EFFECTIVE PRACTICES IN GRADE 9 APPLIED MATHEMATICS

by

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Student achievement in Grade 9 has been linked to both secondary and post-secondary outcomes. Although Ontario has implemented significant curriculum and secondary school reforms, a significant subset of Ontario Grade 9 students consistently do not attain proficiency in mathematics. Students that take the applied mathematics course—on the pathway to college—are more likely to not reach the provincial standard on the provincial Grade 9 mathematics assessment than they are to reach it. This can have long-lasting consequences. The purpose of this qualitative study was to discern practices from the field that might contribute to better student outcomes in Grade 9 Applied Mathematics classrooms. Mathematics education experts from across the province were interviewed and visits were conducted at four of the province’s most successful schools on the Grade 9 provincial mathematics assessment. The findings from this study contribute to our understanding of the types of resources, professional development, departmental, leadership, and teaching practices that support student achievement in Grade 9 Applied Mathematics. The findings can be distilled into six central ideas. These are the importance of: reform-based teaching strategies and dispositions that foster intellectual engagement and investment in learning; instructional leadership by both the school administrator and mathematics department head; collaboration for both the teachers of and students in the Grade 9 Applied Mathematics course; valuing EQAO
assessments at all levels of the system; mitigating the stigma around applied-level courses; and, careful attention to the placement of teachers in Grade 9 Applied classrooms. This study contributes to the Ontario literature on Grade 9 Applied Mathematics and the literature on implementing mathematics reform. The findings of this study are of relevance to policy-makers and practitioners, especially school leaders and teachers. The study concludes with recommendations for both research and practice.
Dedication

For my father,
You are never far from my thoughts.
This one is for you.
Acknowledgments

I have left the writing of this section of my research report as the final act of my EdD journey. And so, I sit here with mixed emotions. Though I am incredibly thrilled to have crossed the finish line, this also marks the tangible end to an amazing journey of growth, discovery, reflection, and intellectual engagement. I think differently now as a result of the journey, and I am forever transformed. There are many people to thank.

First of all, in pursuing my doctorate, I decided to go the route of the EdD cohort. What a great decision that turned out to be! I learned so many lessons from my cohort colleagues and from the opportunity to engage in the academic enterprise with them. Thank you especially to Kathy, Mary, Cindy, Richard, and John who kept in touch with me long after the courses were over, gave me encouragement to carry on, and delivered pep talks as needed.

To the professors and staff at OISE that contributed to my EdD experience, thank you. Whether you taught a course, played a role in, or organized one of the many milestones (internship, comprehensive exam, proposal hearing, ethical review, and final oral examination)… I appreciate what you did to support me along the way.

To Dr. Jane Gaskell, thank you for serving as a member of my examining committee. I appreciate the time and energy that you gave to the cause. It was an added bonus after your presence at my proposal hearing. I valued all your support and encouragement on both of these occasions as well as the perspective that you brought which pushed my thinking in new ways.

To my external committee member and reviewer, Dr. Ann Kajander, thank you. I have followed your work for a long time, and it was a thrill that you agreed to read and
give feedback on my work. Your enthusiasm and encouragement for my research is much appreciated. I am especially grateful that you travelled from the Lakehead to attend my examination in person. Thank you also for your thoughtful questions that facilitated my growth as a new scholar. It was very nice to hear your thoughts and perspective on my work and how it might be helpful to the field.

To my committee members Dr. Carol Campbell and Dr. Doug McDougall, you have been a “Dream Team” to work with… I look up to you both as accomplished scholars and role models, so having you on my committee is indeed a dream come true! I appreciate the time that you both took to read my work, to prepare your thoughtful feedback, and to share your insights. You have helped me to understand the significance and value of the peer review process and how it can make my work and thinking that much better. I am honoured that you believed in this work and what might be learned from it.

To my supervisor Dr. Joe Flessa, your presence along my journey has had a profound impact on me: from my course work, to the comprehensive exam, to the research thesis. You have challenged me to rise to new heights and to become an independent and confident thinker “with a cause.” Your feedback and questioning about what I was learning helped me to consolidate my understanding and clarify my new and emerging insights. You always gave me the perfect advice to polish my writing. I am forever grateful to you for catching the ball in play and helping me make it to the finish line. You so graciously honoured the work as it was and believed in me to carry on. Thank you for the leap of faith! I am quite certain that I would not have made it without
your support, inspiration, and reassurance that the end was in sight. What’s more, I could not hoped for a better outcome in the end! Gratias tibi ago.

To everyone that participated in my study, thank you. I have learned so very much from all of you. Thank you also to the boards and schools that permitted the research. What I have learned from this work is a celebration of remarkable things happening in your remarkable classrooms with your remarkable teachers and their remarkable students. I look forward to sharing the lessons that I have gleaned from them.

To my friends and colleagues who have encouraged and supported me over the past eight years, thank you. Thank you especially to my co-workers Sandra, Natalie, and Beth who were such willing active listeners and sounding boards. I must also thank Maureen for giving me the latitude to make “it” happen, for believing in this work, and my “other” life as a researcher.

I must also extend a special thanks to Sandra for helping me at the drop of a hat, whenever I made a random request of her. I owe Figures 7, 8, and 23 to her genius for transforming my field note sketches to a “thing of beauty” with Geometer’s Sketchpad.

Last, but not least, I must thank my family. For the patience, the faith and the occasional nudges that you have given, thank you. Thank you to my parents and my sister for believing in me and celebrating my accomplishments along the way, not only on this journey but also throughout my life. You have always supported me unconditionally, whatever the venture, and I am so very grateful for that.

Thank you to my husband Don who never batted an eye when I first broached the subject of pursuing my doctorate. He had barely had time to recover from the Masters epoch! Regardless, he has been in my corner this whole time, bestowing unending
support, latitude, and endurance. Eight years is a long time. It is time to turn the page and start a new chapter. And finally to my pets Kobe and the never-forgotten Patches. They have taken their turns in keeping me company during many a late night. There should be lots more time now for walkies, frolics in the park, and Sunday drives!
TABLE OF CONTENTS

ABSTRACT ........................................................................................................ ii

DEDICATION .................................................................................................... iv

ACKNOWLEDGEMENTS .................................................................................. v

TABLE OF CONTENTS .................................................................................... ix

LIST OF TABLES ................................................................................................ xiii

LIST OF FIGURES ............................................................................................. xiv

CHAPTER ONE: INTRODUCTION ...................................................................... 1

Overview .......................................................................................................... 1

Background and Policy Context ...................................................................... 2

Education Reform in Ontario .......................................................................... 3

Statement of the Problem .............................................................................. 5

Guiding Research Questions ......................................................................... 10

Background of the Researcher ....................................................................... 11

Plan of the Thesis ............................................................................................ 17

CHAPTER TWO: LITERATURE REVIEW .............................................................. 19

Overview .......................................................................................................... 19

Literature Review Search .............................................................................. 19

The Evolution of Mathematics Curricula in Ontario ..................................... 21

The Common Curriculum .............................................................................. 21

The Ontario Curriculum: Mathematics ......................................................... 22
<table>
<thead>
<tr>
<th>Chapter Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Ontario Curriculum: Mathematics (revised 2005)</td>
<td>29</td>
</tr>
<tr>
<td>Ontario Provincial Assessments</td>
<td>37</td>
</tr>
<tr>
<td>EQAO Grade 9 Assessment of Mathematics</td>
<td>39</td>
</tr>
<tr>
<td>The Mathematics Reform Movement</td>
<td>47</td>
</tr>
<tr>
<td>Reform-based Teaching Practices</td>
<td>51</td>
</tr>
<tr>
<td>Supports for Mathematics Reform in Ontario</td>
<td>80</td>
</tr>
<tr>
<td>Barriers to Implementing Reform-based Practices</td>
<td>84</td>
</tr>
<tr>
<td>Implementing Change in Secondary Schools</td>
<td>88</td>
</tr>
<tr>
<td>Departmental Structures</td>
<td>88</td>
</tr>
<tr>
<td>Teacher Autonomy</td>
<td>94</td>
</tr>
<tr>
<td>Streaming</td>
<td>98</td>
</tr>
<tr>
<td>The High Stream Advantage</td>
<td>105</td>
</tr>
<tr>
<td>Conceptual Framework</td>
<td>113</td>
</tr>
<tr>
<td>Theoretical Perspective: Social Constructivism</td>
<td>116</td>
</tr>
<tr>
<td>Significance of the Study</td>
<td>117</td>
</tr>
<tr>
<td>Chapter Summary</td>
<td>123</td>
</tr>
<tr>
<td><strong>CHAPTER THREE: METHODOLOGY</strong></td>
<td>126</td>
</tr>
<tr>
<td>Overview</td>
<td>126</td>
</tr>
<tr>
<td>Research Design</td>
<td>126</td>
</tr>
<tr>
<td>Data Collection</td>
<td>127</td>
</tr>
<tr>
<td>Data Management</td>
<td>128</td>
</tr>
<tr>
<td>Phase 1: Focus Groups</td>
<td>133</td>
</tr>
<tr>
<td>Sample</td>
<td>135</td>
</tr>
</tbody>
</table>
## LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 1</td>
<td>Percentage of Ontario Students Reaching Standard in Grade 9 Mathematics</td>
<td>9</td>
</tr>
<tr>
<td>Table 2</td>
<td>Course Content in Grade 9 Mathematics: Academic versus Applied</td>
<td>33</td>
</tr>
<tr>
<td>Table 3</td>
<td>EQAO Student Questionnaire Results: Grade 9 Mathematics, 2011/12</td>
<td>72</td>
</tr>
<tr>
<td>Table 4</td>
<td>Conceptual Framework for the Study</td>
<td>115</td>
</tr>
<tr>
<td>Table 5</td>
<td>Summary of Focus Group Meetings</td>
<td>138</td>
</tr>
<tr>
<td>Table 6</td>
<td>Focus Group Participants</td>
<td>140</td>
</tr>
<tr>
<td>Table 7</td>
<td>School A Trend Data, 2007-2012</td>
<td>149</td>
</tr>
<tr>
<td>Table 8</td>
<td>School B Trend Data, 2007-2012</td>
<td>152</td>
</tr>
<tr>
<td>Table 9</td>
<td>School C EQAO Trend Data, 2007-2012</td>
<td>155</td>
</tr>
<tr>
<td>Table 10</td>
<td>School D EQAO Trend Data, 2007-2012</td>
<td>158</td>
</tr>
<tr>
<td>Table 11</td>
<td>Case Study Schools and EQAO Trend Data for Grade 9 Mathematics</td>
<td>160</td>
</tr>
<tr>
<td>Table 12</td>
<td>Visits to Case Study Schools</td>
<td>161</td>
</tr>
<tr>
<td>Table 13</td>
<td>Case Study Participants</td>
<td>166</td>
</tr>
<tr>
<td>Table 14</td>
<td>Documents Collected During Phases 1 and 2</td>
<td>170</td>
</tr>
<tr>
<td>Table 15</td>
<td>Coding of Data Sources for the Study</td>
<td>176</td>
</tr>
<tr>
<td>Table 16</td>
<td>Level 4 Performances for Case Study Schools and the Province</td>
<td>207</td>
</tr>
</tbody>
</table>
LIST OF FIGURES

Figure 1. Comparisons of EQAO results for Grade 3 and Grade 6 Reading, Writing, and Mathematics, over time. .................................................................8

Figure 2. Course prerequisites for Grade 9–12 Mathematics: The Ontario Curriculum, 1999. ..................................................................................................................................................25

Figure 3. Course prerequisites for Grade 9–12 Mathematics: The Ontario Curriculum, 2007. .............................................................................................................................................30

Figure 4. EQAO assessments results for Grade 9 Mathematics, over time. ..................41

Figure 5. Sample open response question on EQAO Grade 9 Applied Mathematics assessment ..........................................................................................................................43

Figure 6. The area of a triangle as it relates to the area of a rectangle. .........................50

Figure 7. Sample question to explore the Pythagorean Theorem..................................61

Figure 8. Sample solutions to the "gold" problem illustrating that $a^2 + b^2 = c^2$ ........61

Figure 9. The number 7 on a ten-frame. ........................................................................62

Figure 10. Representation of 134 using base ten blocks. .............................................63

Figure 11. Linking cubes as base ten materials. ..............................................................63

Figure 12. The instruction core in a reform-oriented mathematics classroom..............77

Figure 13. The intended versus the attained curriculum. ..............................................95

Figure 14. Data collection methods and tools. ...............................................................127

Figure 15. Creating and organizing nodes in NVivo.....................................................130

Figure 16. Building Themes in NVivo. .........................................................................131

Figure 17. Applying selection criteria to determine consistently high performing schools. .............................................................................................................................................144
Figure 18. EQAO five-year trend data for province and case study schools in Grade 9 Applied Mathematics, 2007-2012 .......................................................... 147

Figure 19. Screenshot of Grade 9 Applied Mathematics class wiki ........................................ 179

Figure 20. Examples of anchor charts in three case study classrooms .................................. 204

Figure 21. Cognitive Skills ................................................................................................ 206

Figure 22. Dimension 5: Constructing knowledge ................................................................ 209

Figure 23. Investigation of the sum of angles in a triangle ................................................... 211

Figure 24. Manipulative cart, Classroom A .......................................................................... 214

Figure 25. Lesson agenda for Classroom C observation ...................................................... 227

Figure 26. Mind map of research findings ............................................................................ 230
CHAPTER ONE: INTRODUCTION

In schools and classrooms around the world, effective strategies are being used to ensure that all students achieve regardless of background factors such as socio-economic status, race, ethnicity, disability, and gender. The tragedy is that these schools and classrooms are not the majority in many jurisdictions…We still have groups of students yet to achieve at appropriate levels. We owe it to these students to ensure that they have access to those policies and instructional practices that we know can help eliminate achievement gaps. (Glaze, Mattingley & Levin, 2012, p. 38)

Overview

This thesis was prompted by concern with a chronic achievement gap in Ontario secondary schools, namely the discrepancy in performance between applied and academic course-takers on the provincial assessment for grade 9 mathematics. Since the time that this test was instituted more than a decade ago, students taking the applied course have lagged behind their peers in the academic course. Currently, close to 40% of students in the applied pathway are reaching the provincial standard. In contrast, 84% of students in the academic pathway are reaching it. When almost twice as many students are successful in one pathway compared to another, it is clear that outcomes in grade 9 mathematics classrooms are not equitable. This is significant when one considers that mathematics skills are regarded as critical for success in life and at work during the twenty-first century (Conference Board of Canada, 2012; Desbiens, 2012; Organization for Economic Development, 2009). The intent of conducting this research was to discern from the field what practices might contribute to fostering better outcomes for students taking Grade 9 Applied Mathematics.

This chapter provides the contextual backdrop to the study. It begins with an explanation of the policy environment from which the research questions emerged.
This is followed by a statement of purpose for the research, situated as a problem of practice for the researcher. This is followed by a discussion of the background that the researcher brings to the work. This chapter concludes with an outline of the thesis.

**Background and Policy Context**

This research study is situated in the province of Ontario, Canada. Ontario is Canada’s most populous province with one in three, or over 13 million, calling it home (Ontario Ministry of Education, 2012c). At the time of the study (October 2012 to June 2013), Ontario schools served more than 2 000 000 students in approximately 4000 elementary and 900 secondary schools (Ontario Ministry of Education, 2012b).

In Canada, the provinces and territories have constitutional jurisdiction over education and in Ontario, primary and secondary education is the responsibility of the Ontario Ministry of Education (OME). Having said this, local district school boards and school authorities administer schools. Although English is Ontario’s official language, French-language rights have been extended into the legal and educational systems (Council of Ministers of Education, 2010). As a consequence, there are both English- and French-language school boards in Ontario. In total, there are 72 local district school boards in Ontario: 60 English-language and 12 French-language. There are also 10 school authorities consisting of four geographically isolated boards and six hospital-based school authorities.

It should be noted that the English- and French-language systems have similar, but different curricula. Consequently, the scope of this research paper is restricted to schools in the English-language system that account for approximately 95% of all students (OME, 2012a). In addition to language affiliation, Ontario school boards also
have a public or Catholic designation. Amongst the 60 English-language districts, there are 31 public and 29 Catholic districts. Approximately 70 percent of English-language students attend schools in the public system while 30 percent go to Catholic schools (OME, 2012b).

Ontario has what is known as a “10–4” educational system. This comprises ten years in elementary school and four years in secondary school. There are four divisions that students will progress through in their journey to graduation: Primary (Kindergarten to Grade 3), Junior (Grades 4 to 6), Intermediate (Grades 7 to 10), and Senior (Grades 11 and 12). Generally speaking, students are housed in elementary schools from Kindergarten through Grade 8 and then they will transition to secondary schools for Grades 9 through 12. Some school districts have intermediate or “middle” schools for Grade 6 through Grade 8 students, although this is not the norm.

Upon successful completion of secondary school, students graduate with an Ontario Secondary School Diploma (OSSD) with which they can enter directly into the world of work. Alternatively and with the required prerequisites, students can proceed to a tertiary stage of education including community college, university, and apprenticeship programs.

**Education Reform in Ontario**

As was the case in other jurisdictions that were coming to terms with an increasingly globalized and competitive reality, Ontario underwent significant change in its education policy during the 1990s and early 2000s (Anderson & Ben Jaafar, 2003). At the time, economic and political uncertainty contributed to a climate of concern about the quality of education (Ontario Principals’ Council, 2009). With the increasingly lackluster
performance of Ontario students on international and national assessments (Winter & McEachern, 2001), cries for higher standards and accountability became louder and more insistent. As a result, three consecutive governments—all with the same intent of improving student outcomes—introduced a succession of substantive education reforms.

One of the pre-eminent features of the reforms was the move towards a tighter coupling between the state and the classroom. There was widespread sentiment among policymakers at the time that, in order to control what happened in classrooms, it would be necessary to more clearly define and articulate what was taught there. Consequently, three successive Ontario governments—each with a different political stripe—introduced increasingly prescribed curriculum and assessment policy for every subject, from Kindergarten through to the end of secondary school. The thinking was that, by holding all students accountable for meeting the same standards, improved student achievement and equality of educational opportunity would result (Sandholtz, Ogawa, & Scribner, 2004).

Other changes that were introduced included the implementation of a standardized report card tied to the new curricula and achievement criteria. Beginning in 1997, new accountability measures in the form of provincial testing were phased in for reading, writing, and mathematics. Therefore, in fairly short order, Ontario teachers had to re-construct nearly every aspect of what they did in the classroom, from instruction and assessment to evaluation and reporting (Leithwood, Fullan, & Watson, 2003).

Nested within this overhaul of the education system was a movement known as “Mathematics Reform,” an effort to transform the way that mathematics was being taught and learned in classrooms. This intensified the degree of adjustment that was required in
the mathematics classroom over a relatively short period of time. To put this into perspective, a secondary mathematics teacher with twenty years of experience in 2014 would have had to implement three significant changes in the mathematics curriculum during their career to date.

**Statement of the Problem**

We are in an era of rapid globalization. Jurisdictions around the globe have been swept into massive education reform efforts aimed at boosting their economic and international competitiveness. Mandated curricula, standardized assessments, accountability systems and the like are often implemented to ensure that children, seen as vital resources for the future, are well equipped to enter the workforce. The basic logic for schooling relies on preparing students for a market economy (Kanpol, 1998) and equipping them with the knowledge, attitudes, and values that will allow them to survive and engage in society as future citizens (Trentacosta & Kenney, 1997).

Dalton McGuinty, the premier of Ontario at the time this research study began, made it known upon his election that he wanted to be remembered as the “Education Premier.” At the time that he came into power in 2003, only about 60% of Ontario students were graduating from Ontario’s 800 high schools in the normal four years. “This,” McGuinty said, “was an unacceptable level in a knowledge society” (Levin, 2008, p. 32). McGuinty’s election platform had included a promise to the electorate that, by 2008, 75% of all Grade 6 students would achieve at or above the provincial standard on the provincial assessments of reading, writing, and mathematics. He also committed to increasing the high school graduation rate to 85%, by June 2011.

To help accomplish these goals, McGuinty focused on three goals: improving
student outcomes, reducing gaps in achievement, and improving public confidence in public education (OME, 2008b). Two organizations were established, each with a budget of some $80 million per year; the Literacy and Numeracy Secretariat (LNS) focused on student achievement in the Kindergarten through Grade 6 panel while its counterpart Student Success focused on Grades 7 to 12. Both organizations worked directly with district school boards, closely monitoring their action plans for improved student achievement. These efforts included:

- Working with school boards to set ambitious student achievement targets and to develop improvement plans;
- Working with school boards to provide the necessary resources and to identify ways to improve student achievement;
- Sharing research on effective teaching;
- Providing professional learning opportunities to teachers, principals, and other educators;
- Building partnerships with principals' councils, teachers' federations, faculties of education and other organizations; and
- Sharing successful practices within and across school boards to build capacity and implement strategies to improve reading, writing, and mathematics skills.

(OME, 2009)

In addition to these strategies, these two organizations were responsible for developing a bounty of resources including research monographs, podcasts, and guides for effective instruction. They also provided special funding to local district school boards for projects such as “Schools in the Middle” and “Collaborative Inquiry for
Mathematics Learning” (CIL-M). The OME also developed the Learning to 18 Strategy for improving high school graduation rates. This strategy focused on six areas: credit recovery; alternative education; student success in Grade 9 and 10; program pathways to apprenticeship and the workplace; college connections; and success for targeted groups of students (OME, 2005b).

As far as the Grade 6 targets are concerned, recent results from the EQAO illustrate that student achievement has steadily improved in the province. Figure 1 shows data from provincial testing in the Primary (Grade 3) and Junior (Grade 6) divisions for the five-year period from 2007/2008 to 2011/2012. Although not all of the promised targets were met, (i.e., 75% of students at Levels 3 and 4 by the end of Grade 6), steady progress was made towards reaching them in the areas of reading and writing. The mathematics results, on the other hand, declined in both the primary and junior divisions.

On its promise to improve high school graduation rates, the OME has made steady progress. Ontario’s high school graduation rate recently increased for the eighth year in a row. Since 2003–04, the high school graduation rate has increased by 15 percentage points—from 68 to 83%. This represents 115 500 more students attaining their high school diplomas (OME, 2013), just shy of McGuinty’s 85% target.

Despite the noteworthy improvements in student achievement that have been realized over the last eight years, a significant number of students in Ontario are still not reaching the provincial standard for achievement in mathematics. This indicator is the farthest from the provincial target in both the primary and junior divisions. Figure 1 illustrates, as of the end of the 2011/12 school year, only 58% of Grade 6 students were currently at or above the provincial standard for mathematics. This trend is exacerbated
in Grade 9 where a persistent achievement gap has developed between students taking the course in the applied pathway and their peers taking the course in the academic pathway.

![Graph showing percentage of Grade 3 and Grade 6 students at or above the provincial standard for Reading, Writing, and Mathematics.]

**Figure 1.** Comparisons of EQAO results for Grade 3 and Grade 6 Reading, Writing, and Mathematics, over time. From “Highlights of the Provincial Results” by EQAO, http://www.eqao.com/pdf+e12/EQAO_PJ9_Highlights_2012.pdf. Copyright 2012 by the Queen’s Printer for Ontario.

