Final Report for the Literacy and Numeracy Secretariat:

Niagara Catholic District School Board's Junior Mathematics Interventions Project

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EXECUTIVE SUMMARY

Background

Teachers hold distinct beliefs about how the relationship between the teacher, the student and the content affects the instructional core (Elmore, 2009). Educational research points to the need to support junior level teachers' professional learning in mathematics problem-solving teaching methods while attending to their beliefs and attitudes about mathematics instruction as well as honouring their content knowledge and experience. Reflection enables teachers to improve their skills, beliefs and perceptions of mathematics teaching and is an overall facilitator of teacher development (Turner, 2009). It is commonly held that supporting the practice and confidence of teachers to instruct mathematics through problem solving takes time.

The Niagara District School Board (NCDSB)*Junior Interventions Project* focused on developing teachers' effective use of diagnostic assessment to identify student misconceptions and drive their instruction of mathematics. 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 coaching. The Facilitators led all professional learning sessions and offered 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 Intervention Coach and three Facilitators. 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. The Intervention Coach was devoted to providing one-on-one mathematics instruction for students targeted by their classroom teachers.

The research was an evaluative case study with the purpose to inquire into an educational program in order to determine its effectiveness. There were five research questions that related to teachers' practices and beliefs, and students' achievement. Quantitative and qualitative data (surveys, interviews, field notes, journals, report card data) were collected from three sets of participants: teachers, facilitators and students. There were 22 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 coaching. All participants (teacher participants, facilitators, parents/guardians of students) signed informed consent forms.

Findings

Beliefs and attitudes about mathematics learning and teaching were shared by the teacher participants. Acknowledging and altering deeply entrenched prior learning experiences as a student is a challenging prospect for any teacher. These beliefs inform teachers' conceptualizations of the relationship between the teacher, the student and the content. The Facilitators of this project honoured and worked with teachers' beliefs systems and teachers shifted toward problem-based methods.

From the beginning of the Junior Interventions Program, the Facilitators recognized that they needed to offer explicit content knowledge support for the teachers and the teachers responded favourably to how this was incorporated into sessions. The Intervention Coach worked with targeted students, and he also recognized the co-dependent nature of supporting teachers` math content knowledge and instructional practice to address students` learning needs.

Teachers talked about the challenges of releasing responsibility for their students` learning back to their students. After a few months, they recognized that the students were not only assuming ownership for their own learning, the students were more motivated to enhance their mathematics skills too. 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.

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. The teachers perceived that their students' learning was significantly impacted by the co-planning, numeracy nets, three-part lessons, and co-teaching. Some of the teachers noted that these mathematics instructional methods were especially poignant at contributing to the learning of their struggling students in math. An unexpected outcome was that teachers were surprised by the realization that teaching from a textbook resource is not as effective or efficient as they believed.

Some teachers noted that their students were uncomfortable with the open-ended nature of the mathematics tasks presented to them. The teachers patiently encouraged peer collaboration and consequently witnessed students working through the problems together. Teachers remarked on the need for their students to have the necessary skills to work in collaborative groups. Grades 3 and 6 teachers also expressed a heightened amount of angst with respect to preparing their students for EQAO testing; they failed to recognize the embedded benefits of the instructional methods in addressing these assessed skills.

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

Implications

Based on the findings, implications for practice and future research are offered. Teachers are calling for a continuation of the program of professional learning that was facilitated within NCDSB. Refinements might include development of a repository of resources, strategies for student collaborative group work, support for curriculum mapping, release time for co-planning and co-teaching and the support of an intervention coach for students.

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Background

Mathematics Achievement in Niagara Catholic District School Board (2007-2011)

The mathematics achievement of students in Niagara District School Board (NCDSB) has been solid over the period from 2007-2011. **Figure 1.** shows the five-year data trend for NCDSB Grade 6 students who consistently perform above the provincial standard on EQAO.

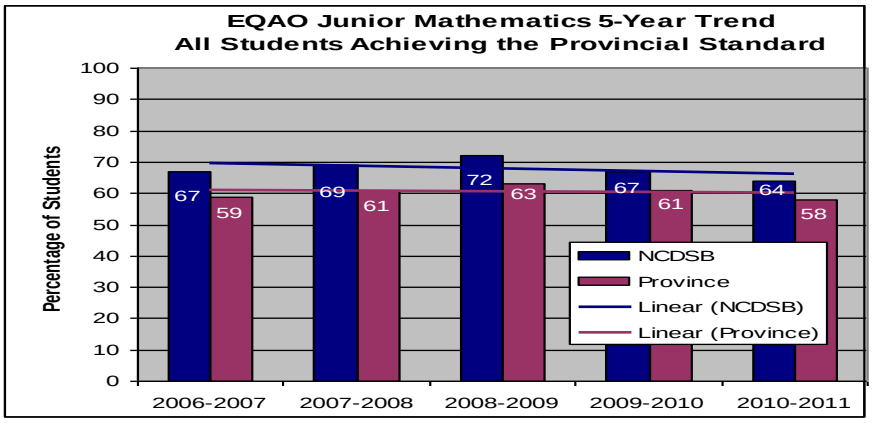

Figure 1. Grade 6 EQAO Mathematics Achievement – NCDSB and Ontario

Niagara Catholic schools have 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.

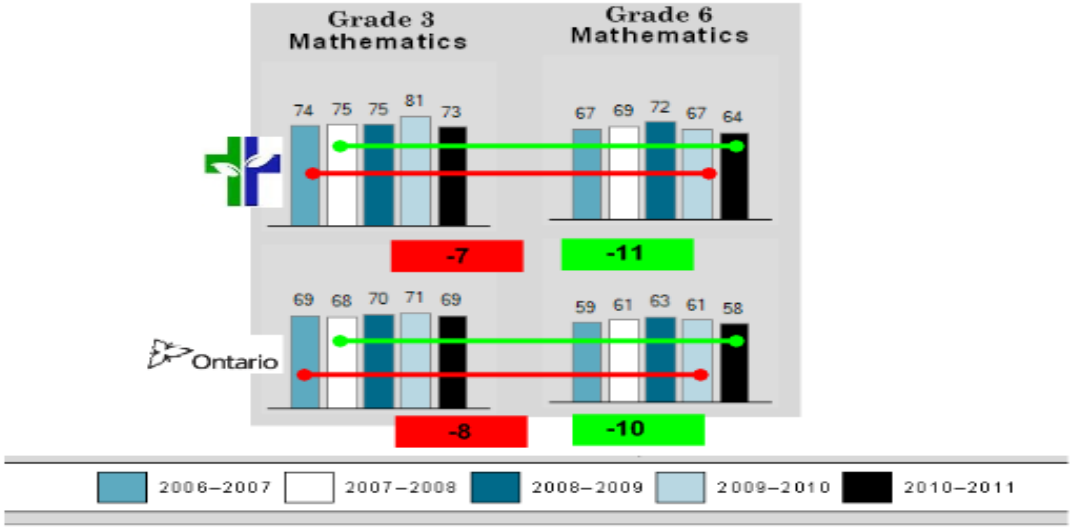

Figure 2. Grade 3 and 6 EQAO Mathematics Achievement – NCDSB Cohort and Ontario

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

Identified Areas of Need

Using Assessment to Drive Instruction

With the release of *Growing SuccessAssessment, 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.

Building "Math Content for Teaching" Knowledge

Over the past four years of CILM 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 2011-2012)

It is the goal of NCDSB to continue to advance students' achievement with Ministry of Education, Board and School initiatives on Provincial EQAO Primary and Junior assessments, EQAO Secondary Mathematics Assessment, and the Ontario Secondary School Literacy Test (OSSLT) by June 2012.

Theoretical and Practical Foundations

Academic Research

The academic research points to the need to support junior level teachers' professional learning in mathematics problem-solving teaching methods while attending to their beliefs and attitudes about mathematics instruction as well as honouring their content knowledge and experience. 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 belief 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). 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 Interventions Project* in NCDSB was conceived with these professional learning design components in mind.

An important appreciation is that for teachers' self-efficacy and attitudes, change in their mathematics instructional practices. The concerns of experienced teachers toward changes in mathematics curriculum and problem solving pedagogy have been documented (Charalambous & Philippou, 2010). 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.

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). Teachers hold different beliefs about the

autonomy of students to construct mathematics knowledge and their own autonomy to make instructional decisions. It is obvious that supporting the practice and confidence of teachers to instruct mathematics through problem solving takes time. Teachers 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). 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.

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 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 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 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 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 and personalized and work with students to set appropriate learning goals" (p.31).

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

This resource was not yet available at the commencement of the *Junior Interventions Project* in Fall 2011, yet it was utilized at the summation of the project. School teams, led by principals, were asked to focus on "*Principle 4: Support collaborative professional learning in mathematics*, and using the *Discussion Tool*," work as a team to evaluate their current breadth, depth and shared practice of the principle, as well as identify next steps to addend to their SIPSA action plan for 2012-2013.

Professional Resources used in NCDSB's Junior Interventions Project

Instructional Rounds in Education *(Elmore, 2009)*

At the heart of the *Junior 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 their classrooms.

Throughout the planning process, the *Junior 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 *(Keith, 2009)*

A core resource for the *Junior 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 *(Lovin &Van de Walle, 2006)*

Lovin and Van de Walle'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 target student misconceptions. Each project school was provided with copies of this professional resource.

