thought they might not do it at the same level, they are trying it. They are asking more questions. The questions are just like those that the high level students ask (Interview, Grade 6 Teacher 5V).

> One of my students was tuned out in math and she was off topic. Now she will participate more and use more appropriate math language. She is more focused and her confidence has grown in math. She knows that it is okay to have a different way to get to the solution. She is a girl with lots of friends and they take her answers more seriously - what she is saying is valid. She gets these affirmations from them (Interview, Grade 4 Teacher 4M).

A difference between the first and second year of this project, was the fact that teachers embraced teaching through problem solving to actually prepare grade 3 and 6 students for EQAO testing. Some of the teachers and interventionists anticipated achievement outcomes on students' EQAO performance. These teachers had perspective to recognize the transferability of problem solving skills that students engaged in as a function of the evidence-based instruction.

> My students are more comfortable and it might not show in their grades. They are confident and equipped with the tools that they need to do well. On EQAO they need to show their thinking – I find that level 4 students sometimes don't do this as they just want to go to the answer. What we have been doing now shows them how they are thinking. They used to put the conclusive statement down and it had no connection to their thinking. Now they will be writing down these connections. I am not worried as I have done a lot to prepare them for the EQAO responses (Interview, Grade 3 Teacher 5R).

> With EQAO coming up, I recognized that the grade 6 students that I was working with needed to be strong in their number sense to see what the question is asking and how to respond to it. The grade 6 teacher saw great change from the first practice EQAO test they took to the one they took recently. Students can now look at a question and know what strategies to use (Interview, Interventionist 5MI).

The results of the quantitative analyses computed using the students` report card data are displayed in **Tables 3. and 4**. Table 3. provides a summary of significant findings of the Repeated Measures ANOVA (Within Subjects) analyses for each of the five mathematics strands. Results are displayed when scores for all schools are combined together and then when the five schools are analyzed separately. There is an interpretation of the significant results in the final column.

Number Sense and Numeration	**Repeated Measures ANOVA (Within Subjects)**	**Interpretation of Significant Results**
School 5	$F(1, 124)=3.81$, $p=.05$	Scores from June/13 (M=78.48)are significantly higher than scores from Jan./13 (M=77.61)
Geometry and Spatial Sense	**Repeated Measures ANOVA**	
School 1	$F(1,90)=21.57$, $p=<.001$	Scores from June/13 (M=77.68)are significantly higher than scores from Jan./13 (M=74.74)
School 3	$F(1,40)=12.42$, $p=.001$	Scores from June/13 (M=77.07)are significantly higher than scores from Jan./13 (M=75.05)
School 4	$F(1,98)=5.72$, $p=.02$	Scores from June/13 (M=77.37)are significantly higher than scores from Jan./13 (M=75.68)
School 5	$F(1,93)=19.69$, $p=<.001$	Scores from June/13 (M=79.91)are significantly higher than scores from Jan./13 (M=77.94)
All Schools Combined	$F(1,409)=25.03$, $p=<.001$	Scores from June/13 (M=77.83)are significantly higher than scores from Jan./13 (M=76.34)
Data Management and Probability	**Repeated Measures ANOVA**	
School 5	$F(1, 67)=11.98$, $p=.001$	Scores from June/13 (M=78.12)are significantly higher than scores from Jan./13 (M=76.07)
All Schools Combined	$F(1, 363)=8.03$, $p=.005$	Scores from June/13 (M=78.01)are significantly higher than scores from Jan./13 (M=77.11)
Patterning and Algebra	**Repeated Measures ANOVA**	**Interpretation of Significant Results**
School 1	$F(1,70)=23.37$, $p=<.001$	Scores from June/13 (M=75.23)are significantly higher than scores from Jan./13 (M=71.97)
School 2	$F(1,58)=4.91$, $p=.001$	Scores from June/13 (M=79.75)are significantly higher than scores from Jan./13 (M=78.08)
School 4	$F(1,98)=12.42$, $p=.001$	Scores from June/13 (M=77.73)are significantly higher than scores from Jan./13 (M=74.83)
School 5	$F(1,124)=12.23$, $p=<.001$	Scores from June/13 (M=78.26)are significantly higher than scores from Jan./13 (M=77.10)
All Schools Combined	$F(1,393)=26.82$, $p=<.001$	Scores from June/13 (M=77.37)are significantly higher than scores from Jan./13 (M=75.79)

Table 3. Repeated Measures ANOVA (Within Subjects): Mathematics strands for all schools combined, separate and interpretation of the significant results

Table 3**.** has summarized 13 statistically significant changes in students` scores for strands in Number Sense and Numeration, Geometry and Spatial Sense, Data Management and Probability, and Patterning and Algebra. Readers are cautioned to the limitations that not all mathematics strands were taught within the duration of the project and some data are missing (i.e., not reported on in all terms).