Table 1 highlights seven years of student achievement data for the EQAO Grade 9 Mathematics Assessments, starting in 2005/06 when *The Ontario Curriculum: Mathematics (2005)* was implemented. This data illustrates that achievement for students in the academic course rose thirteen percentage points from 71% to 84% and that at the end of the 2012 school year, more than three-quarters of students were achieving the provincial standard. Over the same timeframe, achievement for students in the applied course rose nine percentage points from 35% to 44%. That said, less than one-half of the students in the applied course were achieving the provincial standard by June 2012. Put another way, nearly twice as many students in the academic pathway are reaching the standard than are students in the applied pathway.
Table 1

*Percentage of Ontario Students Reaching Standard in Grade 9 Mathematics*

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Grade 9 Test Takers</th>
<th>Number of Academic Test Takers</th>
<th>Number of Applied Test Takers</th>
<th>GAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005/06</td>
<td>n = 154,099 or 67%</td>
<td>n = 103,412 or 67%</td>
<td>n = 50,687 or 33%</td>
<td>36</td>
</tr>
<tr>
<td>2006/07</td>
<td>n = 152,067 or 68%</td>
<td>n = 103,011 or 68%</td>
<td>n = 49,056 or 32%</td>
<td>36</td>
</tr>
<tr>
<td>2007/08</td>
<td>n = 148,640 or 68%</td>
<td>n = 100,823 or 68%</td>
<td>n = 47,817 or 32%</td>
<td>41</td>
</tr>
<tr>
<td>2008/09</td>
<td>n = 149,474 or 68%</td>
<td>n = 100,992 or 68%</td>
<td>n = 48,482 or 32%</td>
<td>39</td>
</tr>
<tr>
<td>2009/10</td>
<td>n = 148,834 or 68%</td>
<td>n = 101,268 or 68%</td>
<td>n = 47,566 or 32%</td>
<td>42</td>
</tr>
<tr>
<td>2010/11</td>
<td>n = 143,373 or 69%</td>
<td>n = 99,278 or 69%</td>
<td>n = 44,095 or 31%</td>
<td>41</td>
</tr>
<tr>
<td>2011/12</td>
<td>n = 139,540 or 70%</td>
<td>n = 97,741 or 70%</td>
<td>n = 41,799 or 30%</td>
<td>40</td>
</tr>
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Note: There is a third course for Grade 9 Mathematics known as “Locally Developed.” Students taking this course are not required to take the provincial assessment for Grade 9 Mathematics. Approximately 6.4% of students in Grade 9 enroll in the locally developed course (People for Education, 2013) and are therefore not accounted for in this study.

Also significant is the fact that the achievement gap between the two courses has remained relatively resistant and even rose over the seven years by four percentage points. The number of students in each stream has remained quite stable with roughly two-thirds taking the academic course and one-third taking applied level; about 3% more students were taking the academic course at the end of the seven years.

The evidence is clear. Students in academic classes are doing better than ever while their counterparts in applied classes appear to be withering on the vine—only 44% of students in applied classrooms achieve what amounts to a “B” on the provincial
assessment. Despite more than seven years of intensive efforts to boost student achievement, less than half of the students in the applied stream are achieving the provincial standard. This is significant when one considers that the number one indicator that a student will not graduate with a high school diploma is failure of Grade 9 Applied Mathematics (M. Ingalls, OME Official, personal communication, October 16, 2008). If a measure of success for a good educational system is that students will graduate and get a job, then this represents a major shortcoming and social justice issue for Grade 9 Applied Mathematics course-takers. Dr. Brian Desbiens, Chair of EQAO’s Board of Directors, put it this way: “In this day and age, solid mathematics skills are crucial to success in all facets of life. The lack of progress in mathematics achievement… is concerning” (Desbiens, 2012, para 4).

For all of these reasons, it is crucial that we begin to understand what kind of practices lead to better student outcomes in Grade 9 Applied Mathematics. At present, there is very little research that documents the success stories of Grade 9 Applied Mathematics. This research sets out to investigate the practices of “successful” and “rapidly improving” schools, as measured by student achievement on EQAO assessments. The results of this study will be useful to teachers, schools, districts, and the OME as we work towards eradicating the stubborn achievement gap in Grade 9 Mathematics.

**Guiding Research Questions**

Given the chronic underachievement of students on the EQAO Grade 9 Applied Mathematics Assessment and the repercussions of this reality, this study set out to investigate practices that might help in countering this trend. Specifically, the
overarching research question was:

- What practices are being used by high performing schools in Grade 9 Applied Mathematics?

A second and related sub-question is:

- Which of the specific practices identified in the mathematics and general reform literature as being related to better mathematics achievement have been adopted by the most successful schools?

**Background of the Researcher**

I am an Ontario-certified teacher. I began my teaching career twenty-five years ago as an elementary classroom teacher. After working as a Math Consultant for 14 years, I returned to the classroom in September 2012 as a Grade 7 teacher. Classroom teachers in the elementary panel are generalists in nature, meaning that they will teach all subject areas (with the exception of French as a Second Language, in my case). By virtue of this fact, I taught mathematics to my students.

Admittedly, I have no experience as a Grade 9 or secondary school teacher. Even so, I believed that I was positioned to conduct this study because I have distance from “the problem” and can perhaps be more objective about it. I am not mired down by any experience or “baggage” acquired from teaching Grade 9 Applied Mathematics. I simply researched a topic that interested me and made me wonder. In part to inform my research for this paper, I became certified to teach Intermediate (Grades 7 to 10) Mathematics. As a result of acquiring my Additional Basic Qualification in Intermediate Mathematics, I can now technically teach Grade 9 Applied Mathematics. More importantly, however, I
now have a better understanding of the course and its content. This knowledge was helpful to me when I conducted the interviews for the study.

Early in my teaching career, I became dissatisfied with my mathematics teaching because I found that, although students seemed to be able to “do the math” in practice, they were not able to apply and use it independently in novel situations. At the time, I was using what is now considered to be a more traditional approach. I would introduce a new piece of learning, help students work through some examples, and then assign seatwork in which they could independently rehearse the new skill. A typical assignment would include a number of practice questions with word problems at the bottom of the page. Invariably there would be a problem in this mix that had nothing to do with the skill that had just been taught, yet the students would “grab” the available numbers and proceed as if it did. The students figured out pretty quickly that today was “three-digit addition day” or “multiplication facts day” or “whatever the new skill was day” and they behaved accordingly. I could not help but feel that I was not really helping the students to develop mathematical thinking skills. In fact, they were behaving more like puppets, or well-trained puppies that followed my cues.

The straw that broke the proverbial camel’s back was the year that, as a Grade 3 teacher, I administered the first-ever Grade 3 EQAO Assessment. I was absolutely stymied by some of the questions that appeared on the mathematics portion of that assessment. I could not, for example, understand how Grade 3 students should be expected to know how to find the perimeter of a zucchini leaf! “How dare they ask such a thing?” I thought. After I got over my initial indignation, I felt that I needed to know what students were supposed to do with such a question. So it was that I applied to be a
scorer of that first-ever EQAO Assessment. When I found out at the training session that students could simply use a piece of string, outline the zucchini leaf with it, and then measure the string, I realized that I clearly was not approaching math as a youngster might and should. I was stuck in a world of formulas and procedures and that was what was valued in my classroom. This was a revelation to me.

I believe that it is important to stress that my experience in administering and scoring EQAO triggered an evolution in thinking for me. It was the stimulus that got me thinking and reflecting on my practice as a teacher. I suspect that it has inspired similar thinking with other teachers in schools and mathematics departments around the province. I hope through this research to illuminate some of that thinking.

My experience at and with EQAO taught me that I needed to learn a lot more about teaching mathematics. And this began a long and what feels like a never-ending journey of transformation for me. I began by seeking out professional learning opportunities in mathematics teaching. I joined the provincial mathematics association. I became involved in a number of writing projects for my board and the ministry. I attained my Masters of Education with a focus on Mathematics Education. Eventually I found myself in the role as Mathematics Consultant for my board. This role changed my perspective yet again because my work encompassed a system view; I was charged with not only helping individual teachers and schools, but with crafting a vision that would move a whole system forward.

From 2004 to 2007, I was seconded to the Ontario Ministry of Education, initially as an Education Officer for the Turnaround Teams program and then as a Student Achievement Officer (SAO) for the Literacy and Numeracy Secretariat. In my work at
the ministry, I witnessed firsthand how students, in all kinds of extenuating circumstances, can rise above their challenges when their teachers are afforded the opportunity to develop their capacity for skillful teaching. This experience helped me to realize how excellent teaching can impact on student outcomes and that we do not have to resign ourselves to bad results.

In early 2007, I heard about the EdD Cohort that would be starting at the Ontario Institute for Studies in Education (OISE). I was intrigued. The fact that the program was focusing on leadership was compelling to me, as was the cohort nature of the program; I felt that having the opportunity to journey through a doctoral program with a network of practicing professionals would provide a rich and engaging learning experience. I applied for the program and began my studies in May of 2007. I have focused my doctoral studies on the intersection of leadership and mathematics education, specifically as it relates to issues of equity, instructional leadership, and building capacity in mathematics teaching. My studies and the program have provided me with the perfect venue and context for “working on” my problems of practice.

A problem that I was reminded of every September with the release of the EQAO results for Grade 9 Mathematics is the lagging performance of our students in applied classrooms. My board met the provincial target of having 75% of students at provincial standard several years ago, but only for the academic course. Though we have made progress with our applied results, we are a long way from the target. The same is true provincially. Therein lies the impetus and interest that compelled me to conduct this research; I know that Grade 9 Applied Mathematics represents a “problem of practice” not only for my board, but also most other boards in the province, and indeed the
province itself.

This dilemma was often underscored during my work as a consultant at the system level. For example, I sat on the founding steering committees for the Ontario Youth Apprenticeship Programs at Durham and Fleming Colleges. The college instructors would regularly lament at our meetings that many of the students did not have the requisite mathematical skills to be successful in the program. Students who were “scraping by” in their high school math courses would inevitably fail in their college courses. I learned that teachers should not be content with “settling” on helping students to simply pass and get the credit. Their students simply would not be well enough prepared and equipped with that. Nor should teachers abdicate their responsibility to teach all students by settling on the notion that some students are not cut out for school and are destined for the trades. Chances are that they will not even survive the training for a trade if they cannot do math. Simply put, if we want our students to excel and thrive in the 21st century, they need to be competent mathematical thinkers. This is true whether they go on to university, college, apprenticeship, or the workplace.

At my thesis proposal hearing, committee member Dr. Doug McDougall asked me why I—an elementary teacher—was embarking on a study of Grade 9 Applied Mathematics. I answered, quite honestly, that I believe that the issue was worthy of study because it really was a problem for so many of us that work to support good teaching and learning of mathematics. However, as I was driving home that day, I found myself reflecting on Dr. McDougall’s question and thinking that there must be more to it than that. I asked myself what it was that compelled me to embark and persevere on this study—after all, it had taken me more than two years to get to the proposal hearing alone.
Why did this study really matter to me? What was driving me? Why did I care so much? Suddenly, the answer came to me.

In my experience as a mathematics consultant, I have been involved in more than one meeting with more than one group of educators in more than one setting where we were trying to “get to the bottom” of the lackluster EQAO Grade 9 Applied Mathematics results. So often I heard the same old blame game—“What do you expect from kids that don’t do their homework?”—“What do you expect from kids that don’t come to school prepared?”—“What do expect from kids that don’t care about school?” On and on, the excuses would come.

Then, one day, I visited a Grade 9 Applied Mathematics classroom for a project that I was working on. I have to confess that going in to that classroom, I was pretty nervous. Everything I had heard about Grade 9 applied classrooms had painted a pretty grim picture and I was expecting complete and utter chaos. I had heard teachers talk about how having to teach these students was “a punishment” after all! However, when those students came in their classroom that day, I very quickly realized that they were bright, that they were curious, and that they brought mathematical knowledge and thinking to the table. What’s more, they wanted to learn.

Looking back at it now, I realize that the experience in that classroom is what gave me the passion to embark on this project. That experience, on that day, put faces on the data for me. It helped me to realize that the students in our Grade 9 Applied Mathematics classrooms are capable, have something to offer, and do not deserve to be “written off.” We must and need to find ways to inspire their learning.

Secondary schools are an extension of elementary schools. Together and
collectively, we educate our students. My responsibility for my students does not end when they leave the physical building that I happen to teach in. I want my students to succeed long after I am their teacher. When my Grade 7 students leave me, they might eventually find themselves in a Grade 9 Applied Mathematics classroom. In that classroom, I want those students to flourish as mathematical thinkers and doers. In a nutshell, I guess that is why this research matters to me—because it matters to them.

**Plan of the Thesis**

This thesis consists of five parts: 1. Introduction, 2. Literature Review, 3. Research Design and Methodology, 4. Presentation of Findings, and 5. Discussion.

The introductory chapter has established my interest in the dissertation topic and its connection to my professional practice. It outlined the problem of practice that I explored through the research as well as the research questions that I set about to answer. The chapter concluded with a discussion of the background that I bring to the work.

Chapter 2 provides a review of relevant literature that informs the study. It begins with an explanation of the changes to Ontario curriculum and assessment policy over the past two decades. Then, I discuss three areas in the literature that shed light on the problem of underachievement in Grade 9 Applied Mathematics, namely: the mathematics reform movement, implementing change in secondary schools, and the practice of streaming. Next, I present the conceptual framework that I devised to guide the collection and analysis of the data. This is followed by a discussion of the theoretical perspective that underpins the research. The chapter concludes with the perceived significance of the study.

Chapter 3 outlines the research design and methodology for the study. It outlines
the two phases of data collection, including the process for determining focus group participants and case study schools. A description of the case study schools is given in order to provide context to the reader. The interview protocols for both the focus group and case schools are outlined, as well as the observation protocols that were used for classroom observations. The other forms of data such as EQAO school reports are also outlined. The procedures that were used for data analysis are then articulated. The chapter concludes with an outline of the ethical considerations for the study.

Chapter 4 outlines the findings that emerged from analysis of the focus group and case study data. These are presented through the lens of the conceptual framework; the chapter describes the resources (material and human), professional learning, math department, leadership, and reform-based teaching practices that were found to be common to the case study schools and triangulated through the focus group and other school data.

Chapter 5 discusses the findings of the research study as they relate to the research questions and the current literature. It also provides a summary of the major findings with recommendations for the ministry, school boards, schools, and teachers. I discuss my reflections on the findings, the limitations of the study, and my thoughts about future research.
CHAPTER TWO: LITERATURE REVIEW

Overview

This chapter will begin with a description of the procedure that was used to conduct the literature search. This description is followed by a discussion of mathematics curriculum and assessment policy in Ontario over the past two decades. Following this, three areas that shed light on the underachievement in Grade 9 Applied Mathematics are explored, namely:

- The mathematics reform movement,
- Implementing change in secondary schools, and
- The practice of streaming.

After discussing the research, I present the conceptual framework that emerged from the review of the literature and was subsequently used to guide the research methodology. Then I describe the theoretical foundation that underpins the study. The chapter concludes with a statement on the significance of the study.

Literature Review Search

Extensive background reading of notable scholars and organizations was undertaken to prepare this literature review. The review provides an account of the current research base as reported in academic journals, books, and other publications in fields related to the study. Conference papers, position papers, and research reports were also explored. The primary goal in conducting the literature search was to approach the task in a systematic, reproducible, and explicit manner (Fink, 1998). To accomplish this end, the search procedure articulated by Ross, Hogaboam-Gray, and McDougall (2002) was used. This included a combination of manual and Internet searches of major journals in mathematics education, secondary education, educational leadership and educational reform/change.
To begin, keywords were discerned and used to conduct searches in the Education Resources and Information Centre (ERIC) database and other electronic search engines, such as ProQuest and Google Scholar. This was accomplished by reviewing mathematics journals and general educational research journals that publish studies of mathematics learning, educational reform in secondary schools, and/or streaming. In order to refine the literature search, the categories of “implementing change in secondary schools” and “streaming” were also cross-referenced using the keyword “mathematics.” Searches on prominent Canadian academics in mathematics education and educational reform were also undertaken. Abstracts from all searches were screened for relevance to the proposed study and its research questions. The references contained in the relevant studies were also scanned for additional sources.

Given that the current mathematics reform movement began with the publication of standards by the National Council of Teachers of Mathematics (NCTM) in 1989, only literature and policy statements published after this date were considered for this review. It should be noted that because this movement was primarily a North American phenomenon, literature from the United States and Canada dominates this paper.

Some of the literature that was reviewed was historical in nature and provided context to the phenomena under study, e.g., the history of mathematics reform and the practice of streaming. In order to broaden the literature search, it was important to consider how these constructs were thought of globally. For instance, while sorting students into ability groups is considered “streaming” in Canada, it is known as “tracking” in the United States and “setting” in the United Kingdom.

Studies were included in this review only if they were peer-reviewed and included empirical evidence, either qualitative or quantitative. Canadian research was included wherever
possible, although research applicable to the constructs under study was found to be lacking. For example, there is limited published research related to Grade 9 Applied Mathematics classrooms, or streaming in Canadian classrooms.

The research that was collected was reviewed and coded by relevant ideas. Throughout this process memos were recorded as new insights or questions came to light. The key ideas that emerged from the literature were then used to develop the conceptual framework for the design of the study.

The Evolution of Mathematics Curricula in Ontario

The Common Curriculum

In 1995, the then NDP-government—headed by Bob Rae—introduced the province’s first foray into outcomes-based education. *The Common Curriculum, Grades 1–9, 1995* outlined a set of curriculum standards that articulated the knowledge, skills, and values that students were expected to learn by the end of Grades 3, 6, and 9. Content was organized into four broad areas: language; the arts; self and society; and, mathematics, science and technology. Outcomes were linked to provincially defined standards and criteria for assessment and reporting (Anderson & Ben Jaafar, 2003; Gidney, 1999) and a provincial standardized report card was implemented through which teachers were to report on student achievement (Winter & McEachern, 2001). Prior to *The Common Curriculum*, local school boards developed their own curricula using guidelines set out by what was then the Ontario Ministry of Education and Training (OMET).

Along with curricular reform, the NDP government was committed to the concept of de-streaming Grade 9; at the time, an abundance of research had demonstrated that grouping students according to ability level was biased in terms of gender, socio-economic status, and cultural background (Radwanski, 1987). In response, policy was introduced in 1993 that would
collapse the three Grade 9 streams (Advanced, General, and Basic) into one. In the de-streamed model, all Grade 9 students followed the same program and teachers were expected to provide instruction for all ability levels in the same classroom (Robertson, Cowell, & Olson, 1998). Under this policy, a pass/fail approach was implemented and upon successful completion of the Grade 9 program, students were granted eight credits towards their secondary school diploma. Although the Rae government considered de-streaming Grade 10, secondary school teachers and strong public opposition sidelined those plans (Anderson & Ben Jaafar, 2003).

The Common Curriculum was still in the process of being implemented when the Rae government was defeated in 1995.

The Ontario Curriculum: Mathematics

In 1995, the Conservatives were ushered to power under the leadership of Mike Harris and the banner of the “Common Sense Revolution.” The Conservatives had campaigned on the promise to reduce education spending and cut all excesses in the system and the new government moved quickly to make changes in curriculum, funding, and the governance of schools. Policy changes included the re-streaming of Grade 9, a new four-year high school program (which would eliminate the fifth year of high school) and the requirement that students pass a Grade 10 Literacy Test in order to graduate (Taylor, 2005). Declaring The Common Curriculum as “too vague and open-ended,” the OME was directed to begin the process of replacing it with a new “Ontario Curriculum” (Winter & McEachern, 2001). Teachers and parents wanted more clarity about the required learning outcomes for each grade level and the province wanted a curriculum that was standard across the province (Craven, 2003).

The Ontario Curriculum was first implemented for mathematics and language at the elementary level (Grades 1 to 8) during the fall of 1997. This new curricula outlined the specific
knowledge and skills—in the form of lists of mandatory expectations—that students were expected to learn in each subject by the end of each grade level. For mathematics, content was organized around five strands: Number Sense and Numeration; Patterning and Algebra; Geometry and Spatial Sense; Measurement; and Data Management and Probability. Each strand had three to four “overall” expectations and a total of approximately 80 to 100 “specific” expectations that were connected to these (Craven, 2003; Suurtamm, Lawson, & Koch, 2008) for each grade. The inclusion of these strands was viewed as a nod toward moving mathematics education beyond the historic focus on numeration and operations, or arithmetic. It should be noted that teachers not only had to teach this content, they also had to report on it by strand.

In addition to content outcomes, The Ontario Curriculum introduced an achievement chart. This was a standard, provincial guide that articulated the performance criteria by which teachers were to evaluate student work collected over time (Council of Ministers of Education, 2010). In effect, the introduction of the achievement chart could be characterized as a move from a norm-referenced to criterion-referenced approach for assessment and evaluation (Craven, 2003).

The achievement chart highlighted four categories of knowledge and skill and delineated four levels of student achievement, with level one being the lowest level of performance and level four being the highest. Each of the four categories of knowledge and skills were to be taken into account in determining a student’s grade:

- Problem solving,
- Understanding of concepts,
- Applications of mathematical procedures, and
- Communication of required knowledge. (OMET, 1997, p. 9)
The new curriculum document also included an overall vision for teaching mathematics that advocated for “the appropriate use of technology, rich problem solving, communication in mathematics, connections within mathematics and between mathematics and other disciplines, and the necessity for students to see the underlying principles of mathematics” (Suurtamm et al., 2008, p. 33). The document provided direction for teachers around the importance of problem solving, the significance of having students reflect on their own thinking, and the fostering of appropriate attitudes towards mathematics. The roles of parents, teachers, and students were also articulated in the explanatory text (or front matter) of the document.

*The Ontario Curriculum: Mathematics* was staged into the secondary school level, beginning with Grade 9 in 1999, Grade 10 in 2000, Grade 11 in 2001, and Grade 12 in 2002. In so doing, the fifth year of high school (known as the Ontario Academic Credit, or OAC) was eliminated. Very few topics from the five-year program were eliminated. In essence, the new curriculum was merely a compressed version of the former (Craven, 2003) meaning that the same content had to be covered much more quickly.

With this restructuring of the secondary school system, the Conservative government made the decision to re-stream students in Grade 9 into two levels: Academic and Applied. This course structure followed through to the Grade 10 year. However, once students reached Grade 11, courses were designed based on postsecondary destination: university, college, or the workplace. Figure 2 illustrates the course offerings from Grade 9 to 12 under *The Ontario Curriculum: Mathematics*, as well as the various prerequisites for each.

The major differences between the academic and applied Mathematics courses were in style and tone. The academic course was designed to develop students’ knowledge and skills through the study of theory and abstract problems—it moved more quickly to “generalizations of
mathematical ideas” and “abstract reasoning” (OMET, 1999a). Typically, students who intended to go on to university after graduating from secondary school took the academic course.

In contrast, the applied course focused on the essential concepts of mathematics and was designed to help students develop their knowledge and skills through practical applications and concrete examples. It was intended to provide “extended experiences with hands-on activities” (OMET, 1999a, p. 18). Typically, students who intended to go to college or enter the world of work upon graduation from secondary school took the applied course. It should be noted that students who took applied mathematics courses could still qualify to attend university; however the applied course was not considered a sufficient pre-requisite for “math rich” programs such as engineering or the physical sciences.

![Course Prerequisites Diagram](image)

*Figure 2.* Course prerequisites for Grade 9–12 Mathematics: The Ontario Curriculum, 1999.

If a student started out in the applied pathway, he or she would typically move on to the college or workplace courses in the senior years, as illustrated in Figure 2. This was because the university-bound courses had Grade 9 and 10 academic courses as prerequisites. Although technically a student with a Grade 9 applied course could take the Grade 10 academic course, there were some additional skills and concepts that he or she would need to be successful with the course content. A crossover course was available to facilitate the transition, but only at summer school when students were likely to be working, or alternatively from the ministry website which required independent study. Therefore this was not a viable option for many, if not most, students.

The hierarchical nature of mathematics course taking and its accompanying structure of prerequisites created a positional advantage to those students who took courses “higher up” in the sequence: if students did not begin in the higher tracks, they had little chance of reaching higher tracks in later years (Riegle-Crumb, 2006). This was and remains significant because it is the higher math courses that most strongly predict college attendance (Schneider, 2003) and achievement (Schollen, Orpwood, Byers, Sinclair & Assiri, 2008). This is important when one considers that the applied pathway has been designed for college preparation.

It should be noted that two additional courses, Grade 9 Essentials Mathematics and Grade 10 Essentials Mathematics (now known as “Locally Developed”) were later introduced to meet the needs of students who had traditionally enrolled in “Basic Level” courses. These courses were developed by local district school boards to meet the specific needs of their students. The locally developed mathematics course is not included in the EQAO testing regimen for Grade 9 Mathematics, so in essence, these students are not factored into the picture of performance that is painted by the provincial assessment for Grade 9 Mathematics every year.
The secondary curriculum was similar in structure to the elementary curriculum. Each course was comprised of three or four strands and included both overall and specific expectations. Like the elementary curriculum, it also included an achievement chart that was to be used to evaluate student achievement and would require the shift from norm-referenced to criterion-referenced assessment and evaluation. Like the elementary curriculum, the achievement chart also included four levels of performance for four categories of knowledge and skills that had to be taken into account when determining a student’s grade:

- Knowledge and understanding (understanding of concepts; performing algorithms).
- Thinking, inquiry, and problem solving (reasoning; applying the steps of an inquiry/problem solving process).
- Communication (communicating reasoning orally, in writing, and graphically; using mathematical language, symbols, visuals, and conventions).
- Application (applying concepts and procedures relating to familiar and unfamiliar settings). (OMET, 1999a, p. 39)

In order to foster consistency in assessment and evaluation practices across the province, the ministry developed exemplars of student work that illustrated performance across these categories and the four levels of achievement.