Research Questions

Research questions were derived based on the *Objectives* and *Goals* submitted in the *NCDSB Junior Interventions Project Proposal* (2011). The five 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

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?

Students' Achievement

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

Research Design

Intervention Design

The overall intention of this initiative was to implement and support 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, NCDSB designed their *Junior Interventions Project* with reference to the document, *Paying Attention to Mathematics Education* (Ministry of Education, 2011). Accordingly, the following aspects of NCSDB's intervention design are examples of the "Seven Foundational Principles for Improvement in Mathematics K-12"as stated in the document:

1. Focus on Mathematics
- chosen schools already designated a math focus
- curriculum, teaching practices (inquiry)

2. Coordinate and Strengthen Math Leadership
- using student work to inform practice
- action based on identified student need
- co-planning/co-teaching

3. Build Understanding of Effective Math Instruction
- problem solving/inquiry focus (3-partlesson)
- setting up a supportive math environment
- using student thinking to propel discussions

4. Support Collaborative Professional Learning in Math
- focus on math knowledge for teaching
- blend of learning inside/outside the classroom
- alignment of goals/strategies across grades

5. Design a Responsive Math Learning Environment
- establishing classroom norms
- build student engagement and respect student voice
- communication skills to promote an inquiry approach

6. Provide Assessment and Evaluation in Math that Supports Student Learning
- not listening for the "correct" answer, but for what can be learned from the student thinking
- creating lesson problems students connect to

7. Facilitate Access to Math Learning Resources
- Numeracy Nets
- Big Ideas
- Teaching Student Centred Mathematics

Operationally, the intervention design included three key components: facilitated teacher professional learning sessions, collegial teacher professional learning,and student intervention coaching.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 intervention coaching in small groups was to assist struggling students in specific mathematics skills and support their learning in the classroom.

Facilitated Teacher 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 January 2012 – May 2012. Three Facilitators and an Intervention Coach from NCDSB provided the teacher professional learning sessions which targeted the following goals:

- improve teacher efficacy through development of mathematics content knowledge
- support the use of assessment strategies and target misconceptions identified through Numeracy Nets
- support teaching through problem solving with strategies (e.g. collaborative inquiry, BANSHO)
- close the gap in mathematics achievement through the use of intervention resources and practices
- affect student learning by focusing on the relationship between the teacher, the student and the content

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 monthly half days, and then finished with one full plenary day. All participating teachers had release time for these sessions.

The two, full day plenary sessions were attended by all teacher participants, most administrators and were co-facilitated by the Intervention Coach and three Facilitators. The first session in January, 2012 was an Introductory Session and the agenda included the following:

- overview of the research project
- project vision and goals
- the "Tiers" (whole class intervention then individual/small group intervention)
- 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)
- readying the classroom for math talk and student participation
- introduction of Numeracy Nets and moderation of individual student work
- aligning mathematics strands between grades

The final session in May, 2012, was a consolidation and debriefing session and the discussion focused on:

- a review of the inquiry focus and the Seven Foundational Principles for Improvement in Mathematics K-12
- same grade teacher discussion groups (lesson problems; classroom environment; misconceptions; teaching through problem solving)
- sharing of grade-specific findings
- school site discussions targeting the Seven Foundational Principles for Improvement in Mathematics K-12
- school site discussions related to SIPSA planning for next year

The four, half day sessions were facilitated by one of the Facilitators at each of the school sites and included the grade 3-6 teachers and their administrator. These four sessions followed an identical agenda at each site which included guided activities for enhancing teachers' mathematics content knowledge and then group discussion. This discussion varied from session to session, however, the focus was typically on some of the following: administration and analysis of *Numeracy Nets to* identify student misconceptions; creating intervention strategies for whole class instruction; collaborative inquiry methods; instructional techniques including open questions and parallel tasks; teaching through problem solving including BANSHO; mathematics curriculum mapping; tracking of marker students. There was time devoted during each of these sessions for teacher participants to share their experiences and successes with their colleagues.

The three Facilitators were also available for needs that arose from facilitated sessions or upon request, to provide the teachers with on-going support in 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: 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 Project Facilitators.

Student Intervention Coaching

An Intervention Coach was devoted to providing one-on-one focused mathematics instruction for students targeted by their classroom teachers. These struggling mathematics learners were given skill-specific instruction in small groups through the use of intervention resources. The intervention coach designed intervention activities and tracked progress to meet the individual needs of targeted students. The Intervention Coach was an itinerant teacher who devoted 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. In particular, 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, facilitators, parents/guardians of students) signed informed consent forms.

School Sites, Teachers and Students

Five elementary schools were invited to participate in this program based on their proven inconsistencies in recent numeracy EQAO scores. These schools indicated their desire to participate and cited goals related to improving mathematics achievement in their school improvement plans. The school staffs expressed a willingness to incorporate inquiry-based professional learning to inform their instructional practice, to build capacity, and to contribute to a culture of learning. There were 22 teachers (grades 3 to 6) that participated in the program and their students indirectly participated as recipients of the teachers' professional learning and intervention coaching. In total, there were 509 students in these 22 classrooms; of this total, 378 students consented to participate. In total there were 115 students that were the recipients of intervention and of this total, 87 consented to participate. The following **Table 1.** offers a profile of each of these school sites, the teachers, their students and the Facilitators:

School	Teacher	Grade	Total Class Size	Consenting Student Participants	Number of Target Students	Consenting Target Student Part.	Facilitator
2	2A	2/3	20 (11/9)	NA/6	0	0	Jasmine (Junior Division
	2B	3	18	16	6	5	
	2C	4	23	18	6	4	

	2D	4/5	21 (12/9)	12/ 8	5	5	Consultant)
	2E	5	23	21	6	5	
	2F	6	26	19	4	4	
	2G	6/7	23 (15/8)	14	5	3	
3	3H	3	15	14	4	4	Jasmine
	3J	4/5	27 (20/7)	20/7	13	11	
	3K	5	24	24	7	7	
	3L	6/7	30 (15/15)	15	3	3	
4*	4M	4	27	25	6	6	Bettina (K-12 Numeracy Coach)
	4N	4/5	23 (8/15)	7/11	5	5	
	4P	5	26	21	6	5	
	4Q	6	22	22	0	0	
	4R	6	24	22	6	4	
5*	5S	2/3	21 (11/10)	9	4	3	Bettina
	5T	3	22	19	5	5	
6	6U	3	20	12	5	4	Mary (Math Consultant)
	6W	3/4	23 (4/19)	3/10	4	1	
	6X	4/5	22 (4/18)	1/9	10	2	
	6Z	6	29	13	5	1	

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

NOTE: * Schools 4 and 5 are twinned as School 4 is junior/intermediate division only and School 5 is primary division only

Data Collection

Data was collected from three sets of participants: teachers, 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

Teachers were surveyed in January, 2012 at the first, full day plenary session to capture their current practices and beliefs related to mathematics instruction. At the end of the final, full day plenary session in May, 2012, the teachers were again surveyed to capture changes in their practices and beliefs as a function of the professional learning project. The survey consisted of 18 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; White, Way, Perry & Southwell, 2005). The surveys were coded for each of the teacher participants and the codes were matched for the January and May administration dates.

2. Anecdotal Notes during Professional Learning Meetings

The researcher attended the two, full day plenary sessions and one of each of the four, half day plenary sessions. During these sessions, the researcher was an unobtrusive observer taking field notes of the professional dialogue and collecting artifacts. Both the teacher participants and the Facilitator were observed.

3. Interviews

At each of the schools, at least three teachers were interviewed (n=14) 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. Finally, they were asked about their own professional learning growth and self-efficacy in mathematics instruction. The 30 minute interviews were transcribed by the researcher.

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 eight 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 throughout the project.

The first log entry was guided to allow the teacher participants to narrate their mathematics experience both as a former student and as a teacher. Subsequent learning log entries were prompted by questions affixed to the back cover of the log. The prompts were clustered under the following categories: Numeracy Nets Assessment (e.g., "How will this information guide your lesson planning for this upcoming concept?"); Co-planning (e.g., "What is the big idea, goal, concept, skills, intended for this lesson?"); Classroom Observation (e.g., "What aspects of the lesson stood out to you?"); Co-teaching (e.g., "How were you able to target specific learning needs or misconceptions?"); Three-Part Lesson Structure (e.g., "What did you learn about your students` thinking during the Activation or Minds on?"); Moderation of Student Work (e.g., "Some patterns or trends I notice include…").

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 were the milestones or pivotal moments along your learning journey?
b. What has changed in your practice as a result?
c. How has this change impacted student learning?

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.

Facilitator/Intervention Coach Data

1. Surveys

The three Facilitators and the Intervention Coach also completed the same surveys that the teacher participants did in January and May, 2012. The surveys were coded for each of the Facilitator participants and the codes were matched for the January and May administration dates.

2. Interviews

Each of the Facilitators and the Intervention Coach were interviewed in May, 2012. 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 and the Intervention Coach 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. Tutoring Tracking Sheets

Evidence of intervention provided to the targeted students was tracked by the Intervention Coach. The Intervention Coach documented the number of times that he worked with each student and the skills that were the focus of this intervention. On-going communication between the classroom teachers and the Intervention Coach was archived. These data provided a trace of the skills and concepts that the classroom teachers recommended that the Intervention Coach address, his subsequent instruction and impressions of the students' learning.