Table 4. provides a summary of the Repeated Measures ANOVA (Between Subjects) analyses for each of the five mathematics strands. Only the statistically significant results are displayed for the main

and interaction effects. There are significant results when scores for all schools are combined together and then when the five schools are analyzed separately. There is an interpretation of the significant results in the final column.

Numeric Sense and Numeration All Schools Combined	
Repeated Measures ANOVA	**Significant Results Explained**
F(3, 469)=2.66, p=.05, $\eta^{2=}$.02	Overall, Grade 6 students made the most growth from T2(M=78.15) than T1(M=76.90)
F(1, 470)=38859.77, p=<.001, $\eta^{2=}$.19	Overall, tutored students were higher in T2(M=70.63.) than T1 (M=69.90)
Numeric Sense and Numeration School 1	
Repeated Measures ANOVA	**Significant Results Explained**
F(1, 90)=18.82, p=<.001 $\eta^{2=}$.17., $\eta^{2=}$.17	Non-tutored students showed significant growth T1 (M=75.68) to T2 (M=76.68)
Numeric Sense and Numeration School 2	
Repeated Measures ANOVA	**Significant Results Explained**
F(1, 114)=19.08, p=.001, $\eta^{2=}$.14	Tutored students showed significant decline T1 (M=72.88) to T2 (M=71.88)
Numeric Sense and Numeration School 3	
Repeated Measures ANOVA	**Significant Results Explained**
F(1, 39)=9.25, p=.004, $\eta^{2=}$.19	Non-tutored students showed significant growth T1 (M=75.75) to T2 (M=77.38)
Numeric Sense and Numeration School 4	
Repeated Measures ANOVA	**Significant Results Explained**
F(1, 96)=47.16, p=<.001, $\eta^{2=}$.33 F(1, 94)=3.91, p=.051, $\eta^{2=}$.04	Tutored students showed significant growth T1 (M=67.96) to T2 (M=70.38) Female, tutored students at School 4 showed significant growth T1 (M=65.92) to T2 (M=69.00)
Numeric Sense and Numeration School 5	
Repeated Measures ANOVA	**Significant Results Explained**
F(1, 123)=21.95, p=<.001 F(3, 121)=3.34, p=.022, $\eta^{2=}$.07	Tutored students showed significant growth T1 (M=70.40) to T2 (M=71.90) Students in Grade 4 at School 5 showed the most significant increase from T1 (M=80.48) to T2 (81.84)
Measurement All schools combined	
Repeated Measures ANOVA	**Significant Results Explained**
F(1, 148)=38.58, p=<.001, $\eta^{2=}$.21	Overall, non-tutored students were higher in T2(M=78.62) than T1 (M=77.88)
F(3, 147)=4.09, p=.008, $\eta^{2=}$.08	Overall, Grade 4 students made the most growth from T2(M=73.55) than T1(M=72.97)
Measurement School 2	
Repeated Measures ANOVA	**Significant Results Explained**
F(1, 28)=7.74, p=.010, $\eta^{2=}$.21	Tutored students showed significant growth T1 (M=73.50) to T2 (M=74.40)
F(1, 361)=69.91, p=<.001, $\eta^{2=}$.16	Female, tutored students at School 2 showed significant growth T1 (M=71.78) to T2 (M=73.13)
Measurement School 3	
Repeated Measures ANOVA	**Significant Results Explained**
F(1, 18)=12.10, p=.003, $\eta^{2=}$.40	Tutored students showed significant decline T1 (M=72.50) to T2