In terms of course content, there were four content strands in the Grade 9 Applied and Academic Mathematics courses: Number Sense and Algebra; Relationships; Analytic Geometry; and Measurement and Geometry. These strands were designed to build on the content that had been taught in the Grade 8 program. In theory, having the same course strands in the two courses would also facilitate a crossover between pathways in Grade 10 for those students wishing to do so.
For some teachers in the province, the new curriculum would also require a change in instructional style. This is because the curriculum expectations made it clear that students must be actively involved in their lessons by engaging in posing problems, formulating hypotheses, designing and carrying out experiments, describing situations that could be modeled graphically, and developing skills through problem solving (Roulet, Cooke, & Lim, 1999). Previous data that had been collected in provincial reviews and international assessments had revealed that such experiences and investigations were infrequent in Ontario classrooms. Therefore, to assist with the implementation of the new mathematics curricula, the ministry provided numerous resources and other supports to assist teachers, such as print resources and in-service opportunities. For example, it sponsored the preparation of course profiles for each secondary school course in the mathematics curriculum. These profiles outlined how course expectations might be presented to students and included examples of rich learning tasks and assessment strategies. The OME also licensed various software applications that would help teachers to address the curriculum expectations that involved the use of technologies, such as dynamic statistical software. It also provided targeted funding to boards to assist with the purchase of computer and calculator technologies, such as graphing calculators and motion sensors (OME, 2004).

The transition to The Ontario Curriculum: Mathematics was emotional and controversial in the field, particularly because of the elimination of the OAC year. In 2002, the OME commissioned Dr. Alan King to investigate the graduation patterns of students in light of the restructuring of secondary schools from five to four years. This influential study found that certain courses had a high rate of failure in the first year of high school, most notably applied courses in English and mathematics. In fact, King found that the majority of students in the Grade 9 Applied Mathematics course were close to or actually failing. As he was also able to
correlate an early loss of credits with the failure to graduate, the impact of this was considerable. Taking Grade 9 Applied Mathematics was like heading down a dead-end street; chances were quite likely that a student would not make it out of this course with a credit (King, 2002). This was significant because, without mathematics credits, students would not meet the criteria to graduate from secondary school. Nor were they likely to be admitted to college, apprenticeship, or university programs.

For these reasons, Dr. King insisted that the high failure rate of applied mathematics courses amounted to a failure of the system. As he put it, “Is it educationally sound to make a ‘required’ subject such a high-risk experience for students?” (King, Warren, Boyer & Chin, 2005, p. 40). Many groups including parents, teachers, and students, had become disillusioned with the implementation and impact of The Ontario Curriculum: Mathematics for secondary schools and King’s position added fuel to their fire. Consequently, the cry for change to the Ontario mathematics curriculum became even louder and more persistent.

The Ontario Curriculum: Mathematics (revised 2005)

In 2003, Dalton McGuinty and the Liberal party defeated the ruling Conservatives. The Liberal party still remained in power at the time that this research was conducted in 20/1213. That being said, Ontario teachers are still teaching The Ontario Curriculum implemented in the Harris years, albeit in a revised state. The policy documents have undergone extensive revision with the Liberal government’s curriculum renewal (a collaborative process involving practitioners, policymakers, stakeholders, and educational researchers).

For mathematics, the OME introduced a revised curriculum in 2005 for Grades 1 through 10 and in 2007 for Grades 11 and 12. The revision process resulted in a substantial change to the structure of the secondary mathematics program; the applied pathway was revamped to provide
access to “Mathematics of Data Management,” a university-bound mathematics course for Grade 12. This was important in that it allowed students in the applied pathway direct access to a university prerequisite course as illustrated in Figure 3 below.

![Prerequisite Chart for Mathematics, Grades 9-12](image)

**Figure 3.** Course prerequisites for Grade 9–12 Mathematics: The Ontario Curriculum, 2007. From “The Program in Mathematics” by OME, 2007, The Ontario Curriculum, Grades 11 and 12: Mathematics, p. 10.

Also, to facilitate transfer between the applied and academic pathways in Grade 9, a transfer course was created. As was the case with the precursor “crossover course,” this option was not very useful or practical because these courses were most often offered in the summer or at night school when many students are likely to be employed (People for Education, 2013).
Anecdotal evidence also suggests that this course was likely to be ineffective. For example, in a People for Education brief, a principal stated that “transfer courses do not adequately prepare students in most cases for success,” and that, in his opinion, “It is often better to redo the grade level at the academic level through summer school or day school” (People for Education, 2013, p. 2).

In terms of content, the revised curricula continued to push the mathematics reform agenda and advocated for an investigative approach that would foster and develop student conceptual understanding of mathematics. A major change was the introduction of process expectations defined as “a set of seven expectations that describe the mathematical processes that students need to learn and apply as they work to achieve the expectations outlined within the strands of the course” (OME, 2005b, p. 12). Often referred to as the “habits of mind of a mathematician,” the mathematical processes include: problem solving; reasoning and proving; reflecting; selecting tools and computation strategies; connecting; representing; and, communicating (OME, 2005b). The revised curriculum policy called for the integration of these process expectations into the planned student learning opportunities for each of the content strands.

Another major change inherent in the revised curricula stemmed from criticism of the original. Teachers and students believed that as originally written, The Ontario Curriculum was not practical enough or sufficiently hands-on to meet the needs of learners in the applied course (Antonelli, 2004). Therefore, the revised curriculum made a clearer distinction between the academic and applied courses by making the respective content more relevant to student learning styles. Both courses were designed to “foster the development of the knowledge and skills students will need to succeed in their subsequent math courses, which will prepare them for the
postsecondary destination of their choosing” (OME, 2005b, p. 4). The revised curriculum policy distinguished the two courses as follows:

**Academic courses** develop students’ knowledge and skills through the study of theory and abstract problems. These courses focus on the essential concepts of a subject and explore related concepts as well. They incorporate practical applications as appropriate.

**Applied courses** focus on the essential concepts of a subject, and develop students’ knowledge and skills through practical applications and concrete examples. Familiar situations are used to illustrate ideas, and students are given more opportunities to experience hands-on applications of the concepts and theories they study. (OME, 2005b, p. 6)

The content in the two courses became much more differentiated as a result of the revision process. Whereas the course content of the original courses was approximately 90% aligned, it was approximately 50 to 60% aligned after the revision. The academic course, for example, included one more strand after the revision. Table 2 contrasts the content that is taught in the academic versus applied courses; significant differences between the two courses are highlighted in bold print.

Another substantial change to the curriculum was the revision of the achievement chart. The four categories of knowledge and skills were amended to be:

- Knowledge and Understanding—subject-specific content acquired in each course (knowledge) and the comprehension of its meaning and significance (understanding).

- Thinking—the use of critical and creative thinking skills and/or processes as follows: planning skills (e.g., understanding the problem, making a plan for solving the problem), processing skills (e.g., carrying out a plan, looking back at the solution), and critical/creative thinking processes (e.g., inquiry, problem solving).

- Communicating—the conveying of meaning through various oral, written, and visual forms (e.g., providing explanations of reasoning or justification of results orally or in writing; communicating mathematical ideas and solutions in writing, using numbers and algebraic symbols, and visually, using pictures, diagrams, charts, tables, graphs, and concrete materials).

- Application—the use of knowledge and skills to make connections within and between various contexts. (OME, 2005a, p. 18-19)
### Course Content in Grade 9 Mathematics: Academic versus Applied

<table>
<thead>
<tr>
<th>Academic</th>
<th>Applied</th>
</tr>
</thead>
<tbody>
<tr>
<td>• This course enables students to develop an understanding of mathematical concepts related to <strong>algebra, analytic geometry, and measurement and geometry</strong> through investigation, the effective use of technology, and <strong>abstract reasoning</strong>.</td>
<td>• This course enables students to develop an understanding of mathematical concepts related to <strong>introductory algebra, proportional reasoning, and measurement and geometry</strong> through investigation, the effective use of technology, and <strong>hands-on activities</strong>.</td>
</tr>
<tr>
<td>• <strong>Students will investigate relationships</strong>, which they will then generalize as <strong>equations of lines</strong>, and will determine the connections between different representations of a linear relation. They will also explore relationships that emerge from the measurement of three-dimensional figures and two-dimensional shapes.</td>
<td>• <strong>Students will investigate real-life examples to develop various representations of linear relations</strong>, and will determine the connections between the representations. They will also explore certain relationships that emerge from the measurement of three-dimensional figures and two-dimensional shapes.</td>
</tr>
<tr>
<td>• <strong>Students will reason mathematically</strong> and communicate their thinking as they solve <strong>multi-step problems</strong>.</td>
<td>• <strong>Students will consolidate their mathematical skills</strong> as they solve problems and communicate their thinking.</td>
</tr>
</tbody>
</table>

**Strands:**
Number Sense and Algebra; Linear Relations; **Analytic Geometry**; Measurement and Geometry

**Strands:**
Number Sense and Algebra; Linear Relations; Measurement and Geometry
Acknowledging that yet another round of considerable change was being demanded of teachers in the field, the OME commissioned research in 2006 to investigate how the revised *Ontario Curriculum: Mathematics* was being implemented in the Intermediate division (Grades 7–10). Known as Curriculum Implementation Intermediate Mathematics (CIIM), this research project explored how Intermediate-level teachers were understanding and teaching the revised reform-oriented curriculum. This was a mixed methods study that collected survey data from teachers and system leaders, and conducted case studies of classrooms identified to be implementing the curriculum.

Through this project, Suurtamm & Graves (2007) found that the system mathematics leaders (consultants and coordinators) had a good understanding of the curriculum and were knowledgeable about the kinds of teaching practices that were necessary to enact it. They also found that:

- The student transition between Grades 8 and 9 was made more difficult by the fact that elementary teachers were widely unaware of the content and expectations of the secondary school mathematics curriculum and vice-versa. The researchers also found that the teaching cultures across panels were very different, making the transition from elementary to secondary school difficult for students. For example, elementary teachers were more likely than their secondary school counterparts to have students learn by participating in investigations. This finding suggested that more opportunities for discussion across panels was necessary.

- *The Ontario Curriculum: Mathematics (2005)* presented progressive messages about the incorporation of technology in the teaching and learning of mathematics. However, the CIIM researchers found that the use of technology in mathematics classrooms was
hampered by a lack of timely and easy access to computer equipment. Many teachers also expressed the need for more professional development in applications such as dynamic geometry software that were prevalent in the Intermediate mathematics curriculum.

- In *The Ontario Curriculum: Mathematics (2005)*, manipulatives were positioned as an important tool in helping students to develop their conceptual understanding of mathematics. However, the CIIM research revealed that many Intermediate-level teachers did not see the value of manipulatives. Many believed that manipulatives are only necessary for assisting struggling students in moving from the concrete to the abstract. Elementary Grade 7 and 8 teachers were more likely to use manipulatives in their teaching practice than were their secondary counterparts in Grades 9 and 10. Secondary mathematics teachers were more likely to use manipulatives in applied and locally developed, as opposed to academic courses. As the grades got higher, teachers tended to view manipulatives more as “toys” than “tools.” Many of the research participants suggested that more professional development on the use of manipulatives would be of value.

- *The Ontario Curriculum: Mathematics (2005)* called for teachers to use a variety of assessment strategies in order to allow students to demonstrate their learning. Central to this idea was that teachers needed to move beyond a reliance on traditional paper-and-pencil tasks (which emphasize knowledge recall and procedural learning) to other forms of assessment that would allow students to demonstrate skills of inquiry, problem solving, and communication. The CIIM research found that although quizzes and tests continued to be the dominant form of assessment in the Intermediate classroom, other
forms of assessment such as performance tasks, observations, and student responses in class were emerging with some teachers. The researchers concluded that new assessment practices could be better fostered through leadership, collaborative work with colleagues, and transparent alignment of curriculum, instruction, and assessment in ministry documents and policies.

The CIIM research also found that the most effective professional learning for mathematics teachers addressed their understanding of mathematics, their understanding of how students learned mathematics, and their confidence to teach mathematics. Teachers indicated that they needed further professional development related to reform-based teaching methods. The opportunity to dialogue with colleagues was found to be very important in supporting change to classroom practice, as was the opportunity to connect with others over time (Suurtamm & Graves, 2007).

The revised Ontario Mathematics Curriculum (2005 for Grades 9 and 10 and 2007 for Grades 11 and 12) is currently in use in Ontario schools and it is expected that it will enter the renewal/revision process sometime after 2015. Even so and despite the tremendous supports that have been designed and put in place to assist with its implementation, most policymakers, mathematics education researchers, and system mathematics leaders would agree that the intended Ontario Curriculum: Mathematics is far from being implemented in all classrooms. The general sentiment is that, although the curriculum is “covered” and taught in classrooms, most teachers use traditional teaching approaches that are not consistent with the spirit of the curriculum policy. And so, this remains an intense focus throughout the province.

Since 1993 there have been three different mathematics curricula in Ontario, along with significant structural changes to secondary schools. This speaks to the level of change, in a
relatively short period of time, which has been required of secondary mathematics teachers. In addition, accountability in the form of standardized assessments was also introduced, including testing of Grade 9 Mathematics.

**Ontario Provincial Assessments**

In 1996, the Rae government created the Education Quality and Accountability Office, or EQAO. This was in response to recommendations by the Royal Commission on Learning, 1995:

The Commission had concluded that system-wide testing was necessary to monitor student achievement and as a vehicle for assuring people that all students, at specific points in the learning process, are being assessed according to the same yardstick. The government also wanted to respond to the public’s demand for clearer information about, and greater accountability for, student achievement in Ontario’s publicly funded schools. (OME, 2009, p. 128)

The EQAO is an independent, arms-length agency of the government that is overseen by a Board of Directors that is appointed by Cabinet. The organization’s initial duties were to advise the Minister of Education on elementary and secondary education assessment programs. However, these duties expanded under the Harris rule to include the development, administration, and analysis of a provincial testing program. Currently there is a mandatory testing regimen in Ontario that includes: reading, writing and mathematics at Grades 3 and 6; mathematics at Grade 9 (applied and academic courses); and a literacy test for Grade 10 that is a graduation requirement.

EQAO assessments require students to independently demonstrate their knowledge and skills on standardized tasks and under standardized conditions, although some accommodations are allowed for students with special education needs (EQAO, 2009). The assessments measure how well students have met the provincial curriculum expectations and thus help to indicate the extent to which the curriculum is being taught by teachers and learned by students. It can be argued that by extension, these assessments help to measure the degree to which educators have
acted upon and implemented mandated changes. As described on the EQAO website:

- EQAO’s mandate is to conduct province-wide tests at key points in every student’s primary, junior and secondary education and report the results to educators, parents, and the public.
- EQAO acts as a catalyst for increasing the success of Ontario students by measuring their achievement in reading, writing and mathematics in relation to Ontario Curriculum expectations. The resulting data provide a gauge of quality and accountability in Ontario’s publicly funded education system.
- The objective and reliable assessment results are evidence that adds to the current knowledge about student learning and serves as an important tool for improvement at the individual, school, school board, and provincial levels. (EQAO, 2012a)

All of the EQAO assessment results are reported using the criteria that are outlined in The *Ontario Curriculum* policy documents. In Ontario, students are evaluated on a four-point scale, with four being the highest level of achievement, equivalent to an “A” grade. Level 3 represents the provincial standard for achievement—the level of proficiency—and is equivalent to a “B” grade. EQAO maintains that parents of students achieving at Level 3 and 4 “can be confident that their children will be prepared for work in subsequent grades or courses” (EQAO, 2010b, p. 1). Reaching the provincial standard of Level 3 or 4 on provincial assessments is, therefore, significant. Levels 1 and 2 represent “passing” marks, however achievement at these levels is below the standard. Level 1 is equivalent to a “D” grade and indicates “limited” understanding. Level 2 is equivalent to a “C” grade and signifies “some” understanding and achievement that is approaching the standard. One can infer that for students achieving at Level 1 and 2, work in subsequent grades and courses will be a struggle.
The Auditor General of Ontario conducted an intensive audit of the EQAO in 2009, which resulted in a strong validation of its assessment program. It concluded that the EQAO has adequate procedures and controls to ensure that its tests fairly and accurately reflect the OME’s curriculum expectations. Additionally, it noted that the tests’ level of difficulty were equivalent from year to year so that data could be compared year over year. Finally, it found EQAO’s assessments are administered and marked in such a way as to ensure the results are reliable indicators of student achievement (Office of the Auditor General of Ontario, 2009).

Furthermore, EQAO has ensured that all province-wide testing instruments are developed by teachers, field-tested by teachers, and marked by teachers (Craven, 2003; EQAO, 2012d). This participation and training of teachers has proven to be of great value in implementing The Ontario Curriculum. In arriving at consensus for scoring student work, participating teachers engage in discussions of the categories, strands, criteria, levels of performance, and curriculum expectations. This kind of discourse helps teachers to better understand the intended curriculum.

**EQAO Grade 9 Assessment of Mathematics**

The purpose of the EQAO Grade 9 Mathematics Assessment is to “assess the level at which students are meeting curriculum expectations in mathematics up to the end of Grade 9” (EQAO, 2009, p. 6). All students working toward a credit in Grade 9 Applied or Academic Mathematics are required to participate in this assessment. This includes adult students, English language learners, and students with special needs (EQAO, 2012b).

The EQAO Grade 9 Mathematics Assessments are administered at the end of the course. They consist of two booklets that are written in two sessions, each lasting 50 minutes. The booklets contain a combination of closed response (multiple-choice) and open response (short answer and extended response) questions. In total there are 24 multiple-choice items, 10 short
answer items and six extended response tasks (Suurtamm et al., 2008) that comprise the test. Though test booklets are sent to EQAO for scoring, teachers have the option of marking all or some of a student’s work and including it as a component of the final course mark (to a maximum weighting of 30%).

As the academic and applied courses are distinct in nature and vary in terms of content, different versions of the assessment are created for each course. Regardless of the course taken, students are required to demonstrate both content expectations and cognitive processes as they relate to the content strands, namely: Number Sense and Algebra, Measurement and Geometry, and Linear Relations. The assessment for the academic course also includes questions related to the additional strand of Analytic Geometry. The assessments provide opportunities for students to demonstrate that they can:

- understand concepts;
- apply procedures;
- apply and adapt a variety of appropriate strategies to solve problems;
- use concrete materials to model mathematical ideas;
- make and investigate mathematical conjectures;
- select and use a variety of types of reasoning;
- communicate their mathematical thinking coherently;
- analyze the mathematical thinking of others;
- use appropriate mathematical language and conventions;
- connect mathematical ideas;
- recognize and apply mathematics in a variety of contexts;
- create and use representations to organize, record and communicate mathematically;
and

- use representations to model mathematical thinking. (EQAO, 2009, p. 12)

The key measure reported by EQAO is the proportion of students in each school who achieve the provincial standard (level 3 or 4 of 4). Since 2000/01 when the EQAO assessment was first implemented in Grade 9 Mathematics, student achievement in the applied course has lagged behind student achievement in the academic course with respect to the standard for that course. In the year that the revised curriculum was introduced in 2005/06, the results for the applied course rose an impressive 9 percentage points, but subsequently flat-lined, as illustrated in Figure 4. Over the past couple of years the results have improved slightly, but the reality is that nearly 60% of students taking the applied course are still not reaching the standard.

![Figure 4](https://www.eqao.com)

*Figure 4.* EQAO assessments results for Grade 9 Mathematics, over time. Adapted from “School, board, and provincial results” by EQAO, 2012, www.eqao.com. Copyright 2012 by the Queen’s Printer for Ontario.

The questions on EQAO Mathematics Assessments are developed by Ontario educators and linked directly to the expectations in *The Ontario Curriculum: Mathematics*. Measurement
experts, in consultation with mathematics educators, design the multiple-choice questions. EQAO establishes teams of Ontario mathematics teachers to develop the short answer and extended open response questions that are later reviewed and validated by specialists in mathematics education. The assessment development teams and reviewers are given specific guidelines to help ensure that the test items match the content strands, as well as the curriculum and process expectations articulated in *The Ontario Curriculum: Mathematics* (Suurtamm et al., 2008).

The multiple choice questions are scored by machine, however, the student responses to the short answer and extended open response questions are scored by Ontario teachers. Members of the Ontario College of Teachers that are in good standing and (a) knowledgeable about and experienced with the mathematics curriculum and (b) have recent classroom experience in mathematics education, are eligible to be scorers of the Grade 9 assessment. Scoring takes place in the summer months and successful applicants are remunerated for both their time and expenses incurred.

At the beginning of the scoring process, all scorers are provided training to develop a common understanding for interpreting and applying the scoring requirements. They are trained to mark only one question and do so using scoring anchors that give examples of answers at various levels, and a scoring rubric that describes what is expected in student answers. To ensure reliability, scorers are required to pass a qualifying test before they can mark any student test booklets (OME, 2009) and their scoring is subject to reliability and validity checks to maintain consistency and accuracy during the scoring process (EQAO, 2013).

Figure 5 typifies open response questions that appear on EQAO Grade 9 Applied Mathematics assessments. For this type of question, students are required to demonstrate their
1. Clown Factor

Clown Factor is a competition in which clowns do circus stunts to try to become the best clown.

In one event, the clowns tie helium balloons to objects to make them float. The data below represents the relationship between the mass lifted, \( M \), in grams and the number of balloons, \( n \), needed to lift the mass.

<table>
<thead>
<tr>
<th>Number of balloons, ( n )</th>
<th>Mass lifted, ( M ) (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>250</td>
</tr>
<tr>
<td>20</td>
<td>500</td>
</tr>
<tr>
<td>30</td>
<td>750</td>
</tr>
<tr>
<td>40</td>
<td>1000</td>
</tr>
</tbody>
</table>

a) Plot the data on the grid below.

![Graph of Mass Lifted vs. Number of Balloons]

b) Determine the number of balloons needed to lift a mass of 1400 g. Justify your answer.

c) How will the graph change if the experiment is repeated with larger balloons the greater masses?

d) Explain how to find the mass that can be lifted if you know the number of balloons.

Figure 5. Sample open response question on EQAO Grade 9 Applied Mathematics assessment.

ability to do and “show” their mathematical thinking and also “justify” and “explain” their thinking. These questions are scored using a scoring guide that outlines a number of codes that may be assigned to a piece of student work; it provides a description of the characteristics and elements of work at each level. At the lowest level of performance, students would show limited knowledge and skills to determine the number of balloons and minimal evidence of a correct problem solving process. At the highest level, students would show a high degree of knowledge and skills by accurately plotting the data on the graph and extrapolating from it. They would also demonstrate a complete and accurate solution process to determine the mass of the balloons.

There are several curriculum expectations—related to conducting investigations—which EQAO does not attempt to address in its assessments. At one time, EQAO did prepare and pilot such tasks, incorporating the use of technologies such as graphing calculators and dynamic geometry software. As it proved to be too difficult and cumbersome to standardize the administration of this type of assessment task and ensure fairness (given that the availability and implementation of technology across Ontario was uneven), EQAO abandoned this type of question (Craven, 2003). This has grown to be a criticism of the test instrument (Suurtamm et al., 2008). Additionally, critics of the test argue that the process of breaking down extended response tasks into component elements that can be reliably scored results in reducing the problems to a series of smaller steps. (Using this logic, one might assume that students should do well on these “easier” tasks.) This leads the students to solve problems in particular ways, rather than letting them tackle the problem in their own way. Suurtamm et al. (2008) argued “these steps lead students in specific directions and scaffold their thinking in a manner that is the antithesis of problem solving within reform” (p. 36). Critics also argue that these kinds of tasks limit the richness and openness of the problem and actually provide false information about what
complex mathematical activity looks like. This could have a negative impact on classroom practice if teachers try to match their own instruction and assessment to EQAO Assessments.