Data Analysis

The interviews (teachers, Facilitators and Intervention Coach) were transcribed by the researcher and qualitative data analysis included coding and collapsing data into themes. These subsequent themes were derived in response to the research questions. The learning logs 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 five research questions in the following section.

The quantitative data (i.e., teachers' surveys and students' report card data) were entered and analyzed using SPSS 19.0 (SPSS Software, 2011). The teacher survey data for January and May, 2012 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 "Students' Achievement." Within these three 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. Finally, the results of the analyses of students' achievement are offered.

Teachers' Practices

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

At the beginning of the Junior Interventions Project, teachers reflected on their prior experience as former mathematics students and their recent experiences teaching elementary math.

> I was the language kid and I did well in math but loved language. As a teacher, my confidence wasn't as great in math. Some of the tips that Mary has given me are great and I am a better teacher. Because I wasn't too strong in math instruction, now I can see other ways in how kids don't get it. I know how to teach the math better. (Interview, Teacher School 6)

> Math always came easy to me. I didn't particularly like the subject but I always got top marks for it. I found comfort in the 'routine' and 'predictability' of math – there was a right answer and I liked that…Since I never had a problem with math, I had a hard time relating to students who can't grasp the concepts. (Journal, Teacher School 3)

They referenced the traditional and rote teaching methods that they were engaged in and in some cases how these methods contributed to their lack of understanding of mathematics concepts and disdain for the subject.

> Mathematics was always a struggle throughout elementary and high school. Some concepts I got, most I didn`t. The concepts rarely came easy to me but I tried my best to keep at it. Practice. Practice. Practice. Math was not my favourite subject…I stopped taking math after grade 10 realizing it was not a field I was interested in. (Journal, Teacher School 2)

Acknowledging and altering such deeply entrenched prior learning experiences as a student is a challenging prospect for any teacher.

A by-product of teachers' traditional beliefs about teaching math is the persistent notion that they need to be doing teacher-directed instruction and leading student learning. This belief speaks to teachers' conceptualization of the relationship between the teacher, the student and the content.

> The teachers buy into the benefits of the students working, talking and sharing ideas as opposed to a more a traditional math lesson with an algorithm. This is a different approach and it is the student telling them what is working and share these ideas with each other. They see value in it. The hesitation right now is that they are feeling like this is on top of what they have to teach from the curriculum. They feel like they have to teach the curriculum too. They have to get to the comfort level whereby this is a part of their instruction. They have taught the lesson after they have supported the three-part lesson. They feel that they need to still do some teaching and present an algorithm. They need to be convinced that the concept has been learned. They perceive that they have not had the ownership of the learning… This is not easy for teachers as we are used to being the instructors. We are the ones used to doing the showing. This is challenging the teachers to think deeper as well. (Interview, Mary Facilitator)

Teachers talked about releasing responsibility for their students` learning back to their students. This was in some cases a bit daunting as the teachers were releasing control of the lesson and assuming the role of facilitator.

> The importance with the 3 part lesson helped to put onus back on the students so that they are exploring and they are explaining and have to justify now. Before I would present a note at the beginning of the lesson and they would take it down, now they explore it and we get together and explore the concepts. Then we get back together to talk about it…I am more confident in taking a different approach. Before I would not take a risk and I would introduce it and have them gathered around me. Now they figure it out and come to the carpet and they have a discussion about what they just did. They come up with the terms and talk about what they did. I find that they retain it more. They come up with the ideas. (Interview, Teacher School 3)

> We are letting the students do all the talking and giving them the time to explain their thinking and hear what they have to say. They bring it up and let the other students challenge it. The teacher is not the only one talking all the time. They have been working hard to promote students to talk and get their explanations across. This part has been difficult for them. The teachers are really stretched and standing back and letting them talk is a huge shift. For many teachers, they believe that they are the knower and the one that delivers the content. This is a huge shift for them to allow it to come out of the students. They have to come to it on their own. I learned this as a consultant too. The learner has to pick up the content, learn how to do it, and you are the guide. (Interview, Jasmine Facilitator)

> While the process seems so simple it is filled with many positioned and nuanced movements that needs a 'knowledgeable other' (of a Facilitator) to interpret and redirect. The purpose of today`s meeting (with the teachers) was to 'engage in' the process of problem solving from a facilitators' stance. To take the stance of "facilitator" is a very difficult shift for teachers. We are still in the land between "knowing and doing" (Journal, Jasmine Facilitator)

However, the net result was that the teachers recognized that the students were not only assuming ownership for their own learning, the students were more motivated to enhance their mathematics skills too.

> Now they are more effective in communicating and independently finding out where they went wrong. On tests they go back and look at what they did wrong. They are interested and they want to see what they did wrong and where they made an error. Before they would say that they made an error because of the steps that I told them to do. They want to understand math and use their math journal to write a quiz and they do. This gives them more confidence too. (Interview, Teacher School 3)

> The creativeness of the students during the problem solving comes out. Sometimes, they are not able to repeat just what you [the teacher] have done and this forces me to not over instruct. They feel good about trying to get to an answer. No more tears in solving problems and they don't dread the problem solving. They like it answering the problems. (Interview, Teacher School 6)

Moreover, providing math instruction that is meaningful was also intrinsically motivating for the teachers.

> I have been teaching 18 years and I am out of my comfort zone but I won't look back. I am eager to sit down with my teaching partner and take the expectations and use the different resources and manipulatives. There is such a variety of them and I am a kid in a candy store… Now I am more humble. I thought that I was set and knew what I was doing but I made me realized that there is more that I want to do and I feel like a new teacher again. I am confident and I am willing to take on more. I am renewed and excited. This was a short period of time in which so much has been achieved. I can't wait to see where it will go. (Interview, Teacher School 2)

Teachers initially felt a lack of control in a lesson when beginning to facilitate students' collaboration, ironically this feeling shifted into an overall sense of command with respect to the meaningfulness of their math program. This has contributed to a sense of self-determination among the teachers involved in the *Junior Interventions Program*.

> Yes, I am more confident and feel a sense of where I want to go. I look forward to next year to plan using the three-part lesson. I feel that I am more focused on the direction that I am trying to get to and I feel like I am making more of the decisions about what to do. (Interview, Teacher School 2)

Are Teachers identifying Curriculum Connections and using Curriculum Mapping?

A few months into the program of professional learning, some teachers began to experience a tension: they were investing more instructional time than they would have typically in the past and they were covering fewer curriculum expectations. By contrast, there were also teachers who recognized the depth and impact of their planning and instruction based on identifying curriculum connections and using curriculum mapping.

> Today, we co-planned a unit for fractions to help us understand the continuum of learning and aligned the expectations. We had an opportunity to deconstruct the fractions expectations and focus on ways to effectively scaffold instruction. This will allow us to address gaps in the learning that we noticed from the diagnostic assessments. We were able to discuss ways to effectively use manipulatives, visuals and hands-on experience to support student thinking. (Journal, Teacher School 4)

> I no longer plan my math lessons following the math text book. The curriculum expectations guide my choices, and I choose problem solving questions that are directly related to the expectations. (Journal, Teacher School 2)

> The experience has initiated more teacher math talk. This even includes the teachers on staff that are not involved in the project. Another positive is that we have further delved into the specifics of the curriculum expectations. (Journal, Teacher School 3)

Teachers acknowledged that they were addressing curricular expectations with greater profundity, however, this amount of comprehensiveness took time.

A few teachers did map curricular expectations. One did this for her split grade class and she used this as a teaching tool with her students. Another teacher commented on her future practice and how she will address instruction to the curricular expectations.

> I put together a continuum to see the progression between grades 4 and 5 and to date back to primary grades for students to see where they have come from. I have done this so that I can see what they need as a foundation and what they will need for next year. Then I can let them see where they are going and how it will apply. They will begin to see mathematics as not isolated but that we are teaching them something that is relevant since they started school. The concepts are connected and meaningful for real life. This is how they will use it in real life and how they will use it again. They are savvy and know that there are things that they need to learn in grade 4 or 5 and they need to make the connections to these things. This is critical. (Interview, Teacher School 4)

> This is the most eye opening year and the most scary too as I wonder how many kids have left without knowing stuff. It worries me because I know what they need to know. It reinforces that there is too much in the curriculum document. Now I am directed to get to the heart of why they don't know what they need to know. If you really want students to know something, then I might need to spend 3 months on a strand. It is like trying to seed a football field with one small bag of grass seed and just throwing here and there and then being surprised when it is patchy. (Interview, Teacher School 3)

Other teachers were not yet at the point where they were seeing the prospect of curriculum mapping as a way to compact learning expectations. The Intervention Coach articulated this as one of his goals as a facilitator.

> The teachers tell me, "We don't have enough time for this." But if you understand the curriculum then you can chunk things and the concepts can be pulled together if you get it. Now they have found that they actually have more time to explore the concepts and they are not overwhelmed. Now their lessons are multi-strand and expectations are clustered together. Then teachers begin to see that the text book has more than they need to teach and they need to abandon it and beginning to group concepts together and show how they are related… I point out to the teachers that way that the expectations are worded lends itself to getting the students to explore, not to give them formulas and work through questions. (Interview, Intervention Coach)

Finally, there was a heightened amount of angst among the Grade 3 and Grade 6 teachers who in Term 2 were faced with preparing their students for EQAO testing. These teachers were dealing with the tension that they perceived from addressing all mathematics curricular expectations in depth and the urgency of EQAO testing.