	(M=68.25)
Measurement School 4	
Repeated Measures ANOVA	**Significant Results Explained**
F(1, 96)=22.91, p=<.001, $\eta^{2=}$.19	Tutored students showed significant growth T1 (M=70.58) to T2 (M=71.46)
	Students in Grade 4 at School 4 showed the most significant increase from T1 (M=72.97) to T2 (73.55)
Geometry and Spatial Sense All Schools Combined	
Repeated Measures ANOVA	**Significant Results Explained**
F(1, 407)=75.38, p=<.001, $\eta^{2=}$.16	Overall, tutored students showed significant growth T1 (M=71.58) to T2 (M=73.20)
Geometry and Spatial Sense School 1 Only	
Repeated Measures ANOVA	**Significant Results Explained**
F(1, 89)=8.02, p=<.001, $\eta^{2=}$.08	Tutored students showed significant growth T1 (M=71.56) to T2 (M=75.74)
Geometry and Spatial Sense School 2 Only	
Repeated Measures ANOVA	**Significant Results Explained**
F(1, 83)=14.82, p=<.001, $\eta^{2=}$.15	Non-tutored students showed significant decline T1 (M=79.01) to T2 (M=77.83)
Geometry and Spatial Sense School 3 Only	
Repeated Measures ANOVA	**Significant Results Explained**
F(1, 39)=4.91, p=.033, $\eta^{2=}$.11	Non-tutored students showed significant growth T1 (M=76.00) to T2 (M=78.22)
Geometry and Spatial Sense School 4 Only	
Repeated Measures ANOVA	**Significant Results Explained**
F(1, 98)=5.72, p=.019, $\eta^{2=}$.19	Tutored students showed significant growth T1 (M=75.68) to T2 (M=77.37)
Geometry and Spatial Sense School 5 Only	
Repeated Measures ANOVA	**Significant Results Explained**
F(1, 92)=22.80, p=<.001, $\eta^{2=}$.20	Tutored students showed significant growth T1 (M=70.00) to T2 (M=75.13)
Data Management and Probability All Schools Combined	
Repeated Measures ANOVA	**Significant Results Explained**
F(1, 361)=69.91, p=<.001, $\eta^{2=}$.16	Tutored students showed significant growth T1 (M=71.78) to T2 (M=73.13)
Data Management and Probability School 1 Only	
Repeated Measures ANOVA	**Significant Results Explained**
F(1, 44)=3.36, p=.07, $\eta^{2=}$.07	Tutored students showed significant growth T1 (M=72.67) to T2 (M=74.56)
Data Management and Probability School 2 Only	
Repeated Measures ANOVA	**Significant Results Explained**
F(1, 110)=27.63, p=<.001, $\eta^{2=}$.20	Tutored students showed significant growth T1 (M=70.52) to T2 (M=74.40)
F(3, 108)=3.43, p=.020, $\eta^{2=}$.09	Students in Grade 5 at School 2 showed the most significant increase from T1 (M=74.07) to T2 (77.27)
Data Management and Probability School 3 Only	
Repeated Measures ANOVA	**Significant Results Explained**
F(1, 38)=1.20, p=.047, $\eta^{2=}$.09	Tutored students showed significant growth T1 (M=72.88) to T2 (M=73.63)
Data Management and Probability School 4 Only	
Repeated Measures ANOVA	**Significant Results Explained**
F(1, 95)=35.40, p=<.001,	Tutored students showed significant decline T1 (M=72.50) to T2

$\eta^{2=}$.27	(M=70.85)
F(2, 95)=3.27, *p*=.042, $\eta^{2=}$.06	Students in Grade 4 at School 4 showed the most significant increase from T1 (M=73.10) to T2 (77.66)
Data Management and Probability School 5 Only	
Repeated Measures ANOVA	**Significant Results Explained**
F(1, 66)=6.70, *p*=.012, $\eta^{2=}$.09	Tutored students showed significant growth T1 (M=71.45) to T2 (M=74.09)
F(1, 66)=9.45, *p*=.003, $\eta^{2=}$.13	Students in Grade 3 at School 5 showed the most significant increase from T1 (M=78.00) to T2 (80.24)
Patterning and Algebra All schools combined	
Repeated Measures ANOVA	**Significant Results Explained**
F(1, 391)=66.12, *p*=<.001, $\eta^{2=}$.15	Tutored students showed significant growth T1 (M=71.58) to T2 (M=73.20)
Patterning and Algebra School 1 Only	
Repeated Measures ANOVA	**Significant Results Explained**
F(1, 69)=11.71, *p*=.001, $\eta^{2=}$.15	Tutored students showed significant growth T1 (M=67.09) to T2 (M=72.77)
Patterning and Algebra School 2 Only	
Repeated Measures ANOVA	**Significant Results Explained**
F(1, 57)=7.48, *p*=.008, $\eta^{2=}$.12	Non-tutored students showed significant decline T1 (M=81.30) to T2 (M=79.21)
F(1, 55)=4.53, *p*=.038, $\eta^{2=}$.08	Female, non-tutored students at School 2 showed significant decline T1 (M=81.13) to T2 (M=77.30)
Patterning and Algebra School 4 Only	
Repeated Measures ANOVA	**Significant Results Explained**
F(1, 96)=27.15, *p*=<.001, $\eta^{2=}$.22	Non-tutored students showed significant growth T1 (M=76.74) to T2 (M=79.56)
Patterning and Algebra School 5 Only	
Repeated Measures ANOVA	**Significant Results Explained**
F(1, 123)=22.69, *p*=<.001, $\eta^{2=}$.16	Tutored students showed significant growth T1 (M=70.20) to T2 (M=71.80)
F(3, 121)=6.34, *p*=.001, $\eta^{2=}$.14	Students in Grade 4 at School 5 showed the most significant increase from T1 (M=81.24) to T2 (83.24)