Regardless of these criticisms, EQAO results do provide a snapshot as to how students from all schools across the province are able to handle certain course expectations given mathematical tasks to solve. Despite the limitations of the test instrument, the reality is that some schools have consistent success with these assessments. All students in the province write the same assessment and students in certain schools consistently perform better. Given the correlation between successes on EQAO Mathematics Assessments with other milestones such as passing the Grade 10 Literacy Test, this accomplishment should not be summarily dismissed.

In addition to student achievement measures, EQAO also collects contextual data through student and teacher questionnaires. After students complete the test booklets, teachers administer a 10 to 15 minute questionnaire. Questions on this instrument pertain to student values and attitudes towards mathematics, student perception of their performance in mathematics, and student habits related to mathematics (e.g., homework completion). On reports provided at the school-, board-, and provincial-levels, student questionnaire data is presented and the results are also disaggregated by gender. A teacher questionnaire is also given to all teachers who teach a Grade 9 Applied or Academic Mathematics course during the semester in which the assessment is administered. Questions on this survey relate to instructional strategies, assessment practices, teacher background, professional development opportunities, and the availability of school resources, such as computer and calculator technologies. Again, the results are aggregated and provided at the school-, board-, and provincial-levels.

As part of a bigger research project (Kozlow, 2012), EQAO included questions on the 2010 student and teacher questionnaires related to the use of EQAO results in the calculation of
students’ final class marks. OME policy states that the final grade for a course must include a final or summative evaluation that is to be worth thirty per cent and administered at or towards the end of the course. This evaluation can be based on an exam, a performance, an essay, or any other means of evaluating course content (OME, 2012a). In an attempt to motivate students taking the EQAO Grade 9 Mathematics Assessments to perform at their best, some teachers incorporate the provincial assessment as part of a student’s summative mark (up to the maximum 30%).

In total, 4,900 Grade 9 mathematics teachers responded to this administration of the survey. The majority of teachers (95%) reported that they use some or all of the EQAO assessment as part of their students’ final marks. Most of them counted it as 6 to 10% of their final class marks. The teachers also reported that they were more likely to mark and include multiple-choice questions in their class marks than open response questions (EQAO, 2011a, 2011b). 140,000 Grade 9 mathematics students responded. Sixty-four per cent of students in academic classrooms said they were aware that the EQAO Grade 9 Mathematics Assessment would count as part of their final mark, compared to 38% of students in applied classrooms (Jackson, 2012). The researchers were also able to demonstrate that students did better when they knew that the assessment played a role in determining their final mark.

The decision as to whether the EQAO Grade 9 Mathematics Assessment would be counted as part of student marks was most likely to be determined by the math department (69% of the time), followed by the collective of Grade 9 mathematics teachers (29% of the time), school board staff (23% of the time), the principal or vice-principal (20% of the time), and by individual teachers (12% of the time). Most of the teachers believed that counting the EQAO assessment as part of their students’ class mark motivated their students to take it more seriously.
EQAO regularly reports to parents, educators, government, and the public-at-large regarding the assessment and questionnaire data. In addition to provincial reports, individual student, school, and school board reports are generated. These reports include overall results as well as disaggregated data around gender, English Language Learners, and students with special needs. Contextual data such as the number of students in each type of course, the number of students who participated in the assessment, and the number of participants in first-semester vs. second-semester courses are also included and reported on.

The ultimate value of a large-scale assessment program is that it can foster an improvement orientation in schools, districts, and beyond. The information provided by the EQAO has the potential to be an important tool that can be used by policymakers and educators alike to inform teaching and to advance student achievement. An important consideration, therefore, is if and how schools and school systems use this information to support student achievement and success.

Having established the kinds of curricular and assessment policy, as well as structural changes that have happened in Ontario secondary schools and mathematics classrooms in particular, I will now move on to a discussion of yet another level of change that was nested within these reforms—The Mathematics Reform Movement.

**The Mathematics Reform Movement**

My examination of the literature related to the mathematics reform movement was not to engage in a study of what has become known as “the math wars,” but rather to understand the philosophy and tenets behind this movement. This is important because *The Ontario Curriculum: Mathematics* embraces the reform movement ideology. For more on the math debates, the reader should refer to Schoenfeld (2004).
Insofar as school mathematics is concerned, mathematics has long been equated with arithmetic—how to add, subtract, multiply, and divide whole numbers, fractions, decimals, and percentages. Historically the school mathematics curriculum has been focused on these computational skills—or what are considered to be the functional aspects of mathematics (Ernest, 1989). This view sees mathematics as a fixed set of rules or procedures and the role of the teacher as being to introduce procedures, rules, and algorithms in a logical sequence, and then provide enough examples and time for learners to practice applying them to a set of problems (Suurtamm & Graves, 2007).

With the advent of calculator and computer technologies, there has been a growing realization that memorizing algorithms and formulas and developing speed and accuracy in their use is outdated. In this school of thought, the general sentiment is that we should be placing less emphasis on the traditional topics involving arithmetic and instead focus on concepts, problem posing, and problem solving (Moursand, 2011)—or what Ernest (1989) identifies as the structural aspects of mathematics (Ernest, 1989). This involves going well beyond knowing mathematical facts and procedures (Suurtamm & Graves, 2007) and includes being able to reason mathematically, being able to interpret and solve mathematical problems, and being able to communicate mathematical thinking (Ball, 2003; Boaler, 2002; Hiebert, 1997; NCTM, 2000; Suurtamm & Graves, 2007). This more robust interpretation of what it means to do mathematics is characteristic of the mathematics reform movement.

One of the most influential organizations with respect to mathematics education is the National Council of Teachers of Mathematics, or NCTM. The NCTM is based in Reston, Virginia and has some 230 affiliates located throughout the United States and Canada. A highly respected organization, the NCTM provides vision, leadership, resources, professional
development, and advocacy for mathematics education. It produces journals for teachers and mathematics education researchers that are amongst the most cited references in mathematics education work. The NCTM is one of the most powerful influences on Canadian mathematics curricula, Ontario included (Small, 2012). In fact, Ontario’s association of mathematics teachers is the Ontario Association of Mathematics Education (OAME) and it is an affiliate of NCTM.

In 1989, the NCTM took the unprecedented step of developing and publishing curriculum and evaluation standards for school mathematics, followed by professional standards for teaching mathematics (NCTM, 1991) and assessment standards for school mathematics (NCTM, 1995). The organization was responding to the widespread dissatisfaction with mathematics teaching and learning that was being expressed at the time by mathematicians, mathematics teachers, employers, post-secondary educators, and students. There was concern that teaching math from the perspective of procedures, rules, and algorithms resulted in limited understanding for the mathematics learner (Doctorow, 2002) and as a result, students were abandoning the subject in droves. In describing the popular sentiment of the time, Ball, Lubienski, and Mewborn (2001) stated, “the school mathematics experience of most Americans is and has been uninspiring at best, and intellectually and emotionally crushing at worst” (p. 434).

The landmark NCTM publications provided recommendations for reforming and improving K–12 school mathematics (Wang & Cai, 2007b). One of the key changes advocated was that students should learn mathematics content through inquiry, rather than the passive reception of rules (Doctorow, 2002). The standards were aligned with a constructivist philosophy and designed to ensure that in addition to mathematics content, students would learn how to think mathematically through problem solving, reasoning and proving, communicating, making connections, and representing mathematical ideas (NCTM, 1989, 2000). For reformists,
understanding how mathematicians work (i.e. using the mathematical processes) was as important as the content. This stood in stark contrast to the traditional practices in mathematics classrooms that relied on teaching algorithms or rules to students (Brown & Saltman, 2005) and having them memorize and master them (Stodolsky & Grossman, 2000; Wang & Cai, 2007b). Although “reformers” did not dispute the importance of computational skills and factual knowledge, they argued that traditional curricula over-emphasized these outcomes at the expense of problem-solving and reasoning skills (Schoenfeld, 2004; Stetcher, Hamilton, Ryan, Williams, Robyn, & Alonzo, 2002; Suurtaam & Graves, 2007).

Teaching mathematics for understanding is one of the hallmarks of the reform movement. By way of example, consider the calculation for the area of a triangle. In a traditional classroom, the teacher would explain—perhaps with the use of diagrams—that the area of a triangle is equal to one-half of its base multiplied by its height, or $A=\frac{1}{2} b \times h$ where $b$ stands for base and $h$ stands for height. In a reform-oriented classroom, students would be led to “discover”—perhaps by using paper cut-outs—that the area of a triangle is one half the area of a rectangle with the same base and height (see Figure 6 for two illustrative examples).

![Figure 6](image.png)

*Figure 6.* The area of a triangle as it relates to the area of a rectangle.

The reformist position is that, if a student understands how a formula is derived,
memorizing it becomes unnecessary. If students are able to function at this level of understanding, they can work their way to the solution, as opposed to memorizing it by rote. This leaves them in a better position down the road. If they forget the formula for the area of a triangle, they can actually re-construct it by thinking their way through the problem. With this approach, students are also actively developing their problem solving and creative thinking skills as they make sense of the mathematics.

**Reform-based Teaching Practices**

With more and more research showing that learning comes from the construction, not absorption of ideas (Butty, 2001), the key to more successful teaching may well lie in changing the instructional approach and how it is that teachers position students to interact with content. As Willms et al. (2009) put it,

> Traditional learning activities that require students to merely remember, recall and regurgitate need to be rethought…. Learning can no longer be understood as a one-way exchange where “we teach, they learn.” It is a reciprocal process that requires teachers to help students learn with understanding, and not simply acquire disconnected sets of facts and skills. (p. 34, 39)

After reviewing 149 studies that examined the characteristics of effective math programs, Slavin et al., (2010) found that changing the way that children work together can improve mathematics instruction for all students. They argued that changing what students do in the classroom every day is what will impact on their performance. Along the same lines, Willms et al. (2009) argued that effective teaching practice begins with thoughtful, intentional designs for learning and attention to helping students “know their way around” the disciplines. This requires immersing students in the work that is done by mathematicians and providing them with “holistic experiences” (p. 35) that mirror the ways in which the discipline works (p. 36). Reform-based teaching practices embrace this notion of the student as “doer” of mathematics.
A significant Ontario-specific literature is beginning to emerge that highlights instructional approaches and high-leverage practices that teachers can utilize in realizing reform-based instruction. It calls for teachers to provide mathematically rich environments that are conducive to investigations emphasizing higher-order thinking and problem solving. For example, in its vision for learning mathematics, the Ontario Association for Mathematics Education (OAME) calls for:

...learning environments where all students do, see, hear, and touch mathematics in a profound and meaningful way. Our association sees the classroom as a community where teachers and students work collaboratively to learn and value mathematics. In such a classroom, students engage in meaningful mathematical experiences through the use of concrete materials and manipulatives, visuals, technology, and other resources. Students build on their prior knowledge of key mathematical concepts and connect these concepts to their world. They understand the purpose of their learning through clearly defined expectations, goals, and assessment criteria. Students engage in inquiry, pose questions, and actively discuss their understandings with one another. Students demonstrate their understanding on a regular basis and strive to become independent and collaborative mathematics problem solvers. (OAME, 2011)

Similarly in *Leading Math Success* (OME, 2004)—the report of the Expert Panel on Student Success in Ontario—effective instructional strategies are defined as those that “emphasize the ability to think, to solve problems, and to build one’s own understanding” (p. 31).

McDougall (2004) has devised a conceptual framework that articulates ten dimensions of good mathematics teaching. Several of these dimensions relate to instructional approaches that are aligned with reformist ideologies including: collaborative learning; rich tasks; constructivism; manipulatives and instructional technology; classroom discourse; assessment for learning; and, fostering positive attitudes and dispositions around mathematics. The next sections will examine each of these dimensions in turn.

**Collaborative Learning (Dimension 2: Learning Environment)**

When the classroom is perceived to be an organized, safe, and positive learning environment, students will feel encouraged to interact and learn mathematics. There are
many ways a teacher can facilitate an inclusive and nurturing environment. (McDougall, 2004, p. 23)

McDougall (2004) found that it is important that teachers use the appropriate physical classroom organizations and student groupings that will promote student learning. For reform classrooms, this necessitates an environment that moves away from one “in which knowledge is transmitted by the teacher to one in which students and teachers interact as a community of learners in mathematical investigation and exploration” (Egodawatte et al., 2011, p. 190).

Contemporary notions on the nature of human learning emphasize the social construction of knowledge (Butty, 2001). It is generally recognized that students benefit the most from hands-on, active learning where they have the opportunity to reason and construct their own understanding in concert with others (Staples, 2007; Van de Walle, Folk, Karp, & Bay-Williams, 2011). Therefore, classroom approaches that encourage communication and dialogue among students are currently favoured in the literature (Butty, 2001; Cobb, Boufi, McClain, & Whitenack, 1997; OME, 2008). Key amongst these is collaborative learning structures.

Collaborative learning is an instructional strategy that involves pairing or grouping students to work on a learning task. Students are challenged to arrive at a solution in concert and through discussion with others (Swan, 2007). Collaborative learning is distinct from “cooperative” learning, which only implies sharing, and not the joint production of mathematical ideas. Staples (2007) defined collaborative learning as “a coordinated, synchronous activity that is the result of a continued attempt to construct and maintain a shared conceptualization of a problem” (p. 162). Collaboration, she argues, “implies a joint construction of ideas, where students offer their thoughts, attend and respond to each other’s ideas, and generate shared meaning or understanding through their joint efforts” (p. 162).

This kind of small-group learning promotes student activeness, resourcefulness, and
inquisitiveness (Lebow, 1992), in part because students have to question and explain things to one another by communicating their mathematical thinking (House, 2002; Wang & Cai, 2007b). Furthermore, communicating and learning with others helps students to surpass the learning and discoveries that they can make working alone or in a competitive situation (Butty, 2001; Wood, Williams, & McNeal, 2006). Collaborative learning also builds upon the social instincts of children and adolescents (Kajander, 2007). This is especially important in this day and age where the patterns of work have evolved to the point where peer relationships are amongst the most significant social and cultural networks for adolescents (Dunleavy & Milton, 2008).

Research has also demonstrated that cooperative learning promotes higher productivity and achievement, more frequent use of higher level reasoning, greater retention of facts, better problem-solving skills, improvement in conceptual skills, and more favourable attitudes towards learning mathematics (House, 2002; Staples, 2007; Swan, 2006). Consequently, collaborative learning can facilitate a higher level of learning (Cobb et al., 1997; Reynolds & Muijs, 1999) and improved student achievement (Corcoran & Silander, 2009; Sabah & Hammouri, 2010). For example, Ridlon (2009) followed two groups of grade six students for two years. The students in the experimental group were given tasks that they had to solve collaboratively in small groups while students in the statistically similar control group learned via the traditional explain-practice approach. Students taught using the collaborative approach were found to have significantly higher achievement and more positive attitudes towards mathematics at the end of the study.

An interesting fact is that researchers have found that both low and high achievers benefit from group learning. Low achievers benefit from working on complex problems and the increased access to discussions that give them understanding (Boaler, 2007). These students are not left to their own fate, but instead are supported by the approaches of their fellow group
members (Lebow, 1992). High achievers also profit from hearing different perspectives and approaches to problem solving. Boaler (1997) found that high achievers “benefited by explaining work, which helped their own understanding… they were able to think more deeply about the math, rather than rushing through more and more, as typically happens in top set (stream) classrooms,” p. 5. *The Ontario Curriculum: Mathematics, Grades 9 and 10 (revised)* states that:

> Collaborative learning enhances students’ understanding of mathematics. Working cooperatively in groups reduces isolation and provides students with opportunities to share ideas and communicate their thinking in a supportive environment as they work together towards a common goal. Communication and the connections among ideas that emerge as students interact with one another enhance the quality of student learning. (OME, 2005a, p. 24)

The benefits of collaborative learning are perhaps summed up best by Brighouse (2003) who said, “All children, however diverse, learn best when they learn together, sharing each other’s insight and experience, absorbing knowledge and recreating knowledge as they collaborate, in the company of their teachers in a common pursuit” (p. 3).

The use of a collaborative learning approach may present both a philosophical and pedagogical hurdle for some mathematics teachers. In traditional forms of instruction, the teacher holds all knowledge and “imparts” it to the students. In collaborative learning situations, students work together to build knowledge. Therefore, collaborative learning requires that the role of teacher transform to that of facilitator. This is a role that many teachers are ill prepared for, at least insofar as the mathematics classroom is concerned. For example, teachers need to know how to select tasks, assign roles and groupings, and monitor small group learning (Boaler, 2003, 2007; Goos, Galbraith, & Renshaw, 2002; Staples, 2007). Effective group learning requires more than putting students in groups and “letting them at it” (Reynolds & Muijs, 1999,
This alone can represent a significant obstacle for teachers in moving towards reform-based practices.

**Student Tasks (Dimension 4)**

Nardi and Steward (2003) found that most students could capture their experience in the mathematics classroom using the mnemonic “TIRED,” standing for Tedium, Isolation, Rote Learning, Elitism and Depersonalization. Indeed, researchers have found that students are frequently disengaged in mathematics classrooms because they feel that the work assigned to them is not worthy of their time and attention (Willms et al., 2009). Canadian researchers Flewelling and Higginson (2003) argued that mathematics classrooms could be “wakened up” if teachers utilized more effective and enjoyable—or what they dubbed “rich”—learning tasks.

Rich tasks are in line with the constructivist view of learning because they provide students with opportunities to explore and investigate mathematical concepts, patterns, procedures, and principles and in doing so engage them in the process of doing mathematics (Crespo, 2003; Swan, 2005). Rich tasks present a learning context that requires students to explore mathematics through inquiry, discovery, and research (OME, 2004). Tasks and learning experiences that allow for original thinking about important concepts encourage students to become proficient doers and learners of mathematics (Anthony & Walshaw, 2009; Butty, 2001). This is in contrast to more traditional tasks where students are asked to follow the teacher’s lead (Anthony & Walshaw, 2009) by blindly “following given recipes to expected end-points with little opportunity to consider alternatives and be creative” (Flewelling & Higginson, 2000, p. 18).

The underlying premise of engaging students in rich tasks is that through them they will develop their own mathematical thinking and understanding. This is quite different from the telling model (Butty, 2001; Takahashi, Watanabe & Yoshida, 2006) and will require a shift of
culture in most mathematics classrooms. As Deizmann (2005) put it, “There is a need to establish classroom norms in which students develop a commitment to tackling challenging tasks and teachers provide judicious support to students” (p. 8). Furthermore, the use of rich tasks may require teachers to reconsider their traditional notion of what counts as math knowledge and to move beyond procedural knowledge. This involves an understanding of what it means to “do” mathematics—including representing ideas, collecting and presenting mathematical evidence, thinking, talking, and reasoning about mathematics (Spillane, 2000; Quinnell, 2010). The use of rich tasks may also require teachers to shift their understanding of the purpose of problem solving from teaching for problem solving to teaching through problem solving.

In articulating the characteristics of rich tasks, McDougall (2004) stated that they:

- are problem based, that is, present students with a problem to solve.
- allow for multiple possible solutions and / or multiple answers.
- enable all students to participate at their own level.
- allow students to generate and select appropriate problem-solving strategies and / or procedures to solve problems.
- involve multiple representations or models, such as manipulatives, drawings, numbers or words.
- present math in a context that makes connections to other math topics, other math strands, other subject areas, and the real world.
- lead students to consider important mathematical ideas.
- expect students to reflect on and communicate their thinking.
- often result in unexpected and ingenious solutions. (p. 25)

In short, rich tasks should engage students in doing the work of mathematicians.
As rich as the learning that accompanies such tasks can be, the reality is that most math teachers rely on a textbook as their primary resource (Kajander & Lovric, 2009; Zevenbergen, 2003). In fact, there is more reliance on commercially produced programs for teaching mathematics than for any other subject in the curriculum (Nicol & Crespo, 2005). The result is that too often the program or textbook, instead of the particular needs of the students, drives instruction in the mathematics classroom (Butty, 2001; Haylock, 1991). Many students experience mathematics by working on their own, page by page, through the textbook without getting any substantial explanation or teaching other than at a procedural level when they get stuck on a particular question.

Boaler (1997) found that students who work through textbook exercises find it difficult to use or discuss their mathematics, whereas tasks that foster collaborative work develop knowledge that is more powerful in authentic situations. Best practices highlighted in a number of OME resources (e.g., Leading Math Success and TIPS4RM) indicate that Intermediate-level (Grades 7 to 10) students, in particular, need to be actively involved in their learning. Furthermore, textbooks tend to atomize the curriculum by dividing content into small sections, isolating and drilling particular mathematical algorithms in turn (Quinnell, 2010). This emphasizes procedural versus conceptual knowledge and the incorrect notion that mathematics is all about getting the right answer.

In their case study research that was conducted in northwestern Ontario, Kajander and Zuke (2007) examined the classroom mathematics experiences of students considered to be “at risk.” In the mathematics classrooms that they studied—including two Grade 9 Applied Mathematics classrooms—the researchers found few opportunities for active and engaged learning. Instead the teachers used highly traditional, procedural, and teacher-directed strategies.
They relied heavily on textbook tasks that were abstract and not engaging to the students. The researchers found that the teachers in their study were reluctant or unable to use investigations, tasks, and other student-centered or reform-based teaching methodologies. Any attempts to do so usually resulted in chaos. For example, one observed teacher attempted a TIPS lesson that involved having students work with snap cubes. Things quickly deteriorated as students began throwing and “making guns” out of the manipulatives. As a result, the teachers quickly reverted back to the tried and true practice that afforded them the most control—formal and direct teaching.

Teaching in an inquiry environment is a key challenge to implementing reform-based practices (Hunter, 2010; Reynolds & Muijs, 1999). In order for teachers to make any significant shift in their teaching practice, they need ongoing professional development and support to implementing the kinds of tasks and student-centred approaches that the mathematics reform movement is calling for (Kajander et al., 2008; Rotherham & Willingham, 2009).

**Constructivism (Dimension 5: Constructing Knowledge)**

As discussed previously, the mathematics reform movement has its roots in constructivist ideology. Perkins (1999) suggested that there are three distinct learner roles inherent in constructivism. The first is the active learner. The constructivist believes that one cannot learn simply by listening, reading, and working through routine exercises. Instead, learning requires active engagement with ideas through such means as discussing, debating, investigating, conjecturing, and taking viewpoints. Second is the social learner. In this view, we do not construct meaning individually on our own, but rather co-construct it in and through dialogue with others. Therefore, content must be linked to processes or larger themes such as problem solving, inquiring, communicating, connecting, reasoning, and using technology. Lastly is the
creative learner. The constructivist believes that learning is a creative enterprise; new knowledge must be created or re-created in the mind of the learner. In other words, it cannot simply be transmitted as a neat little package. Instead, knowledge must be constructed through “activities that involve hypothesizing, testing, manipulating materials, and communicating to help build connections to previously held knowledge” (McDougall, 2004, p. 69). This goes beyond simply being active by requiring students to “rediscover” theories, perspectives and the like.

Constructivist teachers view their role as facilitators to learning; they are fully cognizant of the endpoint of the learning journey and they provide the learning opportunities that will help their students to “rediscover” mathematics theories, principles, and truths, such as the Pythagorean Theory. Their key teaching strategy is to pose problems and ask questions that will move the learning forward. In constructivist classrooms, students actively construct their understanding by exploring and investigating, using reasoning and creative thinking, gathering and applying information, and, inventing, communicating and testing ideas (Golafshani, 2004). In other words, students are immersed in the process of doing, as opposed to rehearsing, mathematics. The constructivist approach in the mathematics classroom is intended to support the development of students who view mathematics as a meaningful activity, have a range of strategies for mathematical work and can employ these in a flexible and eventually efficient manner (Stigler & Hiebert, 1999).

Many of the expectations in The Ontario Curriculum: Mathematics demonstrate and embrace this constructivist approach to learning. For example, in learning about the Pythagorean theorem in the Grade 9 Applied Mathematics course, students will:

- Solve problems involving the measurement of two-dimensional shapes and the volumes of three-dimensional figures.
- Relate the geometric representation of the Pythagorean theorem to the algebraic representation of \(a^2 + b^2 = c^2\). (OME, 2005a, p. 44)
In a constructivist classroom, students might be presented with a scenario such as the following:

Suppose that these three squares were made of solid gold, and you were offered either the one large square or the two small squares. Which would you choose?