> I am so far behind because math lessons take so much longer than they did…I have struggled with this as it is so important for EQAO. I have to take a deep breath and work on preparing them for June and getting them to where they should be. I do believe that they will retain it into grade 4. There are just too many strands and it is hard to get through them all. What do they want? Do they want all the strands covered or to teach them math thoroughly at a deep level. (Interview, Teacher School 3)

> They are understanding more and this has taken me longer than before. This is a question of retention. The real test will be in EQAO and their performance. Because we have EQAO there is the pressure to cover it all. The timeline is different. (Interview, Teacher School 6)

> The grade 3 teachers were overwhelmed with the impending EQAO – and felt like they needed sometime with me to prioritize. The question we were grappling with as facilitators was, "is it better to 'cover' it all, or for the students to 'learn' some of the curriculum". (Journal, Bettina Facilitator)

Are Teachers Promoting Students' Understanding of Math Content?

Some teachers noted that their students were uncomfortable with the open-ended nature of the mathematics tasks presented to them. These students were searching for explicit,

sequential, teacher-guided instruction. They were uneasy with the prospect of taking risks and thinking independently.

> The kids did not like that I offered no assistance – as many do not like to take risks and they automatically think the math is going to be hard before they read the question. (Journal, Teacher School 5)

> Many continued to seek assistance from me but I have to continue to push them to do the work on their own. They had this understanding that there is only one way to do it and it is my way. They have learned that they may do things a different way and as long as they can explain to me how they got to that point that is okay. They had to learn to trust me in that I was doing what was best for them. They became angry and frustrated. But they weren't reading the questions and a lot of them were used to having their hands held. They are far more capable of working with the gradual release on their own and with each other. They had to learn to communicate and trust each other… By the end of the program, they were starting to get better at solving things without my assistance. (Interview, Teacher School 5)

> I am constantly trying to encourage students to take that risk – taking leads to learning. That being said, when I worked with the consolidation with my students, they responded well to the group discussion. Hopefully, they take something away from this and it will transfer into their independent work. (Journal, Teacher School 4)

Teachers expressed how they persisted with methods to overcome students' uneasiness. The benefits of encouraging students to think divergently and support authentic learning were worth the effort. Another teacher attributed students` independence to an increase in their confidence.

> It is important that they represent their thinking in written form and that they communicate with each other and look for strategies. They need to talk to each other, rationalize and confirm or challenge what they are thinking. If they see multiple lines of thinking then they are open to seeing different ways of thinking and challenging each other. They are then willing to probe deep to find another students' mode of thinking. Open ended questions help to get at different ways to solve a problem so that they feel more comfortable solving a problem. (Interview, Teacher School 4)

> My students are better understanding the math because it's authentic to them – not because I taught it, but because they have investigated the math on their own. Authentic learning! it's the best way to learn – when <u>you</u> figure out how to solve your own problem rather than someone telling you how to. (Journal, Teacher School 2)

> I am stepping back a lot more and having more student driven math lessons. As a result, the students are taking more ownership, showing an increase in pride and confidence. I have also found an increase in understanding of concepts by allowing them to choose the approach that works for them. I have also found that when students are struggling they are more comfortable with coming and asking for help. (Journal, Teacher School 3)

Teachers described the practice of deliberately not being available for their students. Consequently, teachers witnessed students working through the problems together.

> I try to let them figure it out on their own rather than me jumping in. I try to hold back and allow them. I walk away and I let them struggle and they get it. I allow them to figure out their answers, I give them some clues and then I walk away. At times I find that if they are able to grasp it better when they work in groups. They have the support of their peers; their peers are beside them. When it was independent they gave up easily. Now they have peer support which allows them to have a better understanding of the content. (Interview, Teacher School 3)

> In the class it has been a learning curve as they are not used to being in groups and they are afraid to struggle. This process is now come a long way. They know that it is okay to struggle and make mistakes. It is a comfortable atmosphere. I am there facilitating and I have to get out of the way. We don't really need to be there and just let things evolve…Even though the expectations state what they need to learn, the teachers have gotten in the way. Allowing the students to learn on their own is important; their own confidence is essential. I am there to facilitate and do only that. It has been great. (Interview, Teacher School 2)

> The problem solving they did enjoy. They like working with their peers and math teams is interactive with their peers. I have taken a step back and am not telling them what to do. I walk around and try not to tell them what to do. This is a change but not a huge change. Often I try to give them a hint and there are kids that want the hand holding. Having a peer with them helps them when I walk away. I have a girl who likes to say she doesn't get it and yesterday she stuck with it because of her peer. I pair them with a strong student in math.(Interview, Teacher School 6)

Finally, teachers were surprised by the realization that teaching from a textbook resource is not as effective or efficient as they believed. Simply, upon close examination, the textbook includes many topics that are not required by our Ontario mathematics curriculum – consequently, time was being wasted on unnecessary topics.

> I love this quote from one of the teachers, "I don't even know where we would be in the text book at this point." I used to say this to parents that the textbook is only one tool that we can pull from. We have to educate parents that the textbook is not important and work through problems. They need to know how this works and why we are doing what we are doing. (Interview, Intervention Coach)

Teachers were beginning to appreciate the depth of teaching through problem solving to promote students` understanding of math content through the three-part lesson, versus the breadth of teaching from the textbook.

Are Teachers Using Instructional Strategies?

One of the key findings is that the Numeracy Nets are invaluable for uncovering the depth of students' understandings and misconceptions. It is essential to have the most appropriate questions as part of the nets and teachers were in some cases looking for a net to cover each of the mathematics curriculum expectations. Using the Numeracy Nets as a guide for instruction was an essential lesson from the professional learning.

> I think the growth for me was using numeracy nets and applying it to what I was teaching them. This gave me a greater understanding of how I can look at things from their perspective. I was able to see why they had answered something wrong. I was making connections between the nets and what they were doing wrong and changing my practice. I had to go back and find the obvious misconceptions. I had to separate myself and my perceptions of math and not look at math through my eyes and look it through their eyes. That was hard. When I was taught math I was told that this is how it was to be done. I learned it so differently and I learned through drill and practice and I had unlearn this. (Interview, Teacher School 5)

> The numeracy nets have given me a focus. I now have an indication of where my students are and it is like a trampoline to take my students to the next level. This has been so helpful. (Interview, Teacher School 2)

A few of the teachers expressed how they used the Numeracy Nets for differentiating instruction to support the learning of students with similar misconceptions and students who are gifted in mathematics.

> I am using the Numeracy Nets as a diagnostic tool and this helps me to hone in on where I think that the possible gaps are and where the misconceptions are on the continuum from grade 3 to 4 to 5. This helps me to cluster kids across grades based on their misconceptions. I find that this is particularly helpful for me in a split grade as I can cluster students together based on their misconceptions, regardless of their grade. It is easier now to draw for small group instruction. I can support them better now regardless of the grade and I have the resources to do this. They can identify with their peers who have similar experiences and understanding. They apply what they need to know and what they are learning. They are now able to take a question and work with it together. (Interview, Teacher School4)

> I have them in small groups and recognize the kids that are able to take the problem and decompose it and pull out the key information. This shows me the kids that don't know how to break down a question. This frees up time for me as I am working with smaller groups and chunk the kids together based on their misconception. Then I go back the next day or during consolidation and we talk about it as a group and this allows me to help clear up some things and re-teach or provide a little bit of bell work to confirm it… When I think of my struggling learners and how they used to groan at the sight of math on the daily agenda, it is not there anymore. It is less dangerous territory and less uncomfortable. Those that were terrified of math look forward to it. I have a student on an IEP for math; he is very strong. He now doesn't need a separate program but he can take it to another level and make more global connections. This hits on all areas and abilities. My strong math students see that everyone has something to contribute and it is now an even playing field. (Interview, Teacher School 4)

Teachers became aware of the instructional potential for "minds-on" activities to identify and clear up students' misconceptions. They resolved to pay more attention to these opportunities. They also resolved to vary lesson consolidation from simply being a form of assessment, which is an aspect that the Facilitators acknowledged as needing further professional learning attention.

> The three –prong approach has changed my lessons and how I have to understand where students may stumble before I give them the question. I also see the value in the "Minds On" to debunk students' misunderstandings with a question before they work on the question in which I am really focusing on. (Journal, Teacher School 2)

> The piece they struggle with is consolidating the lesson. They call it different things like BANSHO or gallery walk and they can't decide how to do it and what to emphasize. They need to move away from the show and tell and the consolidation needs to be better. It needs to do the job of tying together the pieces in a nice package and allow the students to share and hear their voice. It is hard, because you want to directly teach but it should be the students sharing... This has been a challenge for them as teachers. Other schools have me do the consolidation piece as it is new for teachers and principals say that the teachers need to see it in action and have it modelled so that they understand what you mean by tying it together without turning it into show and tell piece. We have to do this next year. (Interview, Mary Facilitator)

A key to teaching through problem solving and the three part lesson was finding the best problem – a problem that generated discussion and multiple solution pathways. Teachers also noted that it was essential that a problem be relevant to junior learners. The teachers came to realize that relevancy adds authenticity and value to the learning activity.