Table 4. Repeated Measures ANOVA (Between Subjects): Mathematics strands for all schools combined, separate and interpretation of the significant results

Table 4**.** has summarized statistically significant changes in students` scores for all strands in mathematics. Results varied widely by schools, genders and those students that were tutored. Again, readers are cautioned to the limitations that not all mathematics strands were taught within the duration of the project and some data are missing (i.e., not reported on in all terms).

In Number Sense and Numeration, overall when schools are combined, tutored students showed significant growth – this was especially the case for Grade 6 students overall, and Grade 4 students at School 5 and female students at School 4. In Number Sense and Numeration, specific schools showed significant growth for tutored students (Schools 4 and 5) while other schools showed significant growth for non-tutored students.

For the Measurement strand, overall when schools are combined, non-tutored students showed significant growth – this was especially the case for Grade 4 students and Grade 4 students at School 4

and female students at School 2. In Measurement, specific schools showed significant growth for tutored students (Schools 2 and 4).

In Geometry and Spatial Sense, overall when schools are combined, tutored students showed significant growth. Specific schools showed significant growth for tutored students (Schools 1,4 and 5) while other schools showed significant growth for non-tutored students (School 3) and significant decline for non-tutored students (School 2).

In Data Management and Probability, overall when schools are combined, tutored students showed significant growth – this was especially the case for Grade 5 students at School 2, Grade 4 students at School 4 and Grade 3 students at School 5. In Data Management and Probability, specific schools showed significant growth for tutored students (Schools 1, 2, 3, and 5) while other School 4 showed significant decline for tutored students.

Finally, for Patterning and Algebra, overall when schools are combined, tutored students showed significant growth – this was especially the case for Grade 4 students at School 5. Interestingly, female students at School 2 who were not tutored showed a significant decline. In Patterning and Algebra, specific schools showed significant growth for tutored students (Schools 1 and 5) while other schools showed significant growth for non-tutored students (School 4) and significant decline for non-tutored students (School 2).

Limitations

There are limitations declared within any form of educational research that might impact the comprehensiveness of the findings and generalizability to other educational settings. For example, Likert-scale surveys such as the one used to capture teachers' beliefs about mathematics instruction and the students' beliefs about learning math, possess natural internal biases when participants self-report their responses. Similarly, teacher and interventionist participants who kept learning logs and were interviewed might have filtered their responses toward a perceived confirmation of the positive effect of participating in a program. Other limitations of this research include generalizability which is based on the reality that this research took place in a medium-sized school board with a small number of teacher participants.

The student report card data presented limitations to the analyses as in some cases it was incomplete as teachers did not report on all strands in mathematics in both Terms 1 and 2. This renders the analyses invalid in some cases (notes have been made in the above tables to this effect). Additionally, there is the potential for a limitation to the instructional validity of the results of the student achievement data based on the fact that not all mathematics strands were the focus of the interventionists; they targeted misconceptions in number sense and numeration. The analyses of student achievement could be more rigorous if teacher participants agreed to report on the same strands in Term 1 and Term 2. Overall, the experimental design of this research could be enhanced with the inclusion of a student (non-intervention) control group. Finally, there is a lack of data from the perspective of the student learners in situ. Teachers commented on students` attitudes and behaviours; it would be optimal to garner the students` voices and examine their learning in the classroom.