![Diagram of squares]

**Figure 7.** Sample problem to explore the Pythagorean theorem.

In answering this question, students will actively explore the relationship between $a^2$, $b^2$, and $c^2$. In doing so they can use models or tools, such as paper cut-outs or Geometer’s Sketchpad, that will engage them in discovering those relationships. This kind of investigation helps students to gain a deeper understanding of the theorem. It also helps students understand what it means to work as a mathematician, e.g., developing proofs.

![Sample solutions to the “gold” problem]

**Figure 8.** Sample solutions to the “gold” problem illustrating that $a^2 + b^2 = c^2$. 
Use of Manipulatives and Technological Tools (Dimension 7)

Studies have shown that the use of concrete materials is positively related to increases in student mathematics achievement and improved attitudes towards mathematics (Grouws & Cebulla, 2000). Generally referred to as math manipulatives in the field, these materials are physical three-dimensional objects that can be manipulated by students in an active, hands-on way to support their mathematical thinking and learning. Manipulatives have evolved so that there are now a variety of virtual (computer) manipulatives that are freely available to students online, even at home (Small, 2012).

Learning and understanding mathematics requires student engagement with ideas—mathematics is not, it has been said, a spectator sport (Utah State University, n.d.). When students are given manipulatives to explore mathematical ideas and to solve problems, conceptual understanding is enhanced (Anthony & Walshaw, 2009; Swan & Marshall, 2010). Research has demonstrated that manipulatives are particularly important for helping students to visualize mathematical relationships and applications—they can be thought of as “thinking tools” that help students to make sense of mathematics (Anthony & Walshaw, 2009; Grouws & Cebulla, 2000; Kilpatrick, Swafford, Findell, 2001) and connect mathematical ideas (Chappell & Strutchens, 2001). They are particularly effective in helping to facilitate the transition from concrete to abstract thinking (Kamii, Lewis, & Kirkland, 2001). For example, Figure 9 shows the number 7 represented on a ten-frame manipulative with seven counters. Using this tool can help students to understand the relationship of 7 to 5 (two more than) and to 10 (three less than).

![Figure 9. The number 7 on a ten-frame.](image-url)
Research has demonstrated that the effective use of manipulatives relies heavily on a teacher’s background knowledge and understanding of mathematical representations (Moyer, 2001; OME, 2008a). Swan and Marshall (2010) also claimed that unless teachers have a clear understanding of how manipulatives assist students learn, they are likely to make token use of them. This may actually be detrimental to learning. For example, one of the traditional materials used to teach place value is base ten blocks, as pictured in Figure 10 below.

![Figure 10](image)

*Figure 10.* Representation of 134 using base ten blocks.

Here, the ones are represented as single blocks, the tens as “sticks” or “rods” of ten single blocks, and the hundreds as a “flat” of one hundred single blocks. The danger here is that when asked how many blocks are in the tens column, students might answer, “three,” losing sight of the fact that each stick actually represents ten ones. Therefore, it is important to introduce base ten blocks with linking versions (see Figure 11) to help students to build the understanding that the ten rod actually represents ten ones and that therefore, three of them represents thirty. This exemplifies why mathematics knowledge for teaching is so important; the teacher needs to be able to respond in a meaningful way to students in order to move the learning forward.

![Figure 11](image)

*Figure 11.* Linking cubes as base ten materials.
Manipulatives are not magic—students will not automatically draw the conclusions their teachers want simply by interacting with manipulatives (Ball, 1992; Kamii et al., 2001; Kilpatrick et al., 2001). Therefore the teacher must carefully link the manipulative with the mathematical idea and concept being taught (Kilpatrick et al., 2001; OME, 2004). This requires deep conceptual understanding on the part of the teacher (Kajander & Zuke, 2007; Kamii et al., 2001). Most teachers will not have experienced the use of manipulatives when they themselves were students. Therefore it is important that teachers are supported in using manipulatives. Professional development that deepens teachers’ knowledge of the materials and their uses is crucial (Swan & Marshall, 2010). This includes modeling the use of these materials (Moyer, 2001; OME, 2008a).

Teachers tend to associate the use of manipulatives with concept formation and as such, the use of manipulatives inevitably decreases as students progress through the grades (Swan & Marshall, 2010). For example, the CIIM research found that 34% of Grade 7 teachers reported using manipulatives in most or every lesson, compared to 17% of Grade 8 teachers and 8% of Grade 9 Applied Mathematics teachers. Furthermore, 48% of Grade 7 and 8 teachers strongly agreed that “Manipulatives are necessary tools to support effective learning of mathematics for all students,” compared to 16% of Grade 9 and 10 teachers (Suurtamm & Graves, 2007). In point of fact, *The Ontario Curriculum: Mathematics, Grades 9 and 10 (2005)* positions mathematics manipulatives as “necessary tools for supporting the learning of mathematics by all students” (OME, 2005a). This premise is echoed by the recommendation of the NCTM that manipulatives be used in teaching mathematical concepts at all grade levels (NCTM, 2000).

An increasing array of technological tools is also available for use in mathematics classrooms. This includes calculators, computer software packages such as Fathom and
Geometer’s Sketchpad, presentation technologies such as interactive whiteboards, mobile technologies such as clickers (an automated response system that allows teachers to gather immediate feedback from students), and the Internet (Anthony & Walshaw, 2009). Each of these tools provides additional opportunities for students to explore and visually represent mathematical ideas (Kilpatrick et al., 2001). Research has demonstrated that increased achievement and improved student attitudes can result with the use of these tools. Again, technological products are only as effective as the teachers using them (OME, 2008a) and so professional training related to the use of such technology for mathematics teaching is vital.

**Classroom Discourse (Dimension 8: Students’ Mathematical Communication)**

A prominent theme in current research around effective mathematics teaching and learning is productive classroom discourse (Hufferd-Ackles et al.; NCTM, 2000). Arbaugh (2010) described such an environment as “a classroom where students are presenting problem solutions, making conjectures about mathematical relationships, proving why mathematical processes work, and challenging others to think explicitly about the mathematics they are learning” (p. 45). This kind of activity is important in helping students to realize that mathematical activity is more than computation (Spillane, 2000) and stands in contrast to the more traditional classroom discourse that is dominated by teacher talk. As Spillane (2000) put it, school mathematics should be about more than equipping students with mathematical concepts. It should also be about helping students to understand what it means to engage in mathematics:

By interacting with their peers about mathematical ideas, students can develop understandings of doing mathematics, learn about ways of representing ideas, collecting and presenting mathematical evidence, and thinking, talking, and reasoning about mathematics. (p. 162)

In keeping with its constructivist underpinnings, the current reform-oriented movement places considerable emphasis on the role that classroom discourse can play in supporting student
understanding (Applebee, Langer, Nystrand, & Gamoran, 2003; Cobb et al., 1997).

Mathematical discussions are a means through which students can build their mathematical thinking and habits of mind (Hunter, 2010). Indeed, research suggests that a whole-class discussion, following individual and group work, improves student achievement (Grouws & Cebulla, 2000). Effective math discourse goes beyond giving the answer to helping students to make sense of the math by discussing alternative representations and solution methods, justifying one’s thinking, and explaining how a problem connects to other problems (Kilpatrick et al., 2001; Stein, Engle, Smith, & Hughes, 2008).

When students have to speak about mathematics and build arguments that justify their solutions and processes in solving a task, they must clarify, refine, deepen and consolidate their own mathematical thinking (Grouws & Cebulla, 2000; Spillane, 2000; Swan, 2006). As Swan and Lacey (2008) put it:

Mathematics is a language that enables us to describe and model situations, think logically, frame and sustain arguments and communicate ideas with precision. Learners do not know mathematics until they can ‘speak it’. Effective teaching therefore focuses on the communicative aspects of mathematics by developing oral and written mathematical language. (p. 4)

Participation in this kind of discourse also supports students in coming to understand the alternate ways of approaching a task (Sfard, Nesher, Streefland, Cobb, & Mason, 1998). Additionally, listening to students engaged in such discourse helps teachers to understand their students’ mathematical thinking (Corcoran & Silander, 2009) and identify misconceptions that they might have developed (Grouws & Cebulla, 2000).

Social learning theory espouses the fact that students need opportunities to interact with one another to construct knowledge. Kilpatrick et al. (2001) found that mathematical proficiency is more likely to develop when a classroom functions as a community of learners as opposed to a
collection of isolated individuals. This is because such talk helps with meaning-making (Newman and Holzman, 1996). This helps students to develop intellectual autonomy (Butty, 2001). Furthermore, group interactions will often surface new insights, understandings, and perspectives on a subject that are not otherwise possible (Spillane, 2000; Sfard et al., 1998). This actually mirrors the ways in which mathematicians actually work (Spillane, 2000).

In a study that involved students upgrading their senior math courses in preparation for university, Swan (2006) found that, in classrooms that established collaborative learning environments where discussion and reflection was central, learning was enhanced. In these classrooms, students had opportunity to voice and work through their misunderstandings and the result was that they became more confident and motivated. In fact the more that discussion-based approaches were used, the greater was the benefit for students.

Research has identified several important features of classrooms that have effective math discourse: ideas and methods are valued, students have autonomy in choosing and sharing solution methods, mistakes are valued as sites of learning for everyone, and the authority for correctness lies in logic and the structure of the subject, not the teacher (Kilpatrick et al., 2001).

Ultimately math talk and dialogue is a shared responsibility in effective mathematics teaching and learning environments—it is not the sole purview of teachers. One of the teacher’s responsibilities is to orchestrate the conversation by engaging students in mathematical ideas (Kilpatrick et al., 2001) and helping students to use their peers effectively as resources to their own learning (Sfard et al., 1998). This notion will challenge the fundamental beliefs about mathematical teaching and learning that many teachers hold and will challenge them to rethink their role within classroom discourse patterns (Hunter, 2010).

Implementing math-talk learning communities can be a daunting task for teachers. For
instance, Hufferd-Ackles et al. (2004) found that teachers find it difficult to manage math-talk because they never know where the conversation is going to go and many are not sure what to do when the student thinking goes awry. Furthermore, they must constantly make judgments about when to tell, when to question, and when to correct (Kilpatrick et al., 2001). Therefore, professional development that has teacher-learning communities engage in math-talk is an important first step in raising their comfort level (Hufferd-Ackles et al., 2004).

**Assessment for Learning (Dimension 9: Assessment)**

Traditionally, assessment has been used to evaluate student achievement (Assessment of Learning or Summative Assessment). Increasingly it is being recognized that student learning improves when assessment is a regular part of classroom practice (Assessment for Learning or Formative Assessment). Willis (2007) explained that Assessment for Learning (AfL) “differs from Assessment of Learning in its timing, occurring within the regular flow of learning rather than the end point, in its purpose of improving student learning rather than summative grading, and in the ownership of the learning where the student voice is heard in judging quality” (p.52).

The focus of AfL is “on improving student understanding and motivation to improve their own learning performances” (Willis, 2007, p. 53) and it has been found to have a profound impact on student achievement, particularly for lower-achieving students (Black & Wiliam, 1998). For example, in their meta-analyses of studies on formative assessment, Ehrenberg, Brewer, Gamoran, and Williams (2001) found that the impact of formative assessment on student achievement is four to five times greater than the effect of reducing class size.

A key tenet of AfL is that it requires the active involvement of students and the idea that they need to be able to assess themselves (Stobart, 2008). This requires the on-going monitoring of student progress (Stobart, 2008; Sutton & Krueger, 2002) and the provision of descriptive
feedback to facilitate learning (Ontario Principals Council, 2009). The most helpful feedback for students focuses on the task, not marks or grades; it describes what to do next or suggests strategies for improvement (Anthony & Walshaw, 2009). AfL practices are also important in providing feedback to the teacher about instruction and are helpful for determining their next instructional moves (Fullan, Hill, & Crevola, 2006). Ongoing AfL can also help teachers to identify students who may need additional help and support.

As was articulated earlier in this paper, a key goal of mathematics reform is the promotion of higher-level thinking and reasoning skills in mathematics. Therefore, if assessment in mathematics is to reflect these goals, assessment instruments need to measure students’ abilities to solve complex mathematical problems, reason mathematically, communicate mathematically, apply concepts and skills, and recall and use various facts and procedures (McDougall, 2004). This requires a shift away from the traditional practice of assessing students’ procedural learning (usually in the form of algorithms) toward assessing students’ full mathematical power (Ontario Principals Council, 2009) and understandings (Suurtamm, Koch, & Arden, 2010). This necessarily involves the adoption of a wider range of assessment strategies (Suurtamm, 2004) than paper-and-pencil tasks. Whereas traditional approaches were dominated by End-of-Unit tests and “correct” answers, new and more robust approaches towards assessment in mathematics include performance tasks, journals, teacher observations, interviews, student projects, portfolios, and presentations (McDougall, 2004; Sutton & Krueger, 2002). The Ontario Curriculum: Mathematics also encourages the use of a variety of assessment methods over a period of time that will allow students more opportunities to demonstrate their full range of learning (Suurtamm et al., 2010).

Current research indicates that effective teachers use a wide range of these assessment
strategies to monitor learning progress, to diagnose learning issues, and to determine what they need to do next to further student learning (Anthony & Walshaw, 2009; Suurtamm & Graves, 2007). Effective mathematics teachers also look beyond whether an answer is correct to the student’s mathematical thinking (Anthony & Walshaw, 2009). Therefore, it is important that assessment tasks give students the opportunity to communicate their mathematical thinking and reasoning.

Mathematics teachers need to be able to look at student work and make sense of what the students are doing and thinking (Kilpatrick et al., 2001). They must use these interpretations to make specific instructional decisions around what questions to ask next, what tasks will move student learning forward, and what work will represent meaningful practice. Therefore, the ability to interpret and use assessment information is a critical factor in the instructional effectiveness of a mathematics teacher.

For assessment to be valid and meaningful, it is imperative that it aligns with instruction. In Ontario, curriculum and assessment policy requires that teachers collect evidence around the four categories of knowledge and skills that are articulated on The Achievement Chart. These are: Knowledge and Understanding; Thinking; Communication; and, Application. Ultimately, information gathered through assessment must be robust enough that it allows teachers to determine student strengths’ and weaknesses in achieving the curriculum expectations in these four categories.

A current focus of the OME concerns the adoption of AfL principles. The relatively new policy document, *Growing Success: Assessment, Evaluation, and Reporting in Ontario Schools* (2010), provides direction on assessment, evaluation, and reporting in Ontario schools. It positions the purpose of assessment as “improving learning and helping students to become
independent learners” and advocates for a collaborative relationship between student and teacher in setting learning goals, developing success criteria, giving and receiving feedback, and monitoring progress (OME, 2010a, p. 30).

While there is mounting evidence that AfL improves student learning, researchers have found that the adoption of AfL practices is challenging for large secondary schools (Hill, 2011), partly because establishing consistency across departments and disciplines is difficult. There is consensus that to gain traction in these efforts, school-based professional learning is key.

**Fostering Positive Attitudes and Dispositions towards Mathematics (Dimension 10: Teachers’ Attitude and Comfort with Mathematics)**

Kilpatrick et al. (2001) have established that a productive disposition is a necessary element of mathematical proficiency and they define this as “(the) habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one’s own efficacy” (p. 116). A component of this is the attitudes and beliefs that students have around mathematics itself. Generally speaking, students who are proficient at mathematics see math as a meaningful, interesting, and worthwhile activity, they believe that they are capable of learning it, and they are motivated to put for the effort required to learn it (Kilpatrick et al. 2001).

With the administration of the Grade 9 EQAO Mathematics Assessment each year, student questionnaires are administered and some of the survey questions are concerned with student attitudes toward mathematics. For example, Table 3 (EQAO, 2012f, 2012g) highlights the provincial data for the 2011/2012 administration of the assessment. This kind of data helps to provide context with which to explore student achievement results. For example, we can see that generally speaking, students in the academic pathway have more positive attitudes towards mathematics than students in the applied pathway. In each of the pathways, males have more
positive attitudes towards mathematics than females, with the exception being that females say that they try to do their best in mathematics class more than do males.

Table 3

*EQAO Student Questionnaire Results: Grade 9 Mathematics, 2011/12*

<table>
<thead>
<tr>
<th>Student Attitudes Towards Mathematics</th>
<th>Applied</th>
<th>Academic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Female</td>
<td>Male</td>
</tr>
<tr>
<td>Number of Students</td>
<td>15,765</td>
<td>19,468</td>
</tr>
<tr>
<td>Percentage of students indicating that they “agree” or “strongly agree” with the following statements:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I like mathematics.</td>
<td>28%</td>
<td>40%</td>
</tr>
<tr>
<td>I am good at mathematics.</td>
<td>28%</td>
<td>43%</td>
</tr>
<tr>
<td>I am able to answer difficult math questions.</td>
<td>16%</td>
<td>30%</td>
</tr>
<tr>
<td>Mathematics is one of my favourite subjects.</td>
<td>18%</td>
<td>25%</td>
</tr>
<tr>
<td>I understand most of the mathematics I am taught.</td>
<td>59%</td>
<td>66%</td>
</tr>
<tr>
<td>Mathematics is an easy subject.</td>
<td>15%</td>
<td>25%</td>
</tr>
<tr>
<td>I try to do my best in mathematics class.</td>
<td>82%</td>
<td>75%</td>
</tr>
<tr>
<td>The mathematics I learn now is useful for everyday life.</td>
<td>36%</td>
<td>43%</td>
</tr>
<tr>
<td>The mathematics I learn now helps me do work in other subjects.</td>
<td>45%</td>
<td>48%</td>
</tr>
<tr>
<td>I need to do well in mathematics to study what I want later.</td>
<td>48%</td>
<td>52%</td>
</tr>
<tr>
<td>I need to keep taking mathematics for the kind of job I want after I leave school.</td>
<td>41%</td>
<td>47%</td>
</tr>
</tbody>
</table>

This might lead us to ask ourselves some “Why” questions:

- Why do students in academic classrooms have more positive attitudes about mathematics?
- Why do males have more positive attitudes than females?
- Why are males more likely to see the relevance of mathematics to everyday life?

Upon further reflection we might ask ourselves:

- What kinds of examples are we providing of math intersecting with life?
• How can we make what we do in the classroom more relevant and meaningful to girls so that they recognize the usefulness of mathematics in their lives?”

The answers to the questions that emerge from this kind of data analysis might very well inform teachers about future directions that they can and should take in the classroom to impact student learning.

It is also interesting that in the primary grades, children report mathematics to be one of the most liked subject areas, however as they progress through the grades, that begins to change. In Ontario, by the time students get to Grade 9, only 28% of females in the applied pathway like math compared to 40% of males. Contrast this to 50% of females in the academic pathway liking math (almost double the number) and 62% of boys liking it. Clearly, females like math less than boys do and they like it even less in the applied classroom setting. Also interesting is the fact that males also like mathematics better if they are taking the academic course. Furthermore, students in the academic course have more positive attitudes towards mathematics than those in the applied course.

Researchers have found that as students progress through school, they begin to perceive that only the “fast” students are good at math (Middleton & Spanias, 2002). Boys are more likely to like this “competitive” aspect than girls and this might explain some of the variance in attitude and subsequent achievement. As students get older, they also begin to believe that success in mathematics can be attributed to innate ability, as opposed to effort (National Mathematics Advisory Panel, 2008). In other words, they come to believe that “you either are a math person, or you’re not.” This belief ultimately shapes the motivation and engagement that students will have towards mathematics (Middleton & Spanias, 2002) and is important because the attitudes that students have towards mathematics are significantly associated with their
mathematics achievement (Sabah & Hammouri, 2010). For example, House (2006) found that students who have positive attitudes towards mathematics tend to have higher test scores in it.

Therefore, it is important that teachers help students to maintain a productive disposition towards mathematics as they progress through school. Some researchers have argued that student confidence in mathematics is as important as achievement itself because students’ belief in their mathematical abilities is an important determinant of their achievement (Bruce & Ross, 2010; Ross et al., 2002). For example, Pajares and Kranzler (1995) found that mathematics self-efficacy (the belief that one is capable of doing mathematics) was a better predictor of senior mathematics achievement than was a student’s math achievement.

Some researchers have argued that if students have more positive feelings about a subject, they are more likely to take risks and engage cognitively in it (Buff, Reusser, Rakoczy, & Pauli, 2011). Ryan and Pintrich (1997) also found that students with high confidence in mathematics do not attribute their need for help to lack of ability and thus are more likely to seek help when they need it. Other research has shown that students who attribute success in mathematics to hard work are much more likely to do well in mathematics when compared to students who believe success can be attributed to good luck (House, 2006) or innate ability (Boaler, 2002; Kilpatrick et al., 2001; Middleton & Spanias, 2002; National Mathematics Advisory Panel, 2008; OECD, 2014). Other recent research findings indicate that self-confidence in mathematics has been strongly associated with mathematics achievement for students in Norway and Canada (Ercikan, McCreith, & Lapointe, 2005) and that participation in advanced mathematics courses can be predicted with 72% to 76% accuracy by this variable alone. With respect to the Grade 9 Mathematics Assessment, the EQAO (2012, May) has
established that students who say that they like math and are good at it are more likely to reach the provincial standard than those who do not.

Given these findings, effective teaching requires that teachers pay attention to helping students to develop positive mathematical identities. It is important that students develop a broader sense of what it means to be “successful” in math class and this goes beyond merely getting the “correct” answers to include thinking for oneself, asking questions, persisting through challenges, and taking intellectual risks (Boaler, 2007; Middleton & Spanias, 2002). This requires that teachers expect and enable complex mathematical work of all students and that they help all students to believe that they can do hard work. This notion may challenge some teachers’ belief systems about the nature of mathematics learning; many teachers also believe that “you are either a math person, or you are not.”

McDougall (2004) cautions that teachers may inadvertently signal to students a less than positive attitude towards math and that they should take care not to do this. This is especially true of teachers that have to teach mathematics, yet do not have confidence in the subject themselves. Therefore, a productive attitude towards mathematics is important to foster in the teaching force as well (Kilpatrick et al., 2001; McDougall, 2004). This is best accomplished through teacher professional learning that helps teachers to see that mathematics makes sense, is useful and worthwhile, and that they are capable of being effective learners and doers of math (Kilpatrick et al., 2004).

This section has illustrated that teaching and learning mathematics is a complex process (Grouws & Cebulla, 2000), especially when one considers all of the “unlearning” related to the traditional practices that have dominated mathematics classrooms. City, Elmore, Fiorman, and Teital (2009) argued that in order to help students to meet rising academic standards, schools
need to improve their core technology—instruction. Corcoran & Silander (2009) define instruction as “the interactions between teachers, students, and content directed toward helping students achieve learning goals” (p. 158). City et al. (2009) conceptualized this interaction as the “instructional core” and described it as “the basic framework for how to intervene in the instructional process so as to improve the quality and level of student learning” (p. 23).

I have borrowed from this work in developing Figure 12. Through this graphic, I attempt to distill my findings from the literature review to present an interpretation of how student, teacher, and content might interact in reform-based mathematics classrooms. The descriptions are meant to provide insights as to how such classrooms might “look” and “sound.”

*The Ontario Curriculum* embraced math reform and its focus on learner-centered and conceptually focused mathematics teaching. This called for new teaching practices with less dependence on teacher explication and more emphasis on student inquiry and group work (Schoenfeld, 2005). This involved a shift from teaching the acquisition of discrete skills and factual knowledge to an approach that stressed conceptual understanding, inquiry, application, and communication of mathematical ideas (Stecher et al., 2002). It is worth considering that this approach to mathematics might stand in contrast to the experience of secondary math teachers. In Ontario, teachers must be certified to teach. To earn teaching certification, teachers first need to earn a bachelor’s degree. Furthermore, to be certified to teach mathematics at the secondary level, a teacher must have a minimum of three undergraduate courses in mathematics. An overwhelming majority of secondary mathematics teachers actually have a degree in mathematics (Melville, 2010). This means that they are initially schooled in mathematics faculties where, among other things, they would have learned mathematical propositions, rules, modes of thinking and methods (Moreira & David, 2008).
Figure 12. The instructional core in a reform-oriented mathematics classroom. Adapted from “The Instructional Core” by E. A. City, R. F. Elmore, S. E. Fiarman, and L. Teitel, Instructional Rounds in Education: A Network Approach to Improving Teaching and Learning, p. 22.