> Focusing on the relationship between the teacher, the student and the content comes through the planning aspect and making sure that what you are going to teach is a problem that they can relate to...The information has to be relevant to them and this makes a huge difference. Now I give them more freedom with a problem and I step back as a teacher and let them work through it. It takes more time. If they don't get something then I relate it to the concept to money and they get it then. Geometry can even be related to money ...They are getting better at

communicating in math and how they did it and why they chose to do it a certain way. Having students explain it and then different groups present the information and post their solutions makes it even more meaningful. Their understanding has increased and it is all because when you present them with something that they can relate to then they are more likely to see how it relates to their lives. (Interview, Teacher School 3)

I tell teachers that just because you use a students' name in a question that you found in a textbook, does not necessarily make it relevant to them and make them want to do it. It has to be based on their inquiry. You have to get them to ask why. The questions should get them to think about how it works and when it works. It does have to be relevant… The students have to want to discover the answer and you have to set the stage up through a story to make the case relevant to them in context. This is the key to understand mathematics. (Interview, Intervention Coach)

Teachers remarked on the need for their students to have the necessary skills to work in collaborative groups. Social and communication skills and how to assume roles in discussion groups needed to be explicitly taught in some classrooms.

They loved the math team concept and they caught on to this. I ran it as I was a commissioner and they drafted the teams and they came up with the team names and they came up with the logos and creative names. We did a discussion about the roles and the captain. They wanted to do it every day. We did it a few times a week…Four in a group was not optimal as one would lag behind and the groups of 3 were perfect. We did this in creative ways. Normally, they would hate to work in groups but loved teams. The changing of wording to "teams" made a difference. (Interview, Teacher School 6)

We all found that creating the appropriate climate in the class was key to having students work effectively in groups and that it is not something that can be done without clear guidelines and expectations for the students. It is a process that needs to be closely monitored and guided at the beginning and students require feedback and multiple opportunities to work together effectively. (Journal, Teacher School 2)

My goal next year would be to try to help the students work better in groups. I found that the social climate of my class had a negative effect on the math work being done and if the students become better at working in groups, then hopefully next year when they are trying it again they will be more successful. (Journal, Teacher School 6)

Other affective student outcomes stemmed from the fact that students' learning was validated through collaborative group discussions and sharing their solutions with the class as a whole. This validation contributed to students' dedication, confidence and encouragement of their peers.

Key pieces were taken from all students and this was motivating for them even if it was just one piece. It built their confidence and self-esteem. The ones that always got the textbook answer began to see others' ways of thinking. They began to appreciate others' thinking and see them listening. I feel that the group is tight and I have seen them being encouraging of each other even outside of the math classroom…My role is different it is more a facilitator than the person that knows the answers and tells them to do it. I set the problem and they are teaching each other and then they come up with it in a group. They are discovering, learning and explaining it to others and they realize that they have a role to play as instructor to each other as their communication skills are improving. The content is more about discovering and they are working through the process and getting to the answer. They are more tolerant and patient to do that. They have to communicate to each other and question rather than tell and they have to get others to explain their thinking and this gives them a challenge to explain their own thinking and recognize their own errors. They have to clearly communicate with each other using the right terminology. (Interview, Teacher School 2)

> They have also developed (over time) better group work skills which was one of the bigger issues at the beginning of this process. Also, there is more sharing of ideas amongst all group members – not just the stronger students. They feel more confident to share because an environment has been created to allow for that especially when doing our BANSHO. (Journal, Teacher School 3)

Collaboration takes to time master but there is value added in students` ability to work together and communicate effectively in other subject areas too.

> Student learning has been greatly impacted. Students are letting go of getting the "answer" and embracing the different ways or processes there are to get a solution. Their learning of how to work together was at first arduous, but well worth it. (Journal, Teacher School 6)

> With individual student work I am finding there are less conflicts and students are focussed more. I found that there was a benefit of the group work: it was great way of not leaving too many students sitting back not contributing. (Journal, Teacher School 5)

> I am guiding them and encouraging them to use math tools independently and they are learning that there is not necessarily one right tool that is perfect for one concept. They are using this to articulate their learning and communicate with me. Earlier in the year when I would ask them a question, they would think that because I am asking them a question that there must be something wrong. Now they understand that when they are challenged, they are not defensive and they are confident in their answer and that it is okay to change their answer. They know that we are going through this together. Through this year they have come so far. Their ability to articulate their understanding has grown in other subject areas such as language and the content areas. They are providing evidence from what they see and their own thinking. They are comfortable and less inhibited in small groups to talk and those that are usually distracted are able to talk in small groups. (Interview, Teacher School 4)

In addition to the process of facilitating conversation, the physical set up of the room was noted as an important implementation consideration to support math talk.

> At the beginning of the year I had to set up collaborative dialogue. I had to understand the kids and their personality and which ones had strengths and who could offer the most in the group work. Then I got the math teaching going. Organizing the math classroom was so necessary prior to doing the work. They had to know what was expected of them when I brought out different materials like chart paper and markers. Building the organization of the math class took 3 months as I didn't know the students coming into the building. The groupings took a long time and I had to work with different numbers of group members. When there were fewer groups you can get to them to hear them and ask them questions. It takes time to build their confidence in small groups, and then they can go to smaller groups. You have to work on building confidence. (Interview, Teacher School 4)

> The physical set up of the classroom is still a hindrance as they need to talk freely and they cannot be sitting on top of each other you need to have space to talk at full voice and you need to circulate to hear them. They need to move desks and find the space. This is a barrier for genuine conversation and they need space to have their own independent conversations. This might also contribute to behaviours. (Interview, Teacher School 3)

Are Teachers Using Intervention Resources?

The role of the Intervention Coach built momentum as the project advanced. Initial communication methods between the Intervention Coach and the teachers needed to be delineated in order to establish a rhythm for incorporating the Coach`s support into the classroom activities. This role included working individually and in small groups with targeted students in order to uncover skill gaps and remediate for them.

> What I did with small groups was try to uncover the misconceptions because teachers only offered me general issues. They didn't know where their students went wrong so I spent time with the students asking questions and getting to the root of the problem. (Interview, Intervention Coach).
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> I was able to drill down to see where the actual misconception was. Once I was comfortable doing this, I would work on this misconception with the student once a week for 40 – 60 minutes. The time was an issue, as in all things, however I was able to move the student farther along than where they were. It will be difficult to see this in report card marks because many of the misconceptions were way below grade level. (Journal, Intervention Coach)
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> I am thinking of one student and he says he doesn't understand math. Then he started to experience some success with the Intervention Coach. It was like cleaning up his attitude and this was important. He had time with the Coach and he experienced some success and then his attitude changed and he could attempt problems. (Interview, Teacher School 4)
>
> The Intervention Coach being in the class was great for my boys. They loved when he was there and working with a group. This made a big difference and I didn't have the social issues. It was great for him to work with my other kids and I couldn't have done it without him. I noticed the biggest difference in their confidence and they felt that they had the secret. This was a privilege and confidence booster. This was the effect of having someone like an Intervention Coach. (Interview, Teacher School 6)

The Intervention Coach did more than just work with the students, he recognized the co-dependent nature of supporting teachers' math content knowledge and instructional practice to address students' learning needs.

> What I did with teachers is run through the 3 part lesson and help them work through this and consolidate. Then the teacher was able to pin point where the misconceptions were. That helped and the teachers were able to take kids off the intervention list because they could help them themselves. The teacher could now get them to explain their thinking and give them the work that they were doing in the classroom. (Interview, Intervention Coach)
>
> The intervention practices have been implemented in both whole class and when pulled, small guided groups of students. They have been happy to have the Intervention Coach come in and he brings in more ideas for them to try. The key is for them to try these strategies out with their own learners instead of leaving the students to work with the Intervention Coach. They have to be carrying it forward. They don't yet have all of the math pedagogical practices and the math content knowledge to target for intervention. Knowing is half the battle of figuring out what a student needs and then it can be brought in anywhere like small group or one-on-one intervention. It doesn't have to be with just the small group… We have to deepen the math content knowledge of the teachers so that they can look at a problem and know where it stems from and they need to keep working on this to get to the struggling math learners. (Interview, Jasmine Facilitator)

Issues were raised about how to use the Intervention Coach's time most effectively given the gaps between his visits. Sustaining the support of a mathematics Intervention Coach for more time and in the upcoming academic year were expressed recommendations from the teachers.

> The ones that are in the intervention groups are excited to go there and are confident to take some risks now. This in itself has hooked them to learn math, to take risks and to discuss their thinking. I talk to them and they get it but you have to be able to pull it out of them. They need to go with the Intervention Coach and see others' work and see that there are strategies that they can use to access what they need. If we continue with this program then it would be beneficial as

we are seeing this momentum right now and the students are in the routine of getting help from the Intervention Coach. We are just seeing the confidence start. (Interview, Teacher School 4)

Teachers' Beliefs and Attitudes

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

At the end of the project, eight 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, effect sizes and interpretations.