Next Steps

Lessons Learned: Implications for Practice

The research summarized here offers a unique perspective as it is founded on two years of implementation of the *Junior Math Interventions* project. This timeframe affords stakeholders with findings based on a comparison between schools involved in the project (either one or two years). Unequivocally, the derived benefits from two years of participation are apparent. Teachers in the Year 2 schools cohesively focused on a collaborative inquiry to enhance teaching through problem solving and they were able to move their instructional practice forward. Their students experienced consistency in mathematics pedagogy and actually recognized the collaboration among their teachers. This implies that this type of professional learning program MUST occur over the course of two academic years and include total division/staff commitment.

Teachers from the schools who have participated for two years should be periodically released to engage in ongoing professional dialogue to validate their progress. They could also be enlisted as partners in professional learning facilitation and act as demonstration model sites. Additionally, it is important to note that their professional learning and self-efficacy gains need to be revisited and acknowledged. A study conducted five years post-reform, suggested that elementary teachers' self-efficacy about mathematics teaching affects their continued practice throughout the post-professional learning implementation. Teachers continue to reflect back on their pre-reform instructional approaches when they incur challenges to their new practices (Charalambous & Philippou, 2010).

Facilitators are reminded that when working with teachers who are participating for the first year in a professional learning project, that beliefs and attitudes about mathematics instruction need to be recognized. This is an ongoing pursuit as teachers` own practices begin to change, their beliefs will be challenged and cognitive dissonance will ensue. Facilitators need to be acutely aware of the discomfort associated with cognitive dissonance, perceived loss of control, and resistance to change that some teachers exhibit.

At the beginning of an academic school year, JMI project start-up should include some key foundations. School staff should be guided by a facilitator to decide on a collaborative inquiry that will drive their professional learning for the year. All schools involved in the project should have professional learning on how to use the *Numeracy Nets* as a diagnostic at the beginning of the school year. This will contribute to early identification of misconceptions for teachers to subsequently program for, and it will help to identify students who will benefit from intervention support. Curriculum mapping and collapsing expectations into groupings to be taught concurrently should be one of the first staff team building exercises – this will also accentuate natural collaborations among adjacent grade partners. Within the classroom, teachers should devote the first three months of the school year to building a math-talk culture and methods for students to work in cooperative groups. Teachers should work with strategies that address physical room set-up, respect, social skills, listening, speaking and role-taking.

Teachers in both Year 1 and Year 2 schools stated that the time that they were allocated to co-plan with their teaching partners was invaluable to share their knowledge and plan to move forward. They regarded this piece as having an impact on both their practice and their students' learning. As they described this professional dialogue, they also included descriptions of the moderation of student work that they engaged in with their teaching partners. This was seen as an inherent component of co-planning and implicitly communicated their assumption of a seamless connection between assessment and instruction. The self-determination that teachers were granted to determine the path of their own professional learning was one of the key contributors to the perceived effect of this component of the

project. Release time for co-planning is an essential aspect of the project that teachers will continue to derive benefit from in the future.

On-going resources for teachers should include a menu of high-yield strategies for them to draw on to support collaborative inquiry and communication among their students. In a similar vein, teachers might appreciate a repository of sample open-ended and open-routed inquiry questions. Since the mathematics textbook is not being comprehensively used, it might be reviewed to identify effective questions and these posted on-line for teachers to access. Teachers are also eager to have access to assessment measures/tools and training on how to take observations and anecdotal notes. Following such affordances, teachers need to use these assessments, then moderate use of these tools and discuss instructional implications.

A very significant implication for practice is the continued deployment of mathematics interventionists and refinement of their role. Sustaining the support of interventionists during subsequent years of this project should be a goal. These educators are invaluable and should be included ubiquitously in their assigned schools: interventionists should participate in doing *Numeracy Nets*, observing in classrooms and building rapport with students. Communication between the interventionist and the teachers needs to be delineated in order to establish a rhythm for uncovering skill gaps, working individually and in small groups with targeted students and remediating for their challenges. Interventionists should be included in all professional learning sessions and also given ample resources (professional and instructional) as added value for their contribution. The interventionists may or may not focus exclusively on number sense and numeracy concepts. During the present year, the interventionists recognized the co-dependent nature of supporting students' numeracy knowledge and skills and their global mathematics learning needs.