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It is worth noting here that professors of mathematics are not mathematics teachers; they are trained in the discipline of mathematics, not the discipline of teaching. Furthermore, many of them focus their energies on their research, not their teaching. As a result, many undergraduate students of mathematics will experience mathematics teaching “as their professors talking to the chalkboard” (Hardy, 2013). A consequence of this is that secondary teachers have likely developed an “allegiance to teaching facts and to following the role model of college professors” (Melville, 2010, p. 986). This is the image of mathematician that they take away from their undergraduate studies.

The next stage of development for a secondary mathematics teacher is teacher training conducted at a Faculty of Education. Here, aspiring mathematics teachers learn about mathematics pedagogy, or how to teach mathematics, through mathematics curriculum and methodology courses. These courses include the study of mathematics curricula and resources, as well as instruction around such issues as how to organize and manage a mathematics class (Ernest, 1989). A recent survey of Ontario faculties of education found that such courses range from a minimum of 24 hours to at most 72 hours (Kajander, Kotsopolous, Martinovic, & Whitely, 2013). Contrast this to the conception of teaching mathematics that the prospective teachers would have taken away from their minimum three courses in university-level mathematics and it is not hard to see why many secondary teachers favour a teacher-directed approach in their mathematics classrooms.

Finally, the last stage of development for secondary mathematics teachers and arguably the most important, takes place during their teaching service. In her research, Kajander (2007) found that teacher candidates with a math or science degree were significantly stronger procedurally than were students without such a degree. Even so, they did not have an adequate
conceptual understanding of Grade 4 to 10 Mathematics (such as was illustrated in Figures 6 and 8) to allow them to probe student thinking, comprehend multiple student solutions or methods, or provide powerful classroom learning experiences. This knowledge, referred to as “Mathematics Knowledge for Teaching,” or MKT, goes beyond subject content knowledge and pedagogical knowledge to include:

- Knowing which concepts are easy or difficult to learn and why.
- Knowing ways of representing concepts so that others can understand them.
- Knowing how to connect ideas to deepen them.
- Recognizing what students might be thinking or understanding. (Ball, Hill, & Bass, 2005)

Research suggests that this specialized pedagogical knowledge is more important in supporting student achievement than is subject knowledge alone (Baumert, Kunter, Blum, Brunner, Voss, Jordan, Klusmann, Krauss, Neubrand, & Tsai, 2010; Hill, Rowan, & Ball, 2005). It is also fair to say that this kind of pedagogical content knowledge goes beyond what teachers are likely to acquire in their formal training. Therefore, it is most likely nurtured during a teacher’s career, through practical experience and in-service learning opportunities. A teachers’ opportunity to learn and develop their mathematics knowledge for teaching is, therefore, a critical mediating policy instrument in moving forward mathematics reform (Cohen & Hill, 2000; Hufferd-Ackles, Fuson, & Sharon, 2004; Ross et al., 2002; Spillane, 2000). This might very well require mathematics teachers to re-construct their notion of what it means to do and teach mathematics, especially when one considers the background and tradition that they will bring to their work. Given this, it should not be surprising that many of the strategies undertaken
by the OME over the last decade have been intended to support practicing teachers in adopting reform-based teaching approaches.

**Supports for Mathematics Reform in Ontario**

The OME has acknowledged that the new reform-oriented approach towards teaching mathematics that is advocated in *The Ontario Curriculum: Mathematics* is challenging for teachers. Therefore, it has provided substantial support for the implementation of the curriculum. Some of this support has come in the form of teaching resources that model the new paradigm for mathematics teaching and learning. Other support has come by way of professional learning events that have been concerned with increasing the use and uptake of ministry resources developed that assist teachers in implementing new, reform-based teaching and learning strategies.

Some of the key initiatives have included:

- *Leading Math Success*, 2004. The OME struck an expert panel to investigate ways and means of supporting success in mathematics, especially for those at risk. This panel released a report commonly known as *Leading Math Success* that summarized much of the current thinking and research around effective instruction and assessment strategies that support student achievement in mathematics. To highlight best practices, the OME provided and funded a number of *Leading Math Success* conferences for board teams.

- *Targeted Implementation and Planning Supports: Grades 7, 8, and 9 Applied Mathematics (TIPS)*, 2003 and *Targeted Implementation and Planning Supports for Revised Mathematics (TIPS4RM)*, 2005. TIPS4RM is a resource developed by teachers and school boards working in partnership with the support of OME funding. It was initially introduced in 2003 and then was updated for the 2005 curriculum revision.
TIPS4RM provides a comprehensive approach to planning and implementing the Grade 7, 8, and 9 Applied Mathematics curricula. It contains sample lessons for teachers, suggestions for ongoing assessment, synopses of relevant research, content-based units, student worksheets, and electronic files for computer-based applications such as Geometers Sketchpad. This resource was intended to support beginning teachers, to provide new insights for experienced teachers, and to help principals and staff developers as they worked toward improving mathematics education. There has been some anecdotal evidence that using these materials has supported student achievement at the individual school level (e.g., OME reports presented at the Ontario Mathematics Coordinators Association [OMCA] meetings and in the success stories highlighted in EQAO Provincial Reports and on the MathGAINS website).

- *Growing Accessible Interactive Networked Supports (GAINS), 2007.* Originally a small-scale initiative for one region in the province, GAINS helped to develop networks focused on improving mathematics teaching and learning. GAINS has evolved to provide a forum for all boards and schools to learn and share best practices, most notably through the MathGAINS website.

- *Critical Learning Instructional Path Supports (CLIPS), 2007.* CLIPS are web-based interactive applets for students in Grades 7 through 12. They provide online learning activities for instruction, remediation, and enrichment. (MathGAINS, 2012a)

- *Coaching for Math GAINS, 2008.* In December 2008, the OME implemented the 2008-2009 Coaching for Math GAINS initiative. This was a $7M investment in math coaches and professional learning opportunities for teachers of Grades 7–12 Mathematics. This funding was intended to support local district school boards in providing job-embedded...
professional development for teachers.

• *Professional Learning for Mathematics Leaders and Coaches (PLMLC), 2008 to 2012.* PLMLC sessions provided opportunities for professional learning, on a variety of timely topics such as disaggregating data, planning system improvement, and developing instructional coaching skills. PLMLCs have, in some cases, related to content areas that students and/or teachers are known to struggle with, such as proportional reasoning.

PLMLCs were made available to a range of representatives from local district school boards, including classroom teachers, instructional coaches, consultants, coordinators, principals, and senior administrators.

• *MathGAINS website, 2008 to present.* A repository for resources that have been developed by the OME, local district school boards, and educational researchers to support effective mathematics teaching and learning practices.

• *Math CAMPPP (Collaborative Actions for Mathematical Professional Learning, Precision, and Personalization), annually from 2008 to 2013.* An extended (five-day) summer institute for K–12 mathematics educators with the intent to deepen teacher understanding of particular mathematics content areas. For instance, the August 2011 Math CAMPPP focused on effective instruction and assessment strategies in the areas of algebraic thinking and proportional reasoning.

• *Collaborative Inquiry for Learning—Mathematics (CIL-M), 2008 to present.* The purpose of CIL-M is to develop job-embedded learning in schools and boards across the province. Teams of educators work together to plan and implement in-class investigations using the collaborative inquiry process. The OME initially provided expert facilitators to build capacity in leading this process in boards and now provides funding
for continued CIL-M work.

- **Grade 6 Gap Closing, 2010** and **Grade 9 Gap Closing, 2011**. The Gap Closing resources were designed to support teachers in providing precisely targeted remediation for students who are significantly behind in mathematics. The goal in using these resources is to close gaps so that students can be successful in learning grade-appropriate mathematics. (MathGAINS, 2012b)

Research has demonstrated that such resources are unlikely to be implemented in the absence of sustained teacher in-service (Ross et al., 2002). This is in because a mathematics teacher is influenced by how he or she views mathematics and mathematics teaching. In their influential research on mathematics education, Stigler and Hiebert (1999) found teaching to be very much a cultural activity. How teachers approach their task is very connected to their own previous schooling experience. Teachers tend to teach the way that they themselves were taught. The kinds of instructional practices that a teacher uses will be closely connected to the models of teaching and learning that they have experienced through an “apprenticeship of observation” (Ball et al., 2001). Most secondary mathematics teachers have learned mathematics, to a very high level, via a traditional approach. So if they are to teach mathematics differently, they need to learn and experience it in the different way. As Suurtamm (2009) put it:

> The kinds of changes teachers are being asked to undertake are not simple and require a substantive re-orientation of their basic beliefs about the world in general and mathematics education in particular. Such a re-orientation can only occur (if at all) over time and requires ongoing and iterative cycles of professional engagement. (p. 4)

The reality is that, although many instructional reforms have been developed and introduced through the research literature and education policy, the basic patterns of classroom interactions between teachers and students in Ontario mathematics classrooms have remained relatively stable (Ross et al., 2002). Cobb, Wood, Yackel, and McNeal (1992) described this
typical instructional approach as being: “checking answers from the previous day’s assignments, working through some of the homework problems on the board, presenting new materials with examples, and assigning seatwork” (p. 20).

**Barriers to Implementing Reform-based Practices**

In the early days of math reform, Dossey (1992) argued that the substantive changes in the teaching of mathematics suggested by the reform movement would be slow in coming and difficult to achieve because of the basic beliefs and mental models that teachers hold about the nature of mathematics and mathematics teaching. Ernest (1989) classified these models as being either instrumental or problem solving in nature. In the instrumentalist model (aligned with a traditional teaching approach) teachers understand mathematics as a useful but unrelated collection of facts, rules and skills. These teachers have likely experienced mathematics as a collection of rules, rituals and routines (Corwin & Friel, 1993) and an authority telling what to do and how to do it. Such teachers are likely to have the perception that teacher is expert and must therefore present and impart knowledge through direct transmission (Ernest, 1989; Kaiser & Vollstedt, 2007; Kilpatrick et al., 2001). They are likely to use teacher centered-approaches including strict adherence to a textbook (Butty, 2001; Staples, 2007) and teach mathematics as rules to be memorized (Golafshani, 2004). Furthermore, because their main objective is for students to master mathematical skills, immersing students in the *rehearing* of algorithms and procedures is likely to predominate and an emphasis on right and wrong answers will likely ensue (Ernest, 1989; Golafshani, 2004). Melville, Kajander, Kerr, and Holm (2013) described the problem this way:

> A serious issue with math education in North America is the belief in the certainty of mathematical knowledge. Math education has been dominated by highly discursive forms of instruction for the past century. An unintended result of this dominance has been the development and persistence of teacher identities that are closely aligned to this
view of the subject, a view that downplays the syntactic knowledge of the discipline. This certainty of knowledge results from the discursive traditions that most teachers have experienced throughout their own school and undergraduate careers. This unexamined, and often unacknowledged, belief in the certainty of mathematical knowledge has a clear implication for the pedagogical actions of elementary teachers, with certainty of knowledge promoting certainty of action. (p. 6)

In contrast, the problem-solving model positions mathematics as a continually expanding field of human inquiry (Ernest, 1989). In this view—aligned with the reform approach—“the processes and strategies of mathematical activity are central and the main goal of mathematics teaching is to empower children to become creative and confident solvers of problems” (Ernest, 1989, p. 22). Reformers regard the engagement of students in problem solving as fundamental to mathematics development and this tenet is also central to and aligned with constructivist teaching principles. In constructivist/reform-oriented classrooms, it is the students’ methods and approaches to tasks that are valued, not the teacher’s. Research has demonstrated that students in such classrooms are less likely to believe that conforming to the teacher’s method leads to success in mathematics. Instead, they believe that success comes from “working hard to understand mathematics” (Middleton & Spanias, 2002, p. 13). This means asking good questions, rephrasing problems, explaining well, being logical, justifying work, considering answers, and using manipulatives (Boaler, 2002).

Mathematics reform is difficult to implement, largely because teachers must be the purveyors of teaching practices that they have not necessarily experienced themselves (Ross et al., 2002). Spillane (2000) argued that, for the most part, math reform is understood and filtered by teachers in terms of a computation-focused (instrumental) perception of doing mathematics. So though teachers may adopt new practices such as the use of concrete materials and manipulatives, they will likely continue to teach the same way that they have always taught, based on their own lived experience (Kilpatrick et al., 2001). For example, when teaching
students about equivalent fractions, a teacher might demonstrate or explain to students how they can use pattern blocks to make equivalent fractions instead of having students work to figure it out for themselves.

In order to truly implement the ideals of reform, teachers need to expand beyond the conventional notion of mathematics (Spillane, 2000). To do so, they need to re-conceptualize what counts as mathematical knowledge to include such processes as making conjectures, determining the legitimacy of mathematical ideas using evidence, representing mathematical thinking, and responding to one another’s mathematical ideas. This requires that teachers also re-define their role:

In traditional mathematics instruction, the role of the teacher is essentially to transmit knowledge to, and validate answers for, students who are expected to learn alone and in silence. In contrast, according to the reform vision of mathematics classrooms, the role of the teacher is diversified to include: posing worthwhile and engaging tasks; managing the intellectual activity in the classroom, including the discourse; and, helping students to understand mathematical ideas and to monitor their own understanding. (Silver & Smith, p. 20)

Research has repeatedly demonstrated that reforms are not self-implementing (Cuban, 1990; Borman & Feger, 2006) and do not penetrate predictably or frequently into the instructional core (Elmore, Peterson, & McCarthy, 1996). Making significant changes on one’s own is difficult. The following sentiments expressed by a teacher in a recent edition of the *Ontario Mathematics Gazette* sum up the way many teachers are apt to feel about making the deep-seated changes required of reform-teaching practices:

The first thing I want to share is that I was scared to death of teaching this way when I started. At one point this past semester, I was more than a week behind the other Grade 9 academic classes. I stopped asking where everyone was, as I was getting worried—kind of like jumping off the scales before it gets to the weight you don’t want to be. Ignorance is bliss. When I realized how far behind I was getting, I almost gave up. (OAME, 2011, p. 34)
Math reform calls for the development of a different mathematics classroom than is typical in most schools (Stinson, Bidwell, Jett, Powell, & Thurman, 2007). Whereas traditionalists understand mathematics as content to be mastered, reformists view mathematical thinking as a disposition to be nurtured. This represents a radical change for many teachers who believe that mathematics is best transmitted to others. The extent to which curriculum innovations or movements take hold will, in part, be mitigated by this reality. The fact is that although the mathematics reform movement has articulated a clear and ambitious vision of mathematics instruction for all students, mathematics instruction in many classrooms continues to be based upon conventional notions of mathematics (Kajander, Zuke, & Walton, 2008; Price & Ball, 1997; Ross et al., 2002; Staples, 2007) and the traditional teaching practices that rely on note-taking from the board, completing worksheets, and following a textbook (Frempong, 2005). Many teachers have yet to shift away from this model towards the new paradigm.

Yet, there is strong evidence that using reform-based teaching strategies can make a real difference in how well our students fare in math class (Slavin, Lake, & Groff, 2010). It is also true that research with respect to mathematics reform in Canada is limited. However, an interesting observation that Willms made in 1999 was that Québec Francophone students were significantly outperforming other Canadian students on national and international assessments (Raptis & Baxter, 2006). Shortly thereafter, policymakers in the province of British Columbia (B.C.) commissioned a comparative study of its’ and the Québec mathematics curricula. Researchers found that whereas the B.C. curriculum was more traditional in its approach, the Québec curriculum was much more in line with the reformist ideology. It is a fact to this day that Québec—which started down the road to reform much ahead of the other Canadian provinces—continues to out-perform other provinces on national and international assessments.
In general, research evidence from schools that are using reform-oriented approaches is encouraging, with students outscoring control groups on a variety of measures and a variety of contexts (Lubienski, 2006). For example, Kajander et al. (2008) found that the principles of mathematics reform are especially important for students that are struggling in mathematics. This suggests that the use of reform-based teaching practices might be more beneficial for students in applied classrooms than the more traditional methods. Furthermore, Willms, Friesen and Milton (2009) contended that the achievement gap could be narrowed, if not eliminated, by consistently using the teaching practices that we know are effective.

**Implementing Change in Secondary Schools**

Secondary schools have proven to be especially impervious to change and to adapting to the changing needs of an increasingly diverse student body (Hargreaves & Goodson, 2006; Stodolsky & Grossman, 2000). Levin (2008) stated that research on high school change indicates that the realities of high schools including their larger size, subject specialization, focus on content, weaker relationships between adults and students, and lower degree of parental involvement make it difficult to create lasting change in high schools. There are two key issues highlighted in the literature that make change especially hard to implement in mathematics classrooms: departmental organizational structures and teacher autonomy.

**Departmental Structures**

There are two common and persistent features of secondary schools that hinder the change process within them. The first is the division of instruction into specific disciplines. In secondary schools, courses are taught by subject specialists (Corcoran & Silander, 2009). Secondary school teachers enter the teaching profession as university graduates with a strong academic background in their subject area (Siskin, 1991). As such, they have been trained and
socialized within distinct academic traditions—each with its own values, techniques, methods, conceptions, and ways of thinking (Egodawatte et al., 2011; Moreira & David, 2008). For the most part, secondary school teachers will spend their entire day teaching in their content area—they love their subjects and believe that what they teach is central to what students need to know (Siskin, 1997).

A corresponding organization of teachers into subject departments is the second feature of secondary schools that impacts change efforts. Departments are characterized by:

- Low permeability—there is little opportunity for departments to interact with one another.
- High permanence—there tends to be stability in staff within a department over time and teachers come to identify themselves not just as teachers, but as math teachers, or science teachers, etc.
- Personal identification—the departmental structure reinforces the sense of belonging that teachers feel to a discipline and its traditions.
- Political complexion—there are only so many resources (including students) available in the school and competition often pits one department against another. (Hargreaves & Macmillan, 1995)

Some departments in a school will have more status and resources than others (Siskin, 1991). In Ontario, schools are often compared using results from EQAO assessments. Therefore, mathematics has a high political focus. With this may come additional resources for the department on the one hand, but added pressure for results on the other (Beswick, Watson, & De Geest, 2010).

In a school building, different departments are often located in different physical spaces. A
A departmental office usually has workspaces for its teachers and it is here that teachers will likely congregate before, between, and after classes, as well as during their planning time. This institutional grouping promotes the development of subject cultures. Not only do teachers in a department share office space, but also as subject specialists they share the specialized knowledge and language of their subject matter (Siskin, 1991; Talbert, 1995). Working so closely with one another, teachers are likely to develop friendships and find support within their departments and therefore strong social affiliations often form between teachers in a department (Corcoran & Silander, 2009). In fact, research has established that high school teachers identify themselves to a greater extent with their respective subject-matter department than with their school (Gutiérrez, 1996; Talbert, 1995).

It is worth noting that a pecking order often develops within subject departments (Talbert, 1995). Those with the highest qualifications are often the ones that teach the highest streams and most senior courses. Conversely, those with lesser math backgrounds are often relegated to the lower-stream classes. Additionally, a department may receive “cross-over” teachers from other departments in order to fill a teacher’s timetable. These teachers are often assigned to teach lower level and low-stream classes as well. Talbert (1995) found that this inequity in status amongst teachers could negatively impact the development of teacher community within a department. However, she also found that if departments rotated their teacher assignment amongst the various courses, a stronger learning community was more likely to develop. This was because teachers worked together to ensure that everyone was well positioned to teach their assigned courses.

Hargreaves and Macmillan (1995) found that teachers within a department develop a sort of nostalgia about their customs and what it is that they do. This is significant because teachers’
conceptions of their subject matter will ultimately impact their curricular activities (Corcoran & Silander, 2009). When a strong departmental community is in place, there is a greater consensus on teaching practice (be it a traditional or reform-based approach) in a school. Furthermore, if a department interacts on issues of teaching and learning, teachers are more apt to explore new teaching approaches and subsequently change their teaching practice (Connolly, 2000; Siskin, 1997; Stodolsky & Grossman, 2000). This suggests that the department can influence instructional practice (Gutiérrez, 1996; Stodolsky & Grossman, 2000) and can contribute to a teacher’s willingness to make instructional changes. Interestingly, Talbert (1995) established that mathematics teachers report higher levels of agreement on subject matter and teaching practices than do teachers of the other academic subjects. For example, teachers of mathematics endorse the practice of streaming of students by past academic achievement more than teachers of other disciplines.

With a school faculty literally organized and divided into these departmentalized subject-specific worlds, there is likely to be little interaction across departments. Because teachers are so strongly isolated from teachers in other departments, colleagues from the same school but different departments might not ever talk (Siskin, 1991, 1997). The result is the emergence of “balkanized” camps (Hargreaves and Macmillan, 1995) and contested spaces (Melville, 2010). This makes it very difficult to establish whole-school learning communities in high schools (Harris, 2001; McLaughlin & Talbert, 2007). Even when change happens in one department, it often remains invisible to the rest of the school. It is probably not surprising, therefore, that Talbert (1995) found departments to have a bigger influence on the development of teacher community than the school or district. Siskin (1997) suggested that those who want to effect changes in high schools have to deal, one way or another, with departments. Whereas
elementary administrators work through teachers to reach classroom practice, high school administrators are faced with this additional layer. Given these facts, the subject department is increasingly touted as a logical vehicle for mobilizing and sustaining school improvement efforts (Harris, 2001; Melville, 2010; Stodolsky & Grossman, 2000). This is especially prudent because high school departments have been linked to bringing about improved student achievement (Gutiérrez, 1996; Harris, 2001; Lomos, Hofman & Bosker, 2011). For example, a study of 52 American high schools found that student achievement increased when departmental faculties exhibited strong instructional norms, consistency of practice, and high “communication density” (Yasumoto et al., 2001).

A lead teacher, often referred to as Department/Subject Head or Chair, typically heads departments. Often these individuals will have longevity in their roles and during their tenure principals will come and go. Department heads have a range of responsibility (depending on the school and board) that can include scheduling, the assignment of teachers, and allocation of resources. However when it comes to the delivery of curriculum and the evaluation of teacher performance, the school administrator must step in. Yet if an administrator does not have a background in a particular subject discipline then he/she is unlikely to feel competent in speaking to teachers about their instruction (McLaughlin & Talbert, 2007; OME, 2010b). To illustrate this point, Elmore (OME, 2010b) outlined the following scenario:

You walk into a secondary math classroom; you see something going on that is really not good. The content is low, the kids are bored, and it’s just not a high-functioning classroom. Do you feel authorized to have a conversation with that teacher about math instruction? Most secondary principals would say “no” because they know that the predictable response from the math teacher is going to be “you don’t know my content, you don’t know my kids, you’re not a math specialist, get out of my classroom.” (p. 8)

Developing instructional leadership in all subjects and disciplines is a tall order for a secondary school administrator, especially given the myriad non-instructional issues that
consume their attention (Klar, 2012). Given this reality, the position of Department Head can be an important one in leveraging change efforts (Harris, 2001). Indeed, a growing body of research has illustrated that teacher leaders can help other teachers to embrace goals, to understand the changes that are needed to strengthen teaching and learning, and to work together towards improvement (Aubrey-Hopkins & James, 2002; Campbell, Lieberman, & Yashkina, 2014; Connolly, Connolly, & James, 2000; Leithwood & Riehl, 2003). By distributing leadership across multiple actors and units, principals are more likely to get traction in implementing reform (Harris, 2001; Klar, 2012; McLaughlin & Talbert, 2007; Siskin, 1997). For example, Ross and Gray (2006) found that an effective strategy is to involve teachers in the development of school goals and improvement plans. Having teachers in a mathematics department convene and strategize about their EQAO Grade 9 Mathematics Assessment, therefore, could be a stimulus to change practice.

Implementing reform has the potential to unite a department as teachers work together to understand how best to adopt the required changes (Talbert, 1995). This being said, the reality is that mathematics teachers and departments are very resistant to change (Staples, 2007). In spite of solid evidence that documents the need for mathematics teaching to move away from transmitting factual knowledge and toward facilitating students’ active engagement with complex problems, there has been little change in teaching approaches in the mathematics classroom (Gutiérrez, 1996; Kilpatrick et al, 2001; Ross et al, 2002; Talbert, 1995). Mathematics teachers generally consider their subject to be sequential in nature, requiring topic coverage and the mastery of algorithms in a set order (Stodolosky & Grossman, 2000). This ties back to the understanding of mathematics that most mathematics teachers have developed in their own formal schooling and how this links to their teaching behaviour. van Driel, Beijard,
and Verloop (2001) argued that mathematics teachers will need to restructure their knowledge and beliefs in order for curricular reform to take hold. Similarly, Melville (2010) concluded that the majority of educational reforms fail because they do not accommodate the difficulties that teachers face in re-negotiating their beliefs, identity, and practice towards the ideal of the reform. In other words, they do not attend to the “cultural aspect” of being a mathematics teacher.