Survey Question	Paired Samples t-Tests	Cohen's d Effect Size	Interpretation of Significant Results
Mathematics is computation.	t(24)=3.068, *p*=.005(two-tailed), *d*=0.74, r=0.34	medium	T1 M (3.08) is greater than T2 M (2.04), therefore they are now more likely to disagree.
Mathematics problems given to students should be quickly solvable in a few steps.	t(24)=2.701, *p*=.012(two-tailed), *d*=0.66, r=0.32	medium	T1 M (2.20) is greater than T2 M (1.68), therefore they are now more likely to strongly disagree.
Young students are capable of much higher levels of mathematical thought than has been suggested traditionally.	t(24)=-3.375, *p*=.003(two-tailed), *d*=-0.70, r=-0.33	medium	T1 M (3.88) is less than T2 M (4.40), therefore they are now more likely to agree.
Being able to memorize facts is critical in mathematics learning.	t(24)=4.370, *p*=.000(two-tailed), *d*=0.97, r=0.44	extremely large	T1 M (3.20) is greater than T2 M (2.24), therefore they are now more likely to disagree.
Mathematics learning is enhanced by activities which build upon and respect students' experiences.	t(24)=-3.166, *p*=.004(two-tailed), *d*=-0.77, r=-0.36	medium-large	T1 M (4.24) is greater than T2 M (4.60), therefore they are now more likely to strongly agree.
Mathematics learning is enhanced by challenge within a supportive environment.	t(24)=-4.000, *p*=.001(two-tailed), *d*=-0.97, r=-0.44	extremely large	T1 M (4.52) is less than T2 M (4.92), therefore they are now more likely to strongly agree.
Teachers or the textbook – not the student – are the authorities for what is right or wrong.	t(24)=2.681, *p*=.013(two-tailed), *d*=0.65, r=0.31	medium	T1 M (2.12) is greater than T2 M (1.68), therefore they are now more likely to strongly disagree.
The role of the mathematics teacher is to transmit mathematical knowledge and to verify that learners have received this knowledge.	t(24)=5.477, *p*=.000(two-tailed), *d*=1.18, r=0.51	extremely large	T1 M (3.16) is greater than T2 M (2.16), 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 less like to hold the belief that mathematics learning is demonstrated through computations and the ability to memorize facts. Consequently, teachers are less likely to contend that their role is to transmit mathematical knowledge and to verify that learners have received this knowledge. 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.

The Facilitators commented on their perception of the teachers` growth in knowledge of mathematics content and instructional methods. From the beginning of the Junior Interventions Program, the Facilitators recognized that they needed to offer explicit content knowledge support for the teachers and the teachers responded favourably to how this was incorporated into sessions. The Facilitators began to acknowledge that teachers were seeing the cohesiveness in using the nets to guide activities, interventions and the three-part lesson.

> I have seen in our facilitated sessions that when teachers look at the student data based on their diagnostics, they are planning and making progress based on their nets. They are determining how to tackle it as a unit. This is a whole class intervention piece. If it doesn't work for a few students, then they refer the students to the Intervention Coach. It is all about the middle tier intervention and trying to figure out how to do things first as a whole group. The intervention that they work on with me is the three-part lesson and how to find good questions to engage their kids and how to use the questions to get the target students' thinking. The discussions with the teachers are coming. They are on the road but it is varied. They are open and understanding the theory behind what we are doing. (Interview, Bettina Facilitator)

> Each of the sessions that we got together with them we talked about the diagnostic nets, moderating them, the needs of the student, the three-part lesson, and then the other piece that I would also bring in was some content PD. This does two things: it shares with them some cool things about a concept that they have asked me to bring information on and it introduces them to different models, ideas and strategies. They liked it and they have used it with their students. I introduce new things and they see the resources that I pull them from are linked to the misconceptions and what is underlying them. They are explicitly told how to address the needs of the students and follow it up with these resources. Hopefully they see the resources as tools to dig deeper. I encourage them to look at different ways to present the content and the skills. (Interview, Mary Facilitator)

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

The Facilitators perceived that some of the teachers grew in their confidence to teach mathematics. This enhanced teacher self-efficacy is likely to have a residual influence on boosting students` confidence in math.

> Pivotal moments for me were the co-planning and co-teaching sessions. Having the uninterrupted time to make common lessons with same grade partners and to moderate the work together helped build my confidence in knowing what I'm looking for. Having the time to go through individual student work and find those misconceptions was great. I now have a stronger sense of the consolidation piece of the three-part lessons. (Journal, Teacher School 4)

> The discussions of the students have shown me more confidence in their math abilities. It is nice to hear the teachers talk about how the students' confidence has improved and their own

> confidence has improved. If the students are more confident hopefully then the teachers are too. You hope that there is a relationship there but it is hard to predict. I believe that it is working. (Interview, Bettina Facilitator)

> The teachers seem excited about the project – but there is a level of anxiety I can see that as we move forward with the project that part of our job as facilitators is going to be to support our teachers through content, instructional strategies and emotionally. (Journal, Mary Facilitator)

The trajectory of enhanced teacher self-efficacy in mathematics instruction is positive and in the right direction. Realistically, time and continued opportunities to realize success are key contributors to teachers' confidence in any new instructional approach.

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

Teachers 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. This was an essential aspect of the project that they would derive benefit from in the future.

> This has helped us as a part of JMI is the PD. It helped us delve into what is going on in grades 3, 4, and 5. We did a lot of work together looking at the cross-strand relationships and this helped us as we had the time to figure out how we would do it. The time to do this uninterrupted was enormously beneficial for us. We made up five units and did as much cross-strand connection as possible. This was great to transfer knowledge between colleagues. (Interview, Teacher School 4)

> Co-planning was a pivotal moment for me. I felt that we (my team) used our P.D. opportunities to the fullest. We learned, talked, and collaborated on the needs of the students and how to make lessons more meaningful. (Journal, Teacher School 4)

As they described this professional dialogue, they also included descriptions of the moderation of student work that they engaged in with their teaching partner. This was seen as an inherent component of co-planning and implicitly communicated their assumption of a seamless connection between assessment and instruction.

In terms of impacting practice for the upcoming year, some of the teachers expressed their intentions to alter how they will complete their long range plans and how they now conceptualize teaching math in an interconnected fashion.

> My long range plans were out the window in January and now the students direct how long we stay on a concept and how often I need to revisit a topic. Now I go back and revisit a strand to see what they have retained from before… I am rethinking how I will teach next year and I will be combining the strands. I will try to convey the idea that math is continuous… I know a lot of what they don't know and a lot of ways to connect the math to other strands and I want to have a more connected math curriculum. I won't do my long range planning around strands instead I will do it around the big concepts and then work back to the strand. I want the kids to see math as a cohesive subject and not as strands. (Interview, Teacher School 3)

> I need more continued support with problem solving and now I see the validity in the numeracy nets. I will look at the Nets when I am doing my long range plans and now I know that I might need to take a step back. In order to connect it all, I will map the curriculum a bit better with math. The planning for next year will include identifying the misconceptions that I saw this year and I will be ready to deal with them too. (Interview, Teacher School 3)

Teachers will begin the next academic year differently and incorporate their professional learning from this year into their long range planning.

Longitudinal sustainability with any professional learning is an issue. Teachers commented on the need for on-going efforts to continue the dialogue with their peers in an attempt to sustain the students' learning.

> It has given me the opportunity to go through different resources and dialogue with other teachers. I am more efficient now in my planning and focus in on what is the most useful resource for my own students right now. I have the confidence to see that I have a wealth of resources that are available for my students and the confidence to evaluate the resources and target what my students need. The collaboration has helped me to see that we are working together as a team and we have relied on each other – now I can see that we are working on the same goals with the students because we as teachers are all on board. When the students see it again next year and we move on, then we aren't re-teaching the routine things like problem solving and appropriate dialogue. We are setting up the students for future years as well. Without the program we would have not had the release time and the uninterrupted time to have rich discussions about our resources and student work. (Interview, Teacher School 4)

Teachers acknowledged that the project is aiming in the right direction, however, it needs to be sustained and inclusive of the support of other educators.

> I think that there were measurable differences and a step in the right direction. They [students] needed to know that they were a part of the process and that there were gaps. The project has not been long enough to sustain great gains. We just started and it needs to continue to see changes in the kids and teachers. I want it to continue and having the support in the classroom is helpful. It was most helpful to have the Intervention Coach. This could branch out to the ERT and EA's and if they know the same things than we can have small groups working together (Interview, Teacher School 4)

An unanticipated positive outcome of this project has been the prospect to include exemplary classroom teachers in future professional learning projects. This validates teachers` practices and contributes to a culture of collegial collaboration and respect.

> With these projects we have unearthed talent and people who are willing to learn together and we can share with other teachers. The people that are on the road and can talk about their struggles. For one of the teachers I have worked with, he has come a long way in setting up the classroom climate and got the dynamics going. Others need to see what he is doing. He has set up his classroom and students have been well trained to get the learning going in math. He knew his learners. All the pieces were in place: there were two groups going and there were two different problems. He was dancing between the two. He is a resource to tap into. These teachers are the ones helping with the scope and sequence. Almost all of our schools know the mechanics of the 3 part lesson. Most have adopted it. With the success of JMI, we can say, look at how it has happened with junior teachers. Now it might spread across the building and into other school hubs. We need to continue to build these relationships. (Interview, Jasmine Facilitator)

At the final plenary session, teacher participants were asked to confidentially reflect on nine aspects of the project with respect to impact on their teaching practice and impact on their students' learning. Responses were garnered on a 3-point Likert scale (significant impact; moderate impact; no impact). **Tables 3. and 4.** summarize this reflective feedback:

Aspect of Project	**Significant Impact**	**Moderate Impact**	**No Impact**
Numeracy Nets (using diagnostic assessment to target misconceptions)	11	9	0
Establishing Classroom Norms for Collaborative Group Work	8	12	0
Student Collaboration (and math talk)	10	8	3

Co-Planning (lessons and units)	20	1	0
Co-Teaching (lessons)	12	7	2
3 Part Lessons (teaching through problem solving)	11	10	0
Discussion on math content (investigating the math)	7	12	2
Targeting Interventions (with help of intervention coach)	9	11	1
Reflection Journal	2	3	16

Table 3. Teachers' reflections of impact on their teaching practice

Aspect of Project	**Significant Impact**	**Moderate Impact**	**No Impact**
Numeracy Nets (using diagnostic assessment to target misconceptions)	10	10	0
Establishing Classroom Norms for Collaborative Group Work	7	14	0
Student Collaboration (and math talk)	7	12	2
Co-Planning (lessons and units)	14	7	0
Co-Teaching (lessons)	9	9	3
3 Part Lessons (teaching through problem solving)	10	11	0
Discussion on math content (investigating the math)	3	17	1
Targeting Interventions (with help of intervention coach)	7	14	0
Reflection Journal	0	2	19

Table 4. Teachers' reflections of impact on their students' learning

Based on the data summarized in **Tables 3. and 4.**, the majority of teachers believed that their teaching practice was significantly impacted by the use of the numeracy nets, co-planning, co-teaching, three-part lessons and student collaboration. The teachers perceived that their students` learning was significantly impacted by the co-planning, numeracy nets, three-part lessons, and co-teaching. These findings reveal inherent reciprocity between the key aspects of the project.