Finally, the most important implication for future practice is that teaching through problem solving with collaborative inquiry begin in primary division classrooms and intervention support for struggling math students begin as early as grade 1. The teachers, interventionists, and facilitators recognized that students' lack confidence in mathematics most likely stems from early learning challenges and uncorrected misconceptions. Primary division implementation will support students' early learning success in mathematics, encourage risk-taking during problem solving, and inoculate against poor self-efficacy as a math learner.

Implications for Future Research

Longitudinal research tracking the effects of teacher professional learning on both educators` practice and students` achievement is rare in educational research. An opportunity exists for a sustained investigation into the program of mathematics professional learning that has been presented herein. The teachers that have served as participants for this portion of the project are well-positioned to further enhance their mathematics instruction and be tracked into the next academic year. This poses interesting prospects as some teachers enter their first, second or third year of the project. The achievement of their former and present students could also be studied. The research design could be extended to include additional teachers who might be mentored by the experienced ones. This type of parallel professional learning is collegial and affirming for all participants and would make a significant contribution to the research literature.

Moving Forward: Our Plan of Action for 2013-2014

The following are steps that NCDSB may take next year in response to these lessons and to address the remaining implications:

- continue JMI research framework to provide a 2nd year of development for JMI school sites that were new in 2012-13. Provide on-going support as they delve into their own teacher professional inquiry.
- periodically follow-up with former JMI schools to provide support for teacher driven collaborative inquiry
- build system capacity by using former JMI project schools as model or demonstration sites.
- introduce JMI project to two new SIM school sites for 2013-14. Emphasis in JMI facilitated sessions for first year schools must include:
    - Setting the classroom culture (respectful speaking and listening, physical environment, etc.
    - Curriculum mapping of content to show interconnectedness of concepts
    - Co-administering *Numeracy Nets* with coach, teacher and interventionist
    - List of additional high-yield strategies that support teaching through problem solving
- all teachers in JMI should also have an opportunity to co-plan and co-teach with a numeracy coach and learn to take observational and anecdotal notes
- delve deeper into Cathy Fosnot's *Landscape of Learning* in facilitated sessions as an *assessment for learning*
- provide professional development for primary teachers in JMI schools, developing number sense and numeration pedagogical content knowledge
- continue use of financial resources in 'Tutor' program to develop Interventionists with mathematics content and pedagogical expertise
- assign 'Interventionists' to schools outside of JMI project if they are willing and able to create 'numerate pictures' for targeted students.

Below, **Table 5.** provides a description of the proposed components of the JMI Coaching Focus Framework (2013-2014). **Table 6.** provides an overview of the proposed addition of a Primary Teacher Initiative. Finally, **Table 7.** provides an associated Budget Request for 2013-2014.

Year One Schools	***Year Two Schools***
Cycle #1: October	

• Co-administer Numeracy Nets
• Moderation of Numeracy Nets
• Creation of numerate picture of target students
• Getting Ready for Problem Solving (Classroom Norms etc.)
• Set short term goal for next session
	• Revisit school developed Collaborative inquiry If-Then statement
	• Administer numeracy net to create numerate picture of student(s) targeted for intervention
	• Set short term goals including:
	  ○ Classroom Norms etc.
	  ○ Refresher on Co-teaching/Co-planning 3-part lessons
	  ○ Focus on consolidation of 3-part lesson

Cycle #2: November / December	
• Check on short term goal & numerate picture • Interventionist begins work with students focused on targeted misconceptions stated in Numerate picture • Co-teaching/Co-planning 3-part lessons based on Numeracy Nets • Content PD	• Check on short term goals - teachers to bring classroom evidence of goal • Review numerate pictures • Interventionist begins work with students focused on targeted misconceptions stated in Numerate picture • Determine next phase in If-Then statement • Content PD or strategy PD to ensure that all are able to achieve next phase of goal • Set short term goal & evidence of achievement

Cycle #3: January / February	
• Check on short term goal • Interventionist continues work with students focused on targeted misconceptions stated in Numerate picture • Co-teaching/Co-planning 3-part lessons based on Numeracy Nets • Content PD	• Repeat cycle
Cycle #4: March / April / May	
• Check on short term goal • Interventionist continues work with students focused on targeted misconceptions stated in Numerate picture • Co-teaching/Co-planning 3-part lessons based on Numeracy Nets • Content PD	• Repeat cycle • Create presentation of Collaborative inquiry journey complete with evidence & next steps to share at final session