This suggests that the mathematics department may be an ideal space through which mathematics teacher can reform their practice. Not only is it a natural community of practice, but also a social space through which teachers can have the critical conversations needed to transform their practice. For example, in her study of three “reformed” high school mathematics departments, Talbert (2002) found that as teachers worked together to make higher-order learning in mathematics a reality for all students in their school, they questioned and rejected the sacred traditions that had previously defined their practices. Additionally, subject departments already have the infrastructure in place to allow for collegial work on professional projects like implementing curricula (Egodawatte et al. 2011). However, Melville (2010) cautioned that when left to their own devices, departments are likely to preserve the status quo and that often something is needed to trigger disequilibrium and challenge the teachers’ beliefs about their practice.

**Teacher Autonomy**

Though teachers are organized into departments at the secondary school level, the bulk of their time is spent alone, in their classrooms. The fact is that teaching goes on in classrooms where teachers are relatively insulated from their colleagues and administrators. And although the curriculum policy is very explicit in terms of defining the desired learning outcomes for students, it provides little guidance as to how teachers should teach (Anderson & Ben Jaafar,
As Sherin, Mendez, and Louis (2004) put it:

... reform recommendations usually reach the classroom in the form of new curricula that teachers are expected to implement. However, teachers often transform such new materials in light of their own knowledge, beliefs, and familiar practices; as a result, the ‘enacted curriculum’ can be quite different from the ‘written curriculum’. (p. 210)

As Figure 13 illustrates, what students learn (the “Attained Curriculum”) is mediated by what it is that teachers do in their classrooms (the “Implemented /Enacted Curriculum”) which may not have the intent or depth of the intended curriculum prescribed by policy makers (the “Intended Curriculum”) (Handal & Herrington, 2003). Ultimately, when it comes to the core of schooling—classroom instruction—teachers have the last word (Cuban, 1990).

Figure 13. The intended versus the attained curriculum. Adapted from “What we have learned from 20 years of school effectiveness and school improvement research, and what this means to schools and teachers” by T. Townsend. Retrieved April 2, 2011 from http://www.autostream.com/Presentation/WoodRock-19877-Townsend-Accountability-Game-2004-Rules-Regulations-Real-Improvement-new-Third-International-Maths-the-as-Entertainment-ppt-powerpoint/.

Handal and Herrington (2003) found that, if teachers hold beliefs that are compatible with an innovation or reform, then acceptance and adoption will more likely occur. Therefore teachers can be either major conveyances or obstacles to change (Prawat, 1990). Taking this one
step further, Lipsky (1983) referred to teachers as street level bureaucrats—they are the final brokers when it comes to implementing policy (Spillane, 1990).

The research literature suggests that teachers can greatly alter the intent of school reform at the implementation stage by fully or partially rejecting (or embracing) the reforms (Watanabe, 2007). Teachers have the ultimate discretion and control over what gets policy gets implemented behind the classroom door. There are very few mechanisms that allow entry into the classroom; even data for EQAO assessments are aggregated at the school, not the classroom level. Having said this, it should also be stated that although teachers have considerable autonomy in their own classrooms, there are external pressures on them to conform to what the rest of the teachers in their department are doing. Even if a teacher is willing to go out on a limb and try something completely new, it is likely that he or she would be eventually forced back to “toeing the line.” In this sense, implementing change often becomes a collective endeavor.

As has been argued earlier, the mismatch between curricular goals and teachers’ (traditional) belief systems can be a major obstacle to mathematics reform. This is because “teachers, who must be the agents of change, are products of the system they are trying to change” (Anderson & Piazza, 1996, p. 54). If teachers have not learned mathematics in a reform-oriented way, it will be hard for them to teach mathematics in a reform-oriented way. Changing their practice will require them to unlearn and re-learn (Handal & Herrington, 2003).

Finding a way to support teachers in transforming their teaching practice, therefore, is paramount in bringing alignment between the intended and attained curricula. Recent research suggests that altering the core elements of teaching requires extended opportunities for teachers to learn, generous support from peers and mentors, and occasions to practice, reflect, critique, and practice again (Cohen & Hill, 2000).
There is some promise that organizing professional learning as a collective endeavor, as opposed to an individual one, is more likely to impact mathematics teacher practice (McLaughlin & Talbert, 2007) and student achievement (Gallimore, Ermeling, Saunders, & Goldenberg, 2009). Recent research highlights teacher “learning communities” as being a critical context for developing teachers’ understandings, skills, and identities as reform mathematics educators. For example, in a study of 11 secondary schools, Egodawatte et al. (2011) found that, when teachers collaborated in a school team to improve the quality of learning in Grade 9 Applied Mathematics classrooms, the culture eventually shifted from a transmission mode of teaching to a transaction mode of teaching.

Spillane (1999) posited that there are three “zones of enactment” that are important in supporting teachers as they go about reconstructing their mathematics teaching practices. First, learning must be social rather than individualistic (Yates, 2012). The premise is that teachers are ill equipped and unlikely to implement reforms and changes to practice in isolation and that they need opportunities to socially re-construct their notions of effective teaching and learning (Cohen & Hill, 2000; Lave & Wenger, 1991; Spillane, 2000). Teachers that move outside of their individual classroom zone have more success with enacting mathematics reform, so it should follow that when schools replace the norm of privacy with the norm of collaboration and deliberation about practice, change is more likely to occur. This is important given that teacher collaboration has been linked to higher student achievement (Boaler, n.d.; Bruce & Flynn, 2013; Desimone, Smith, & Phillips, 2007; Egodawatte, McDougall, & Stoilescu, 2011; Goddard, Goddard, & Tschannen-Moran, 2007).

Second, effective teacher learning must involve rich deliberations about the substance of the reforms and the practicing of reform ideas. It is important that teachers have the opportunity
to both deliberate with others about what the reforms might look like in their own classroom contexts and to debrief their attempts at changing their practice (Guskey & Yoon, 2009; Hill & Ball, 2004; Puchner & Taylor, 2006). It is particularly effective when teachers from the same school, subject, or grade collaborate (Garet, Porter, Desimone, Birman, & Yoon, 2001; Penuel, Fishman, Yamaguchi, & Gallagher, 2007) and when learning is situated in the classroom setting (Bruce, Ross, Flynn, & Lessard, 2011; Lave & Wenger, 1991) and centred on teachers’ daily pedagogical challenges (Garet et al., 2001; Moyer-Packenham, Bolyard, Oh, & Cerar, 2011; Ostermeier, Prenzel, & Duit, 2010).

Third, teachers need access to a variety of resources, including artifacts of best practice. They need to have opportunities to move from looking at their own classrooms, to looking at other classrooms, ideally beyond their own school and district. It has also been demonstrated that expert facilitators are instrumental in mediating the exploration and learning of math content; therefore, teacher learning about reforms will likely be deeper when external experts are involved (Bruce et al., 2011; Gallimore et al., 2009; Macaulay, 2005; Moyer-Packenham et al., 2011; Timperley, Wilson, Barrar, & Fung, 2007; Yates, 2012).

Given these professional learning “ideals,” the high school mathematics department emerges as having great potential for leveraging change improvement efforts.

**Streaming**

A common educational practice is to sort and group students, based on their perceived ability, for the purpose of instruction (Oakes, 1985). The alternative to teaching based on ability is to teach mixed-ability or heterogeneous groupings. Teachers often struggle with the complexity of heterogeneous classes and for this reason find it easier to teach ability-grouped classes. Also referred to as streaming, tracking, and setting in the literature, there are several
methods for grouping students and the practice looks decidedly different in elementary versus secondary schools. In elementary schools, grade levels generally serve as the organizer for classes and grouping happens within the classroom setting for the purpose of differentiating instruction. As such, groups tend to be temporary and flexible, in response to student learning needs. In secondary schools, courses are the organizer for classes and students are grouped for entire courses. Different levels or streams of a course might be offered, with students being placed according to their perceived abilities. In some boards, some students might even be streamed into specialty schools, such as “Arts” or “Africentric” schools.

The practice of grouping students by ability level is particularly prevalent in the teaching of mathematics (Boaler, n.d., 2007; Boaler, Wiliam, and Brown, 2000; Cogan, Schmidt, & Wiley, 2001; Forgasz, 2010; Ireson, Hallam, Hack, Clark, & Plewis, 2002). In Ontario, for example, students are streamed into three different ability levels for Grade 9 Mathematics, namely: Academic, Applied, or Locally Developed. These different streams are referred to as “pathways.”

Streaming is premised on the idea that students have relatively fixed levels of ability and should therefore be taught accordingly (Boaler et al., 2000). Generally it is thought that brighter students need a faster pace and enriched material while lower ability students need remediation, repetition, and review (Glass, 2002). The typical rationale for streaming is an efficiency argument (Van Houtte, 2004)—presumably when students are placed in homogeneous classes or groupings, teachers can adapt the materials, level, and pace of instruction to better meet the needs and cognitive level of individual students (Burris, Wiley, Welner, & Murphy, 2008; Gamoran, Porter, Smithson, & White, 1997; Hattie, 2002; Lleras & Rangel, 2009; Rubin, 2008). Following this logic, one would expect students to do well when placed in the appropriate level,
whether high or low. However, studies of streaming consistently demonstrate that students in “higher” streams have higher academic outcomes than students in “lower” streams (Allensworth, Nomi, & Montgomery, 2009; Burris & Welner, 2005; Callahan, 2005; Gamoran, 2009). For example, various analyses of the Second International Mathematics Study (SIMS) and the Third International Mathematics and Science Study (TIMSS) have proven that a traditional low-stream and remedial curriculum actually depressed the mathematics performance of students, rather than improving it (Burris, Heubert, and Levin, 2006).

There is mounting evidence that this phenomenon also holds true in the Ontario context where studies have established that successful completion of 16 high school credits by the end of Grade 10 will keep students on track to graduate in four years (OME, 2009). Yet according to the OME, 41.3% of students who started in Grade 9 Applied Mathematics had not earned 16 credits by the end of Grade 10, taking them off course from graduating on time. This compares to a much smaller 14.4% of students who did not earn 16 credits by age 16 that started in Grade 9 Academic Mathematics (People for Education, 2013).

Furthermore, according to a 2010 Colleges Ontario report:

- Students in Grade 9 Applied Mathematics had a 58.4% chance of graduating in five years, while students in Grade 9 Academic Mathematics had an 86.5% chance of doing so; and,

- 24.1% of students in Applied Mathematics went on to register in university or college after secondary school, compared to 60.6% of students in Academic Mathematics who went on to do so. (King et al., 2010)

EQAO longitudinal data adds further fuel to the fire. Table 1 and Figure 4 both illustrated that students in the higher stream (Academic) are out-performing those in the lower stream.
Typically, twice as many students in the academic course reach the provincial standard of Level 3 than do students in the applied course. Moreover, although student achievement in both streams is steadily improving, the gap in student achievement has increased marginally.

This is an interesting phenomenon, given that applied mathematics is perceived to be the easier of the two Grade 9 Mathematics courses tested by EQAO. One might reasonably expect students to do better in it, but they do not. In fact, a 2012 report released by the EQAO suggests that just taking the applied course may actually exacerbate the achievement gap:

- Of the students who met the provincial standard in both Grade 3 and Grade 6, 92% met it again in Grade 9 in the academic mathematics course, compared with only 79% in the applied course.

- Of the students who had not met the provincial standard in Grade 3 or Grade 6, 53% did not meet it in Grade 9 in the academic course, compared to 70% in the applied course.

- Of the students who had not met the provincial standard in Grade 3 but had met it in Grade 6, 77% met it in the Grade 9 academic course, compared with 61% in the applied course. (EQAO, 2012h)

In the researcher’s own experience, tracking or streaming is widely perceived to be a vehicle that will foster educational achievement. However, this is hardly how it plays out in reality. In fact, researchers have demonstrated that when they control for ability level and socioeconomic status, being in the top stream accelerates achievement and being in the low stream significantly reduces achievement, especially for mathematics (Gamoran & Berends, 1987; Slavin, 1990). Furthermore, when students are divided for instruction based on so-called
ability, their achievement will become more and more unequal over time (Gamoran, 2002) and the gap between students in high-and low-level streams will inevitably widen over time (Callahan, 2005; Gamoran, 2009; Linchevski & Kutscher, 1998; Oakes, Gamoran, & Page, 1992) as is evidenced by the Ontario situation. Streaming might, in fact, derail more students than it helps.

Proponents of streaming often claim that mixed grouping will be detrimental to the higher performing students. Research has refuted this claim. For example, in a study of three English secondary schools, Boaler et al. (2000) found many negative effects for the presumably more able students in the highest mathematics stream. These effects included being taught at a pace too fast for students to develop understanding of what they were learning, and being taught too prescriptively. Teachers expected all of the ability-grouped class members to work at the same pace and this was a stress for some students who felt that they could not keep up. Furthermore, the students in the top classes were found to be more negative about mathematics and more likely to believe that memorization was more important than thinking in mathematics, as compared to students in lower or mixed-ability classes.

Another and related rationale for streaming students stems from the fact that inevitably students will take different life pathways depending on their interests, enjoyment, or preferred occupational trajectory (Australian Association of Mathematics Teacher, 2009; Ayalon, 2006; Van Houtte, 2004). As a consequence, not every student needs to study high-level mathematics. That being said, all students should experience rich and challenging mathematics because in the 21st century all people require mathematical skills for effective participation in their personal lives and communities, their education and training, and in the workplace. According to the OECD, “The objectives of personal fulfillment, employment, and full participation in society
increasingly require that all adults, not just those aspiring to a scientific career, should be mathematically, scientifically, and technologically literate” (OECD, 2004, p. 37). This includes the ability to evaluate, communicate, reject or defend ideas, reflect, revise, and pose questions (Quinnell, 2010). Quite simply, all students do well in mathematics—no matter the stream taken.

Researchers have gathered a solid base of evidence that demonstrates that poor, working-class, and minority students are disproportionately labeled as slow learners in elementary schools and assigned to the lowest streams in secondary schools (Boaler et al., 2000; Curtis, Livingstone, & Smaller, 1992; Davies & Guppy, 2006; Gamoran et al., 1997; Lee & Bryk, 1988; Oakes, 2005). This contention is supported by Ontario evidence. For example, although neither the applied nor the academic curricula was intentionally designed to be more suitable for students with special educational needs, the percentage of students with special education needs in applied courses is approximately four times that for the academic course (EQAO, 2012, June).

An abundance of research has documented strong links between students’ academic and social background and their course taking (Allensworth et al., 2009; Callahan, 2005; Forgasz, 2010; Gamoran, 2009; People for Education, 2013). Typically, students with strong academic skills and advantaged backgrounds select college/university bound courses while those with weak academic skills and less advantaged backgrounds take lower-level courses (Boaler et al., 2000). Canadian researchers Davies and Guppy (2006) found that students from wealthier and more advantaged family backgrounds are more inclined to enter academic programs while students from poorer and disadvantaged families are more likely to enter vocational programs. Similarly, Krahn and Taylor (2008) found that students from more affluent families were more likely to be enrolled in courses that keep their postsecondary school options open. In fact, the
odds of a 15 year-old having all postsecondary school options open were two and a half times higher for students if they had at least one university-educated parent. Additionally, it is mathematics (or lack of it) that reduces the proportion of students with the most postsecondary school options.

An Ontario study found that when the 10% of schools with the highest concentration of students taking Grade 9 Applied Mathematics were compared to the 10% of schools with the lowest concentration of students in Grade 9 Applied Mathematics, students in these schools were:

- Two and a half times as likely to have parents who did not finish high school;
- Almost two-thirds less likely to have parents who attended university;
- From families where the average family income was almost half that of schools with the smallest proportion of schools taking the applied course;
- More than three (3.7) times as likely to be Aboriginal; and
- Nearly twice as likely to be English-learner learners. (People for Education, 2013, p. 3)

If anything, streaming seems to perpetuate the cycle of low levels of education, disadvantage and poverty.

In contemporary times that are marked by increasingly diverse societies, researchers have found new patterns of inequality associated with streaming, namely for English Language Learners (ELL). These students are often streamed into classes with modified curricula that are less rigorous than that of mainstream classes (Gamoran, 2009). One needs to question the wisdom of this practice when one considers that Callahan (2005) was able to demonstrate that the stream placement of an English Language Learner was a better predictor of achievement than his or her proficiency in English.
The central equity concern stemming from streaming is the disparity that exists between the quantity and quality of education in the high versus low streams. A substantial literature base documents that students placed in lower streams learn less over time than they would have had they been placed in higher streams (Lleras & Rangel, 2009). Furthermore, it has been demonstrated over and over again that students in the lower streams are provided a substantially different curriculum and set of learning experiences than students in the higher streams. The pace, complexity, and challenge of classroom instruction tends to be higher in high-stream versus lower-stream classes (Applebee et al., 2003; Callahan, 2005). Many researchers agree that the benefits that high achievers enjoy in streamed classes are likely not from the homogeneity of their group, but from their enriched curriculum (Frempong, 2005; Gamoran, 1990; Goodlad, 1984; Haimes, 1999; Watanabe, 2008). It could be said that students in higher streams are given the opportunity to learn more.

**The High Stream Advantage**

The instruction in high and low stream classrooms clearly produces different student outcomes. In fact, research suggests that high stream classes bring students an academic benefit. These classes tend to develop more work-oriented cultures and their teachers tend to be more enthusiastic, more motivated and better trained (Berry, White, & Foster, 2002; Crosby & Owens, 1993). Oakes (1982, 1986) established that students in high stream classes have a more rigorous curriculum, higher quality instruction and lessons that engage higher-level thinking skills compared to the drill-and-practice activities focusing on memorization that are more typical in lower stream classes. In higher stream classes, students have higher expectations placed on them and are taught and expected to be critical thinkers (Callahan, 2005). Furthermore, students in high stream classrooms often have better equipped classrooms, smaller class size and are more
likely to be engaged in active problem solving and dialogue (Applebee et al., 2003; Callahan, 2005). Peer relations in higher stream classes tend to be more positive, more cooperative, and connected than those in lower streams (Wilson, 1992). Moreover, students in high stream
classes tend to develop higher educational aspirations and more positive academic and personal self-concepts (Berry et al., 2002; Goodlad, 1984; Oakes, 1985). Ultimately, students in higher
streams perform better on standardized tests and have better college outcomes than students in lower streams (Allensworth et al., 2009).

In contrast, there is a substantial body of evidence that instruction in lower streams is qualitatively different than that provided in higher streams. For starters, lower stream
classrooms are more likely to be staffed by teachers with the least experience and fewest qualifications (Boaler et al., 2000; Hanushek, Kain, Markman, & Rivken, 2003). Students in low
streams are generally expected to learn more slowly and at lower cognitive levels (Applebee et al., 2003; Callahan, 2005); therefore lower stream classes are associated with fewer intellectual challenges (Oakes, 2005) and often relegated to a less challenging curriculum that is focused on drill, practice, and repetition (Hanushek et al., 2003). As a consequence, students in the lower
streams tend to have fewer demands placed on them and therefore have little motivation to work hard and earn high grades (Ayalon, 2006). Carbonaro (2005) argued that ultimately, sense of agency—whether a student chooses to engage himself or herself in the learning process—is highly influenced by stream placement, and that students in the higher streams develop higher agency and vice-versa.

Boaler et al. (2000) found that opportunities to learn were restricted in lower streams. They found that students in lower-stream mathematics classrooms typically report very negative experiences including frequent changes in teachers, non-mathematics teachers allocated to their
classes, and low level work that they find too easy. In low stream classrooms, instruction is more often fragmented and emphasizes isolated bits of information instead of sustained inquiry (Hattie, 2002). Furthermore, Gamoran, Nystrand, Berends and LePore (1995) found that questioning patterns differ significantly in honours, regular, and remedial classes. For example, students in lower stream classes will answer five times more multiple-choice, true/false, and fill-in-the-blank style questions than their high stream counterparts (Gamoran & Mare, 1989).

Teachers in more academic streams also place more emphasis on reasoning and inquiry skills than do teachers of classes in the lower streams. As a result, where students in higher stream classes are likely to participate in hands-on inquiry, their peers in lower stream classrooms are likely to spend more time reading textbooks and filling in worksheets (Gamoran et al., 1995).

This lack of opportunity to learn challenging mathematics contributes to the gap in performance between streams (Balfanz & Byrnes, 2006). This also becomes an issue of institutionalized expectations, or lack of them, and the consequence is a system that is often demoralizing and demotivating for the children who end up in the lowest streams (Rubin, 2008). As Shanker (1993) described, “Kids in these [lower] tracks often get little worthwhile work to do; they spend a lot of time filling in the blanks in workbooks or ditto sheets. And because we expect almost nothing of them, they learn very little” (p. 34).

As might be expected, studies have also suggested that streaming has a negative effect on the attitudes, self-esteem, and motivation of students that are placed in the lower-ability groups (Berry et al., 2002; Callahan, 2005). Students internalize labels, become alienated and develop anti-school attitudes that put them at risk of delinquency, dropping out, and other social problems (Ireson et al., 2002; Slavin, 1990). As a result, many students in the lowest tracks drop out of school altogether. Leithwood likened this effect to inflation, saying that “through the process of
streaming, the rich get richer and the poor get poorer” (Curtis et al., 1992, p. 12).

Another adverse effect of streaming is the loss of opportunity for the low-stream students to interact with and discuss material with well-motivated and high-achieving students (Hanushek et al., 2003). In other words, having high-achieving and motivated students raises everyone’s level of achievement. When lower ability students are separated from higher-ability students, this peer group effect is diminished. Closely related to this is the fact that, over time, streaming fosters friendship networks that are linked to students’ group membership (Lleras & Rangel, 2009). Low-stream students tend to “hang out” with low-stream students and high-stream students likewise hang out with high-stream students.

Furthermore, students tend to be labeled and stereotyped by teachers according to the stream that they are in (Ireson & Hallam, 1999). For example, Wilson (1992) found that teachers of low stream classes are likely to use words like “hostility,” “discipline,” and “conflicts” when describing their classes whereas teachers of high stream classes are likely to use words such as “positive,” “friendly,” and “relaxed” when describing theirs (p. 29). Even before teachers have met their students, they have formed pre-conceived notions of their academic abilities, based on the assigned stream, and they adjust their educational goals to those expectations (Van Houtte, 2004). This is significant because teachers will often engage in deficit thinking around students in the lower streams (Callahan, 2005), believing that they are destined to fail because they “don’t have what it takes” to be academically successful. In fact, an identity often emerges around students that are in the lowest stream and a sort of “Sweathog” persona often surrounds them. The term “Sweathog” was made popular by the 1970s American television show “Welcome Back, Kotter.” The Sweathogs were the remedial students around which the show revolved. Nicknamed so because remedial classes were often held on the top floors of a school, the
Sweathogs were dismissed as “unteachable” and unruly hoodlums by the school administrators. Their teacher, Mr. Kotter, was charged with “controlling them” until they inevitably dropped out. This “group” identity tends to paint all students with the same brush. In the Ontario context, for example, teachers will often refer to the students taking applied classes as “applied kids” and will often say that behavior in “applied classrooms” is challenging, even futile. I have heard it said, on more than one occasion, that having to teach applied courses is a “punishment.”

Another reality is that secondary school teachers are unlikely to have been students in lower-stream classes themselves. As secondary mathematics teachers have a university background, most of them would have been in university-bound streams when they attended secondary school. The differences in these travelled trajectories make it difficult for secondary mathematics teachers and students in the lower streams to identify and relate with each other.