Students' Achievement

Teachers naturally related their instructional practices to their students` performance. They described their perceptions of their students` learning and affective changes and then cited anecdotal evidence of it.

> In their communication and reasoning and their thinking that through the three-part lessons, open response and discussion that they have shown me that they really understand mathematics

concepts and they have learned. When I feel most confident about their learning is when I can sit and listen to what they are discussing. (Interview, Teacher School 4)
In the future I know I will continue with collaborative learning. I witnessed for myself, that these students benefit from learning through each other. The learning that they have experienced with their peers they will retain. (Journal, Teacher School 3)

Some key things worth highlighting are an increase in self-esteem when kids are sharing their thinking. It wasn't always the level 4 kids who were solving the problem or getting it, all students had their moments of glory or "ah ha" because they got it. (Journal, Teacher School 2)

There were a few pivotal moments this year along my journey. One happened the other day when a few students came to ask me when we were going to do problem solving again. I said "why do you like it and they sad yes!!" (Journal, Teacher School 2)

There have been two milestones or pivotal moments for me this year: 1) the leadership of students other than the typical class leaders; 2) students who had challenges socially, became valuable members of their math teams. (Journal, Teacher School 6)

Some of the teachers noted that these mathematics instructional methods were especially poignant at contributing to the learning of their struggling students in math.

I had a student in my class who figured out a formula on her own and I said it was because I was a great teacher. Then she corrected herself and said it was because she was a great student in math. She was previously quite apprehensive in math. She won't ever forget this now. (Interview, Teacher School 2)

A student who formerly failed in math is now walking out with a B. She has opportunities to use her skills; before she was just memorizing facts. I see it in marks and performance and I see it in pencil and paper tasks and how she applies it. (Interview, Teacher School 2)

Talk about differentiated instruction! When kids are working on a problem using a hands-on approach, the understanding is much more concrete, and allows those struggling learners to experience success. Students who are more successful and fail less are now challenged by math and can extend their thinking. My math program will forever be changed by this, I believe. (Journal, Teacher School 2)

The teachers appreciated that evidence of the students` growth would take time to present and that there was a potential long-term dividend to be realized from engaging in the problem solving methods.

I see a measurable difference, but this was just their first year in this and they are in grade 4. It will become clearer in grades 5 and 6 and in a few years to come in grade 7 and 8. It is like learning to read in grade 1 and seeing how critically they read in grade 8. This year they have spent so much time learning how to use the techniques then in grade 7 and 8 you will see growth in independent learning and thinking. Now it is still guided by the teacher as they are just learning the math talk. (Interview, Teacher School 3)

A lot of the students are strong and the report card data will show this. I have seen growth in those who have actively participated in the teams have grown the most. One of the students who is challenged socially is offering a lot in the group work because he thinks about things differently. Now confidence in math is the case with some students. There are more students that like math now. If you enjoy what you are doing it will have an impact on how well you do. (Interview, Teacher School 6)

The results of the quantitative analyses computed using the students` report card data are displayed in **Tables 5. and 6**. Table 5. 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, 27)=5.121, *p* =.032	Scores from June/12 (*M*=78.32)are significantly higher than scores from Jan./12 (*M*=75.61)
Measurement	**Repeated Measures ANOVA**	**Interpretation of Significant Results**
All Schools Combined	(*F*(1,198)=6.947, *p* =.009	Scores from June/12 (*M*=75.81)are significantly higher than scores from Jan./12 (*M*=74.90)
Geometry and Spatial Sense	**Repeated Measures ANOVA**	
School 5	(*F*(1,26)=5.465, *p* =.027	Scores from June/12 (*M*=77.63)are significantly higher than scores from Jan./12 (*M*=74.33)
Data Management and Probability	**Repeated Measures ANOVA**	
-	-	-
Patterning and Algebra	**Repeated Measures ANOVA**	**Interpretation of Significant Results**
School 3	*F*(1,14)=10.270, *p* =.006	Scores from June/12 (*M*=78.53)are significantly higher than scores from Jan./12 (*M*=74.67)

Table 5. Repeated Measures ANOVA (Within Subjects): Mathematics strands for all schools combined, separate and interpretation of the significant results

Table 5**.** has summarized four statistically significant changes in students` scores for strands in Number Sense and Numeration, Measurement, Geometry and Spatial Sense, 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 6. 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(1, 375)=2.322, *p*=.006	Female students were higher in T2(M=77.59) than T1(M=76.73)
F(1, 375)=39.631, *p*=.000	Non-tutored students were higher in T2(M=78.10) than T1 (M=77.38)
F(1, 356)=2.285, *p*=.001	Students in Grade 4/5 Teacher`s class in School 6 showed the most growth from T1 (M=79.30) to T2 (86.60)

F(1, 372)=4.241, *p*=.002	Overall, School 5 showed the most significant growth from T1 (M=75.61) to T2 (78.32)
F(1, 325)=5.451, *p*=.020	Males in Grade 5 in School 6 had the most growth from T1 to T2
Number Sense and Numeration School 2	
Repeated Measures ANOVA	**Significant Results Explained**
F(1, 111)=31.736, *p*=.000	Non-tutored students showed significant growth T1 (M=79.52) to T2 (M=79.99)
Number Sense and Numeration School 3	
Repeated Measures ANOVA	**Significant Results Explained**
F(1, 72)=2.800, *p*=.046	Non-tutored students in Grade 5 Teacher`s class showed the most growth from T1 (M=68.71) to T2 (M=81.47)
Number Sense and Numeration School 4	
Repeated Measures ANOVA	**Significant Results Explained**
F(1, 102)=4.061, *p*=.020	Females in Grade 6 in School 4 showed the most growth from T1 (M=77.20) to T2 (M=78.15)
Measurement All schools combined	
Repeated Measures ANOVA	**Significant Results Explained**
F(1, 189)=5.158, *p*=.000	Students in Grade 5 Teacher`s class at School 4 showed the most significant increase from T1 (M=76.38) to T2 (77.52)
F(1, 179)=2.081, *p*=.033	Male students in Grade 4/5 Teacher`s class in School 4 showed the most significant growth from T1 (M=79.45) to T2 (M=82.09)
F(1, 180)=3.291, *p*=.002	Tutored students in Grade 6 class in School 4 had the most significant growth from T1 (M=65.60) to T2 (M=78.20)
Measurement School 2	
Repeated Measures ANOVA	**Significant Results Explained**
F(1, 28)=5.991, *p*=.021	Tutored students in Grade 6/7 Class in School 2 were significantly higher at T2 (M=72.67) than T1 (M=70.67)
F(1, 28)=5.991, *p*=.021	Tutored students in Grade 6in School 2 were significantly higher at T2 (M=72.67) than T1 (M=70.67)
Measurement School 3	
Repeated Measures ANOVA	**Significant Results Explained**
F(1, 47)=7.585, *p*=.008	Tutored students in Grade 4/5 in School 3 were significantly higher at T2 (M=77.10) than T1 (M=75.70)
Measurement School 4	
Repeated Measures ANOVA	**Significant Results Explained**
F(1, 102)=13.556, *p*=.000	Students in Grade 5 in School 4 had significantly higher scoresthan all others in T2 (M=77.52) than T1 (M=76.38)
F(1, 101)=3.111, *p*=.049	Females in Grade 4 in School 4 showed the most increase from T1 (M=70.82) to T2 (M=71.09)
Geometry and Spatial Sense All Schools Combined	
Repeated Measures ANOVA	**Significant Results Explained**
F(1, 268)=3.528, *p*=.000	Students in Grade 3 were more significant at T2 (M=77.41) than T1 (M=76.44)
Geometry and Spatial Sense School 2 Only	
Repeated Measures ANOVA	**Significant Results Explained**
F(1, 73)=5.618, *p*=.020	Non-tutored students in School 2 grew significantly from T1 (M=78.94) to T2 (M=80.32)
Geometry and Spatial Sense School 6 Only	
Repeated Measures ANOVA	**Significant Results Explained**
F(1, 33)=4.931, *p*=.013	Students in Grade 3/ 4 in School 6 showed the most significant growth from T1(M=76.31) to T2 (M=77.54)