Table 5. JMI Coaching Focus Framework (2013-2014)

Target Group: Primary Teachers in all JMI Schools	**Focus: Develop Number sense & numeration content and pedagogical strategy expertise**
3 days/teacher @ ½ day intervals Combination of whole group & school based sessions May coincide with JMI facilitated sessions ie. (AM/PM)	• Learning trajectories (Doug Clements) • Use Cathy Fosnot's Landscape of Learning place value, addition & subtraction • Games and strings

Table 6. Primary Teacher Initiative

Item #	Units	Description	Analysis	Cost/unit	Total
1	8 days	**Teacher Release Days**	36 teachers x $245	**$8820**	**$70560**
2	3 days	**Primary Teacher Development**	12 teachers x $245	**$2940**	**$8820**
3		**Resources Needed for Year 1 Schools**			
	20	One copy per teacher of *Big Ideas* from Small	20 teachers	**$70**	**$1400**
	8	One set of Van de Walle's *Teaching Student-Centred Mathematics* per school	2 Year 1 schools 6 interventionists	**$80**	**$640**
		manipulative/supplies cart for interventionists			**$1000**
4	4	**Intervention Tutor Wages for 1 Year 36 weeks 6hrs/week x 36 weeks**	$5400/tutor x 4	**$5400**	**$21600**
5	4	**Intervention Tutor Wages for 1 Year** 4 additional schools to be supported by interventionist only (2 previous JMI schools & 2 schools outside project)	$5400/tutor x 4	**$5400**	**$21600**
6	8	**Interventionist training sessions ½ day monthly**	10 months x 8 interventionists x ½ day	**$600 x 10 mos**	**$6000**
					$131620

Table 7. Budget Request for 2013-2014

References

Barlow, A. & Cates, J. (2006). The impact of problem posing on elementary teachers' beliefs about mathematics and mathematics teaching. *School Science and Mathematics*, *106* (20), 64-73.

Bauman, K. (2009). *Ontario numeracy nets: Grades 3-6.* Toronto: Pearson Education Canada.

Beghetto, R. & Baxter, J. (2012). Exploring student beliefs and understanding in elementary science and mathematics. *Journal of Research in Science Teaching, 49*(7), 942-960.

Bruce, C. & Flynn, T. (2011). Which is greater: One half or two fourths? An examination of how two grade 1 students negotiate meaning. *Canadian Journal of Science, Mathematics & Technology Education*, *11*(4), 309-327.

Charalambous, C. & Philippou, G. (2010). Teachers' concerns and efficacy beliefs about implementing a mathematics curriculum reform: integrating two lines of inquiry. *Educational Studies in Mathematics, 75*, 1–21.

Elmore, R. (2009). *Instructional rounds in education*. Cambridge: Harvard Education Press.

Foong, P. Y., & Perry, B. (1998). Proportional reasoning and mathematical beliefs of student teachers from Singapore and Australia. *The Mathematics Educator, 3*(2), 38-53.

Fosnot, C. T., & Dolk, M. (2001). *Young mathematicians at work: Constructing number sense addition and subtraction.* Portsmouth NH: Heinemann.

Hufferd-Ackles, K., Fuson, K., & Sherin, M. (2004). Describing levels and components of a math-talk learning community. *Journal for Research in Mathematics Education*, *35*(2), 81-116.

Hye, Y. & Reifel, S. (2011). Promoting children's communication: A Kindergarten teacher's conception and practice of effective mathematics Instruction. *Journal of Research in Childhood Education*, *25* (2), 194-210.

Inoue, N. & Buczynki, S. (2011). You asked open-ended questions, now what? Understanding the nature of stumbling blocks in teaching inquiry lessons. *Mathematics Educator*, *20*(2), 10-23.

Kramarski, B. (2009). Developing a pedagogical problem solving view for mathematics teachers with two reflection programs. *International Electronic Journal of Elementary Education, 2*(1), 137-153.

Knott, L. (2010). Problem posing from the foundations of mathematics. *Montana Mathematics Enthusiast, 7* (2/3), 413-432.

Merriam, S. B. (2001). *Qualitative research and case study applications in education (2nd Ed.*). Jossey-Bass.

Mercer, N. & Sams, C. (2006). Teaching children how to use language to solve maths problems. *Language & Education: An International Journal*, *20*(6), 507-528.

Ministry of Education. (2010). Assessment for learning and as learning. *Growing success: Assessment, evaluation, and reporting in Ontario schools,* 27-36.

Ministry of Education. (2010). *School Effectiveness Framework. Components, Indicators and Evidence, 11-37.*

Ministry of Education. (2011). *Paying Attention to Mathematics.*

Obara, S. & Sloan, M. (2009). The evolving role of a mathematics coach during the implementation of performance standards*. Professional Educator*, *33*(2), 11-23.

Parks, A. (2010). Explicit versus implicit questioning: Inviting all children to think mathematically. *Teachers College Record, 112*(7), 1871-1896.

Perry, B., Howard, P., & Tracey, D. (1999). Head mathematics teachers' beliefs about the learning and teaching of mathematics. *Mathematics Education Research Journal, 11*, 39-53.

Perry, B., Vistro-Yu, C., Howard, P., Wong, N-Y., & Fong, H. K. (2002). Beliefs of primary teachers about mathematics and its teaching and learning: Views of Singapore, Philippines, mainland China, Hong Kong, Taiwan and Australia. In B. Barton, K. Irwin, M. Pfannkuch, & M. Thomas (Eds.), *Mathematics education in the South Pacific* (Proceedings of the 25th annual conference of the Mathematics Education Research Group of Australasia, Vol. 2, pp. 551-558). Sydney: MERGA.

Perry, B., Wong, N. Y., & Howard, P. (2006). Comparing primary and secondary mathematics teachers' beliefs about mathematics, mathematics learning and mathematics teaching in Hong Kong and Australia. In K. D. Graf, F. K. S. Leung, & F. Lopez-Real (Eds.), *Mathematics education in different cultural traditions: A comparative study of East Asia and the West* (pp. 435-448). New York: Springer.

Piccolo, D., Harbaugh, A., Carter, T., Capraro, M., & Capraro, R. (2008). Quality of instruction: examining discourse in middle school mathematics instruction. *Journal of Advanced Academics*, *19(*3), 376-410.

Quillen, M.A. (2005). Relationships among prospective elementary teachers' beliefs about mathematics, mathematics content knowledge, and previous mathematics course experiences. http://scholar.lib.vt.edu/theses/available/etd-03252004-144145/unrestricted/Quillen_Dissertation.pdf

Sakshaug, L. & Wohlhuter, K. (2010). Journey toward teaching mathematics through problem solving. *School Science & Mathematics, 110*(8), 397-409.

Small, M. (2009). *Big ideas from Dr. Small: Grades K-3; 4-8.* Toronto: Nelson Education.

SPSS Software. (2011). *PASW statistics 19.0.* Chicago, IL: SPSS Inc.

Stake, R. E. (1995). *The art of case study research*. Sage Publications.

Stake, R. E. (2006). *Multiple case study analysis.* The Guilford Press.

Turner, F. (2009). Growth in teacher knowledge: individual reflection and community participation. *Research in Mathematics Education, 11*(1), 81-82.

Van de Walle, J. & Lovin, L. (2006). *Teaching student-centred mathematics: Volumes 1-3.* Toronto: Pearson Education.

Vanderhye, C. & Demers, C. (2008). Assessing students' understanding through conversations. *Teaching Children Mathematics, 14*(5), 260-264.

Warfield, J., Wood, T., & Lehman, J. (2005). Autonomy, beliefs and the learning of elementary mathematics teachers, *Teaching & Teacher Education*, *21*(4), 439-456.

White, Way, Perry & Southwell, 2005). Mathematical Attitudes, Beliefs and Achievement in Primary Pre-service Mathematics Teacher Education. *Mathematics Teacher Education and Development*, Vol. 7, 33–52. http://www.merga.net.au/documents/MTED_7_White.pdf.

Wilkins, J. (2008). The relationship among elementary teachers' content knowledge, attitudes, beliefs, and practices. *Journal of Math Teacher Education, 11,* 139–164.

Yin, R. K. (2009). *Case study research: Design and methods (Applied Social Research Methods)* (4th Ed.). Sage Publications.

Yin, R. K. (2004). *Applications of case study research*. Sage Publications.

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