Data Management and Probability School 4 Only	
Repeated Measures ANOVA	**Significant Results Explained**
F(1, 84)=4.042, *p*=.048	Tutored students in School 4 had the most significant change from T2 (M=75.38) compared to T1 (M=73.19)
F(1, 84)=3.951, *p*=.050	Females in Grade 6 in School 4 showed the significant growth from T1 (M=76.50) to T2 (M=76.70)
Patterning and Algebra All schools combined	
Repeated Measures ANOVA	**Significant Results Explained**
F(1, 96)=24.200, *p*=.000	Non-tutored students showed the most growth from T1 (M=80.06) to T2 (M=80.42)
F(1, 96)=4.572, *p*=.035	Grade 6students showed the most growth from T1 (M=75.14) to T2 (M=77.50)
Patterning and Algebra School 2 Only	
Repeated Measures ANOVA	**Significant Results Explained**
F(1, 55)=36.343, *p*=.000	Tutored students showed the most significant change from T1 (M=70.84) to T2 (M=73.53)

Table 6. Repeated Measures ANOVA (Between Subjects): Mathematics strands for all schools combined, separate and interpretation of the significant results

Table 6**.** has summarized statistically significant changes in students` scores for all strands in mathematics. Results varied widely by schools, teachers, genders and those students that were tutored. In Number Sense and Numeration, the performance of female students in Grade 6 (overall and at School 4) and male students in Grade 5 (at School 6) was noteworthy. Overall, students in School 5 showed growth in this strand. In Measurement, there was significant growth in the tutored students in Grades 4/5 (at School 3), Grade 6 (at Schools 2 and 4), and Grade 6/7 (at School 2). At School 4, there were remarkable changes in scores for students in Grades 4/5 and Grade 5 in Measurement. The results for Geometry and Spatial Sense point to overall significant growth in Grade 3 students and in particular Grade 3/4students at School 6. For Data Management and Probability, again School 4`s tutored students had the most significant change and female students in Grade 6. Finally, for Patterning and Algebra, overall, Grade 6 students showed the most growth and tutored students at School 2.

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).

Limitations

It is typical with any educational research to declare limitations in the research methodology 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, possess natural internal biases when participants self-report their responses. As well, teachers` interview responses might be slanted toward a perceived confirmation of the positive effect of participating in a program. Other

limitations of this research generalizability are based on the realities 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 professional learning sessions. The 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

Practicing teachers need a safe forum to express their beliefs about mathematics instruction. Facilitators need to begin this discussion with a debriefing about prior experiences as a student learning mathematics. Memories of effective and ineffective practices need to be deconstructed and connected to current, research-based instructional methods. The teacher`s role as a director of knowledge versus a facilitator of student-directed learning should be explicitly addressed as part of teachers` beliefs and attitudes. 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.

Teachers are appreciative of direct supports for mathematics assessment and instruction. The Numeracy Nets were regarded as invaluable assessment tools and the teachers were looking for nets to cover all curricular expectations. This might be a focus of the curriculum department in the school board. Further, examples might be drawn from the teachers that are currently using the Numeracy Nets effectively to group students and differentiate instruction. There might be an emphasis on how this addresses the challenges in split grade classrooms and classrooms with a diversity of student needs in mathematics. In a similar vein, teachers might appreciate a repository of examples of ``minds on`` activities to identify and clear up students` misconceptions, problems that generate multiple solution pathways, and a variety of lesson consolidation activities.

Since the mathematics textbook was not comprehensively relied upon, it might be reviewed by a sub-committee of the curriculum department in order to identify specific and effective questions and activities. These might then be cross referenced to curricular expectations and recommended for classroom use in assessment or instruction.

With respect to the discomfort that teachers felt regarding covering fewer curriculum expectations than they had in the past, professional learning might focus on curriculum mapping and collapsing expectations into groupings that could be meaningfully taught concurrently. Modelling how to cluster expectations across strands and develop integrated mathematics lessons would be a next step in implementing this program of professional learning.

Teachers of students in Grades 3 and 6 need to become explicitly aware of how teaching through problem solving is embedded in EQAO assessment question items. In other words, EQAO preparation is ongoing throughout the primary and junior grades and inherently a part of mathematics instruction. Teachers should not be regarding EQAO preparation as a distinct educational entity. Moreover, they should not be communicating it as such to their students as this reinforces the notion that it is a one-off assessment that does not require students to transfer their knowledge and skills.

A part of the initial professional learning agenda should include classroom set up and methods for students to work in cooperative groups. Teachers should work with strategies that address respect, social skills, listening, speaking and role-taking. Teachers might model `math talk` and appropriate protocols for working in discussion groups. For students that are having difficulty engaging in open-ended problems, teachers could model their own conscious stream of inquiry through a talk aloud. When teachers highlight the fact that there is often no single best pathway to finding a solution, this provides validation for the multiple explanations.

Teachers should recognize that some of their students lack confidence and self-efficacy in mathematics and need positive reinforcement and assurance. Opportunities for this are presented when teachers are conferencing (one-on-one) with students and when students are presenting and sharing their work with their peers.

The role of the Intervention Coach should be sustained in a capacity that fully utilizes this educator`s time and expertise. Tracking systems and procedures for identifying students` needs should continue to be honed and coaching time should be extended so that more students can be supported.

Without question, an essential component of this professional learning project was the release time that teachers received to co-plan and co-teach with their teaching partners. They regarded this piece as having an impact on both their practice and their students` learning. The time devoted to co-planning was used in a variety of ways and in some cases included teacher moderation of student work. Time allocated to co-teaching also varied and often included observation of students. 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. Circuitously, this mirrors the key elements articulated in the purpose of the project as a whole: identifying needs, discussion, collaboration, problem solving and intervening.

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 for a full academic year – 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 2012-2013

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

- continue JMI research framework in 3 of four school sites in 2012-13
- introduce JMI project to three new school sites for 2012-13
- network each Year Two school with a Year One school
- alter to role of the Intervention Coach to gradually phase in all components of the project in Year One schools
- introduce Fosnot's *Contexts for Learning Mathematics* and *Landscapes of Learning* as a new resource to Year Two schools
- analyse teacher efficacy data for the following 4 parameters: Year One Teachers in Year One Schools, Year One Teachers in Year Two Schools, Year Two Teachers in Year Two Schools and Year Two Teachers in the non-participating school site.

Figure 3. below offers a flowchart of the JMI Project Framework (2012-2013) and **Table 7.** provides a description of the components of the JMI Coaching Focus Framework (2012-2013). Finally, **Table 8.**provides an associated Budget Request for 2012-2013.

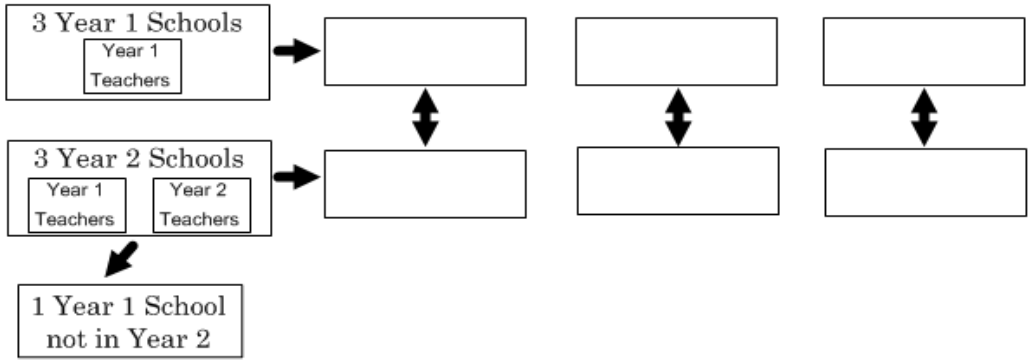

Figure 3. JMI Project Framework (2012-2013)

Year One Schools	***Year Two Schools***
Cycle #1: September / October	
• Numeracy Nets • Moderation of Numeracy Nets • Getting Ready for Problem Solving (Classroom Norms etc.)	• Getting Ready for Problem Solving (Classroom Norms etc.) • Co-teaching/Co-planning 3-part lessons (focus on consolidation) • *Year 1 teachers may need more of a Numeracy Nets focus*
Cycle #2: November / December	

• Co-teaching/Co-planning 3-part lessons based on Numeracy Nets	• Intervention Coaching begins focused on teacher-targeted misconceptions • *Each teacher is released to meet 1-on-1 with coach for 1st debrief*
Cycle #3: January / February	
• Intervention Coaching begins focused on teacher-targeted misconceptions • *Each teacher is released to meet 1-on-1 with coach for 1st debrief*	• Intervention Coaching focused on teacher-targeted misconceptions
Cycle #4: March / April / May	
• Intervention Coaching focused on teacher-targeted misconceptions	• Intervention Coaching focused on teacher-targeted misconceptions

Table 6. JMI Coaching Focus Framework (2012-2013)

Item #	Units	Description	Analysis	Cost/unit	Total
1	8 days	**Teacher Release Days**	6 schools 6 teachers/school = 36 teachers x $245	**$8,820**	**$70,560**
2		**Resources Needed for Year 1 Schools**			
	18	One copy per teacher of Big Ideas from Dr. Small	18 teachers	**$70**	**$1,260**
	3	One set of Van de Walle's Teaching Student-Centred Mathematics per school	3 Year 1 Schools	**$80**	**$240**
3	1	**Intervention Coach Salary for 1 Year**			**$90, 000**
					$162, 060

Table 7. Budget Request for 2012-2013

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