Given the overwhelming evidence that streaming students does not support student success or achievement, a natural response might be to place all students in mixed-ability classes. The National Governors’ Association in the United States, for instance, has recommended de-streaming as part of its strategy for meeting national education goals. This is in part attributable to the fact that on recent PISA results, Finland ranked first among 29 industrialized nations in mathematical literacy, and second in problem solving. This success, and Finland’s overall narrow achievement gap, has been linked to its de-streamed education system (Oakes, 2008). Similarly, Poland improved its results dramatically between 2000 and 2006 by de-streaming its secondary school system. The OECD has amassed compelling evidence that the kind of academic selection that takes place with streaming widens achievement gaps and inequities:

Student selection, and in particular early tracking, exacerbates differences in learning between students. It has an impact on educational inequities, as any given pathway and any given school affects learning in two ways. Firstly, the teaching environment can vary, since it depends on the curriculum, the teachers and the resources. Less demanding
tracks tend to provide less stimulating learning environments. Secondly, students’ outcomes can also be affected by the students alongside them. These policies determine the way students are put together or directed to separate classrooms, pathways and schools according to their abilities, and have an impact on equity and on educational failure. Evidence shows that the track where students are assigned has a great impact on their educational and life prospects. (OECD, 2012, p. 56)

Furthermore, the OECD has established that when schools take a more comprehensive (de-streamed) approach to mathematics instruction, more equitable outcomes result (OECD, 2012a).

The reality, however, is that success with de-streaming is hard to achieve (Gamoran & Weinstein, 1998). Oakes (1994) identified three problems that make de-streaming difficult: overcoming the prevalent belief that students need to be separated based on cognitive ability; the political problem of overcoming the resistance of stakeholders who believe that streaming benefits their interests, e.g., parents of high-achieving students or teachers of high-ability classes who fear that de-streaming will result in lowered academic standards; and the technical problem of finding effective methods for teaching students who differ in their performance levels.

The Ontario experiment with de-streaming in the early 1990s is a case in point. Researchers who have tried to unpack what de-railed the initiative speak to (a) issues with the curriculum and (b) lack of support for teachers who were trying to implement it (Haines, 1999). The curriculum that was put in place was basically a derivative of the previous Grade 9 Advanced curriculum. Instead of embracing newer approaches such as those being advocated by the NCTM, the de-streamed curriculum encouraged teachers to do what they always did which was to focus on the functional aspects of mathematics, such as algebraic manipulation. Second there was very little guidance offered to teachers as to the types of techniques and strategies they could use to teach students with varying abilities in the same room (Haines, 1999).

There is growing evidence that an accelerated or enriched curriculum is more effective than remediation in increasing the achievement of lower achievers (Burris, 2010). In fact,
schools and systems that have successfully de-streamed have tended to redesign their curriculum around rich and complex ideas. In other words, the curriculum that is typically reserved for the highest achievers is the best curriculum for all students (Burris et al., 2006). It is now widely believed that the higher performance of students in higher stream classes most likely stems from the rigorous curriculum and high expectations, not from the grouping practices that sorted students in the first place (Burris et al., 2008). As Hattie (2002) put it:

> Whether a school tracks or not appears less consequential than whether it attends to the nature and quality of instruction in the classroom, whatever the within-class variability in achievement. It is almost certain that there are conditions of learning (such as specific and challenging goals, the presence of feedback, and structure in the activities) that are far more powerful. (p. 449)

In their work following high schools that dismantled streaming, Burris and Welner (2005) found that when all students have access to first-class learning opportunities, closing of the achievement gap could be realized. In other words, the achievement gap will be hard to close when a curriculum gap exists (Burris, 2010). Some academics have suggested that instead of spending our time and energy labeling students and putting them in the “right” tracks, perhaps our time would be better spent taking action inside classrooms to support individual students. Along this vein, Kaser and Halbert (2009) talked about the need for schools, in a knowledge society, to shift their focus from sorting to learning. They argued that it is the quality of teaching and the nature of the student interactions that are the key issues, rather than the compositional structure of the classes:

> Making the move from a sorting to a learning system requires educators and policymakers to shift from a fixed to a growth-oriented mindset. They need to learn new behaviours that demonstrate their conviction that virtually all young people can learn and achieve at high levels. (p. 56)

In a concrete example, Boaler followed 700 students from three demographically similar secondary schools over a four-year period (Boaler, 2007; Boaler & Staples, 2008). She was
studying the impact that different mathematics teaching approaches would have on their achievement. At Greendale and Hilltop schools, students were streamed into three different ability levels and teachers used traditional teaching approaches involving a predominance of teacher lecture and independent student practice. In contrast, students at Railside School were assigned to heterogeneous, mixed-ability classes and the predominant teaching strategy was to assign students longer, conceptual problems that they would work on in groups, often presenting their work to the rest of the class. Boaler found that although students at Railside School started secondary school at significantly lower levels of achievement, they were out-performing the students at both Greendale and Hilltop within two years. Moreover, questionnaires revealed that the Railside students were enjoying mathematics more than the students in the other two schools.

Upon further investigation, Boaler found that 97% of the students in the traditional classrooms at Greendale and Hilltop said that to be successful in mathematics, “you need to pay careful attention” (p. 185) whereas at Railside, the students believed that be successful in mathematics, “you need to ask good questions, rephrase problems, explain well, be logical, justify your work, consider answers, and use manipulatives” (p. 185). The students at Railside clearly developed a different conception of what it meant to do and be good at mathematics. Boaler concluded that it was in part the relationships that Railside students developed with one another as they went about solving complex problems that anchored their success.

Boaler’s research clearly supports the fact that, when de-streaming is implemented with the belief that all students can learn and when teaching is aligned with what we know are good instructional practices in mathematics, all students can indeed learn at high levels. This discredits the belief that students must be grouped by ability in order to succeed and challenges the kind of deficit thinking that many educators typically engage in (Rubin, 2008). Similarly,
Burris et al. (2008) suggested “it is worth moving beyond debates about class composition to enhancing the quality of teaching regardless of the compositional effects of the students,” (p. 474). They argued that de-streaming can be an effective strategy to help *all* students reach high learning standards if it embraces high expectations for all students, sufficient resources, and a commitment to the belief that students can achieve when they have access to an enriched curriculum.

We have learned that it is the curriculum, the teaching, and the learning opportunities in the classroom that foster achievement, or lack of it. Regardless of how we organize our schools and our classrooms, it is what goes on behind the classroom doors that will impact what students do and do not learn. It is also true that students—no matter where they sit in the school—should receive appropriate and effective teaching.

Each of the areas explored in this literature review shed some light on what might be contributing to the lower performance of students in Grade 9 Applied Mathematics and have ultimately been important in developing the conceptual framework for the study.

**Conceptual Framework**

In Ontario, EQAO mathematics assessments measure the extent to which students are acquiring some of the requisite mathematical knowledge and numeracy skills. They are significant in that they provide a measure of how students are meeting the curriculum expectations that are outlined in OME policy documents; they can help us to understand the degree to which the intended curriculum has been implemented in classrooms. EQAO data for the past five years suggests that students taking the applied stream of mathematics courses are not developing—to provincial standard—the mathematical skills that are needed in the 21st century.
It has been suggested that one way schools can better help students to meet rising academic standards is by improving the instruction that goes on within classrooms (City et al., 2009; Corcoran & Silander, 2009). In mathematics education, there has been a recent shift from traditional to reform-based teaching practices involving a movement away from the transmission model to more constructivist approaches. This approach is also apparent in *The Ontario Curriculum: Mathematics*. This study sets out to investigate if elements of reform practices (e.g., problem solving focus, rich tasks, cooperative learning, and classroom discourse, use of manipulatives and instructional technologies, assessment for learning principles, attention to positive dispositions around mathematics) are indeed evident in the most successful Grade 9 Applied Mathematics classrooms, as measured by EQAO scores. It also sets out to understand resources, both material and human, that are important in teaching the Grade 9 Applied Mathematics course.

The current literature also suggests that many of the intended teaching practices in *The Ontario Curriculum: Mathematics* are outside of the experiences of many classroom teachers and so they will need professional learning related to the changes. Research also suggests that the kind of changes required will need uptake beyond individual teachers—teachers working in isolation will be hard pressed to effect change on their own. This study sets out to understand how the math department and school leadership might support this growth.

The conceptual framework developed for this study—outlined in Table 4—positions five elements as being important to supporting student achievement in Grade 9 Applied Mathematics. These include:

- Resources (material and human),
- Teacher professional learning,
• Math Departments,
• Leadership, and
• Reform-based teaching practices.

Table 4

*Conceptual Framework for the Study*

<table>
<thead>
<tr>
<th>Effective practices in Grade 9 Applied Mathematics classrooms</th>
<th>Resources</th>
<th>Teacher Professional Learning</th>
<th>Math Department</th>
<th>Leadership</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Instructional resources</td>
<td>• District-level professional learning</td>
<td>• High expectations for all students regardless of stream</td>
<td>• Focus on EQAO results</td>
</tr>
<tr>
<td></td>
<td>• Availability of math manipulatives</td>
<td>• School-level professional learning</td>
<td>• Shared responsibility for all students</td>
<td>• Distributed leadership (Math Chair)</td>
</tr>
<tr>
<td></td>
<td>• Access to instructional technologies</td>
<td>• Access to instructional coach</td>
<td>• Collaborative structures, e.g., shared planning time</td>
<td>• Appropriate allocation of resources</td>
</tr>
<tr>
<td></td>
<td>• Membership in professional organizations, e.g., OAME</td>
<td>• Affiliation with outside experts, e.g., Faculties of Ed</td>
<td>• Clearly articulated goals for improvement</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Human resources, i.e., number and qualifications of educators</td>
<td></td>
<td>• Practices around assigning students into applied vs. academic</td>
<td></td>
</tr>
</tbody>
</table>

The data collection methods for this study were designed to capture the practices—with respect to these elements—of some of Ontario’s most successful schools on EQAO Grade 9 Mathematics assessments.
Theoretical Perspective: Social Constructivism

The theoretical perspective of this paper aligns with the social constructivist theory of learning that views learning as a social activity and calls for students to be active participants in their own learning. This position is linked to the work of cognitive psychologists such as Vygotsky (1978) who argued that social interaction promotes development and learning and Leont’ev (1981) who believed that engagement and participation in activity is necessary for learning to occur. The key premise of this theory is that knowledge is constructed in the mind of the learner. Learning, in other words, is not a passive exercise:

It is now commonly understood that human organisms act on their world, coupling with it, interpreting every experience. They do not simply take in, or absorb information. They interpret it, organize it, and infer about it with the cognitive structures that they have previously constructed. (Fosnot, 2005, p. 4)

This notion of constructivism is relevant to this paper for two reasons. First, much of the current thinking around effective teaching and learning practices in mathematics has constructivist underpinnings. Constructivist theories are based on the belief that children construct their knowledge and understanding through their own activity (Doctorow, 2002). In this view, concepts are internalized through active and hands-on learning. Therefore, the role of the teacher must shift from someone who transmits knowledge to someone that facilitates learning by helping learners to make connections and construct meaning. Constructivist approaches towards mathematics position inquiry, investigation, and problem solving as the primary vehicles for learning (Suurtamm et al., 2008). This is in contrast to the conventional notion of mathematics teaching that assumes mathematical knowledge can be transferred or transmitted from teacher to student through the passive reception of rules and procedures. This notion of constructivism is important to this paper because The Ontario Curriculum: Mathematics embodies and values constructivist ideals.
Second, it is naïve to expect that teachers will change their practice simply by shifting policy. Therefore, this research presumes that to meet the spirit of the intended curriculum, teachers might similarly need to re-construct their own understandings of teaching and learning mathematics.

In summary, the theory of constructivism is central to this paper because (a) it is important to the implementation of *The Ontario Curriculum: Mathematics*, and (b) it is presumed to be an important element in helping teachers to understand and implement the required curriculum policy.

**Significance of the Study**

The reality is that mathematics is deeply embedded in the workplace and everyday life (Conference Board of Canada, 2012; Organization for Economic Development, 2009). In its resource entitled *Leading Math Success*, the OME asserted that mathematics “is a fundamental human endeavor that empowers individuals to describe, analyze, and understand the world we live in” (OME, 2004, p. 9). Therefore, ensuring that all students are mathematically literate is essential to preparing them to face the challenges of being an adult in the 21st century and should be a key priority for all educators. It seems imperative, therefore, that *all* students—no matter the course that they elect to take—be successful. Levin reminded us that educators need to be concerned that students develop skills; however, they should not lose sight of the fact that “we want them to have those skills in order to contribute to the betterment of human life” (Levin, 1998, p. 62). Therefore, the discrepancy between how academic students fare in their courses and how applied students fare in their courses needs to be challenged.

This concern has been underscored with the recent release of the Programme for International Student Assessment (PISA) results. PISA is an international assessment of 15-
year-old-students in the areas of reading, mathematics, and science. Initiated by the 
Organization for Economic Co-operation and Development (OECD), PISA is developed by 
participating countries and administered in Ontario under the auspices of the EQAO. The PISA 
assessments focus on:

…skills that are generally recognized by participating countries as key outcomes of the 
education process. The assessment focuses on young people’s ability to use their 
knowledge and skills to meet real life challenges. These skills are believed to be 
prerequisites for efficient learning in adulthood and full participation in society. (Brochu, 
Deussing, Houme, & Chuy, 2013, p. 9)

PISA goes beyond merely measuring knowledge by requiring students to reflect on and 
apply what they know: in PISA assessment tasks, students are typically required to extrapolate 
from what they have learned in school to solve mathematical problems in a variety of situations 
and contexts related to home and work-life outside of school (OECD, 2009; 2012b). This 
includes reasoning mathematically and using mathematical concepts, procedures, facts, and tools 
to describe, explain, and predict phenomena (OECD, 2012c, p. 2).

A recent administration of PISA took place in 2012 at which time the major domain was 
mathematics. Reading and science were minor domains. Sixty-five countries participated in the 
assessment, including all thirty-four OECD countries. In Canada, 21 000 15-year-olds from 
approximately 900 schools and 10 provinces participated. Of those, 3 699 students were from 
Ontario. The results from the assessment show that Ontario students perform well. It is also 
worth noting that historically on PISA assessments, Ontario students have had above average 
performance and below average variation based on socioeconomic background, indicating high 
levels of achievement and equity (CMEC, 2012; EQAO, 2010a).

Though Ontario students match the Canadian average in mathematics, their results are on 
the decline—in fact, over the past nine years the results have declined by sixteen score points,
dropping from an average score of 530 points in 2003 to 514 points in 2012. To put this into perspective, the OECD average declined six points during the same timeframe, from 500 in 2003 to 494 in 2012. Whereas seven of the 74 other participating jurisdictions performed better than Ontario in 2009, ten of the other 64 participating jurisdictions outperformed it in 2012.

Furthermore, Ontario achievement was at the Canadian average in 2009 along with Alberta and British Columbia and only Québec performed statistically better. In 2012, Ontario achievement remained at the Canadian average along with Alberta and British Columbia. Now, however, Saskatchewan and New Brunswick joined this group. Again, only Québec outperformed it.

Upon closer examination of these results, it is noteworthy that the countries outperforming Canada (and Ontario) are more likely to have a higher proportion of students who reach the highest performance levels (levels 5 or 6 of 6) and that:

Towards the top of the scale, the tasks typically involve a number of different elements, and require high levels of interpretation. Usually, the situations described are unfamiliar and so require some degree of thoughtful reflection and creativity. Questions generally demand some form of argument, often in the form of an explanation. Typical activities involved include: interpreting complex and unfamiliar data; imposing a mathematical construction on a complex real-world situation; and using mathematical modelling processes. At this level of the scale, questions tend to have several elements that need to be linked by students, and successful negotiation typically requires a strategic approach to several interrelated steps. (OECD, 2010b, p. 122)

This performance is significant because “the number of students reaching Level 5 or 6 in mathematics and science will be particularly important for countries wishing to create a pool of workers able to advance the frontiers of scientific and technological knowledge in the future and compete in the global economy” (OECD, 2010b, p. 160).

Further evidence of the need to pay closer attention to our mathematics performance comes from the 2011 Trends in Mathematics and Science Study (TIMSS). TIMSS is a worldwide assessment undertaken every four years by the International Association for the
Evaluation of Educational Achievement. The purpose of this study is to assess the mathematics and science skills of Grades 4 and 8 students from around the world. TIMSS data has demonstrated that Ontario student performance in mathematics has not improved since the 2003 and 2007 studies (EQAO, 2012c). On the most recent TIMSS results, former EQAO Chief Executive Officer Marguerite Jackson said, “These latest results confirm what has been seen on EQAO’s provincial tests in recent years. They provide yet another piece of evidence that we need strong action to improve math (and science) achievement…” (Jackson, 2012, para 5).

Critics argue that standardized testing can actually have a negative impact if the focus becomes all about raising test scores. Teachers and schools can be “driven to distraction” if their focus becomes all about finding and applying an instant solution to raise test scores (Shirley and Hargreaves, 2011). Undoubtedly, this kind of focus can have significant and negative consequences. As Sahlberg pointed out, standardized testing increases teaching to the test, narrows curricula to prioritize reading and mathematics, and distances teaching from the art of pedagogy to mechanistic instruction (Sahlberg, 2012).

All things considered, however, there is fairly compelling evidence that we should pay attention to the kind of data generated by EQAO assessments. Though it is a single measure, when considered with other such evidence, strengths and weaknesses emerge. Worth mentioning here is the fact that the assessments produced by EQAO are based on The Ontario Curriculum and reflect the expectations that are outlined for each grade or course of study.

Of particular concern in this research study is the fact that students in Grade 9 Applied Mathematics are not developing the mathematical skills that they need, especially at the higher levels of performance. Ultimately, this level of functioning might well be magnified as they progress through high school, into tertiary education and the world of work, and ultimately onto
the world stage. Consequently, this study is important for four reasons.

First of all, this persistent underachievement of students in Grade 9 Applied Mathematics is an issue of equity. No matter which mathematics course students elect to take in Grade 9, they should reasonably expect to learn the course content and develop the knowledge and skill with respect to that content. Currently, if students take the applied course, they are more likely to leave it without reaching the provincial standard than reaching it (at least as far as the EQAO assessment is concerned). In fact, students taking applied courses have a reduced chance of graduating from high school on time (King, Warren, King, Brook, Kocher, 2009) or graduating from high school period (People for Education, 2013). This translates into students leaving our high schools ill prepared and with insufficient skills for success in postsecondary education, the workplace, and life in general. Sadly, enrolling in the Grade 9 Applied Mathematics course is a risky venture. This is not an acceptable outcome.

Furthermore, students that take Grade 9 Applied Mathematics are likely to be excluded from certain destinations and life paths because they lack adequate standing or prerequisites in secondary school mathematics. It appears that applied courses may not adequately prepare students for post-secondary mathematics courses. For example, the College Math Project, a recent and important Ontario study, found that over 50% of those students who had taken Grades 9 and 10 Applied Mathematics were at risk in college, compared with fewer than 30% of those who had taken the academic courses (Orpwood, Sinclair, & Schollen, 2008). Furthermore, researchers have found that merely obtaining an applied credit is of less importance in predicting subsequent achievement in college than is the level of achievement in the course (Orpwood, Schollen, Leek, Marinell-Henriques, & Assuri, 2011). For instance, the College Math Project has demonstrated that students coming into college with a D in applied mathematics either fail or
drop out of college in their first year. This translates to over 10,000 Ontario students being at risk of not completing their college programs because of their first semester mathematics achievement (Orpwood et al., 2011).

Therefore, there is a need for students to reach high standards in required skills if they are to be successful at the college level. A mere pass in a math course, regardless of level, does not bode well for future study. This is significant when one considers that the grade that a first-semester college student gets in mathematics often leads to dropping out of college altogether. Therefore, success in high school math courses is linked not only to success in postsecondary education, but also to lifelong opportunities for success (Balfanz & Byrnes, 2006; King et al., 2009). In a recent vision statement for education, the OME also recognized that “merely passing is not good enough for students heading into the global economy and complex society” (OME, 2008, p. 5).

The second reason that this study is important moves beyond an economic to include a democratic justification (Buckley, 2010). It is important to consider that secondary schools need to be concerned with helping students to acquire the basic skills and capabilities that they will need as future citizens in an increasingly sophisticated technological world. Ordinary citizens need to be socially responsible and critical thinkers, able to reason mathematically, and effective at problem solving. Rotherham and Willingham (2009) argued that these skills are not new—critical thinking and problem solving have been associated with human progress since the dawn of time. What is new, they suggested, is the extent to which individual success now depends on having such skills. In fact, high levels of numerical skills and the ability to think critically and solve problems are seen to be integral to students’ full participation in a knowledge-based and technological-oriented society (Hunter, 2010).
The third reason that this study is important relates to the gap in research related to Grade 9 Applied Mathematics. Levin (2013) argued that education systems benefit from research that is focused on legitimate problem of practice. There have been many efforts across Ontario to improve student achievement in Grade 9 Applied Mathematics; however there has not been a lot of research conducted to determine what practices actually make a difference. This study will contribute to the emerging empirical knowledge base concerned with this persistent problem of practice.

Finally, this study is important because many educators will dismiss findings of the EQAO and excuse poor performance based on factors such as the background of their students. Admittedly there is not a lot that teachers can do in the short term to change such conditions. What teachers and schools can do to impact long-term social change, however, is to help children overcome any disadvantages of their backgrounds and thereby facilitate social mobility (OECD, 2010b). Some teachers debunk the whole notion of a paper-and-paper test for students in applied classrooms, saying that it is not the best way for them to demonstrate their learning. True though that may be, all students in the province write the same test. Students from some schools consistently do well on this test and this begs the question, “What is going on in those classrooms that prepares students to be successful?”

Our current EQAO scores indicate that we are missing the mark for a large number of our students, with potential and significant repercussions to them. My hope is that this study will contribute to the dialogue that can help to stem this tide.

**Chapter Summary**

This study was designed to understand practices that might support and improve student achievement in Grade 9 Applied Mathematics classrooms. It set out to answer two research
questions:

• What practices are being used by high performing or rapidly improving schools, as measured by the Grade 9 EQAO Assessment for Mathematics?

• Which of the specific practices identified in the mathematics and general reform literature as being related to better mathematics achievement have been adopted by the most successful schools?

This chapter has highlighted the changes to structures, curriculum, and assessment policy that have impacted Ontario Grade 9 mathematics classrooms over the past two decades. It has also discussed three areas in the literature that shed light on student under-achievement in Grade 9 Applied Mathematics, namely mathematics reform, implementing change and reform in secondary schools, and streaming.

The literature related to mathematics reform has illuminated the kinds of teaching practices that should be evident in Ontario classrooms, given the influence of mathematics reform on The Ontario Curriculum. This information was important for answering both of the research questions.

The literature related to implementing reform in secondary schools was important for situating student under-performance in applied courses within the larger context of secondary schools. Given the magnitude of changes being required of secondary mathematics teachers over the past two decades, it was useful to establish what practices have helped to support change efforts in secondary schools, particularly given their departmental nature. This information was important for answering both of the research questions.

The literature related to streaming was important for understanding the kinds of practices that are often used in the lower tracks and higher tracks, and how they can contribute to
inequitable outcomes. This information was important in discerning the kinds of practices that might better support students in applied classrooms and to answering the second research question.

After presenting the review of the literature, I provide the conceptual framework that I developed to collect and analyze the data that would help me to answer the research questions. The framework outlines five broad areas that emerged from the literature and theoretically should support effective mathematics classrooms. The next chapter focuses on the methodology that was used to collect data regarding these practices in effective Grade 9 Applied Mathematics classrooms.
CHAPTER THREE: METHODOLOGY

Overview

This chapter describes the specific research methods that were used to collect the data necessary to answer the research questions of this study. It discusses two phases of data collection, namely focus groups and case study. For each, the data collection instruments, research sample, and procedures used to collect the data are described. The chapter also includes an outline of how the data collection was managed and analyzed. It concludes with a discussion of the ethical considerations for the study.

Research Design

The research design for this study was intended to discern practices that appear to support student achievement in Grade 9 Applied Mathematics. Specifically, the overarching question that guided the research was:

• What practices are being used by high performing or rapidly improving schools, as measured by the Grade 9 EQAO Assessment for Mathematics?

A second and related sub-question was:

• Which of the specific practices identified in the mathematics and general reform literature as being related to better mathematics achievement have been adopted by the most successful schools?

A qualitative approach was used to answer the research questions. Qualitative methods are used in order to develop a detailed understanding of a process or experience—in this case, consistent and noteworthy performance on provincial Grade 9 Applied Mathematics assessments. Such investigation typically necessitates the gathering of data from a purposively derived sample (Bazeley, 2007). In accordance with the qualitative research tradition, multiple
Data sources were used for this study (Merriam, 1998).

**Data Collection**

Data collection for this study was multi-method and took place in two phases. The intent was to gather data from multiple perspectives. The first phase consisted of focus group interviews with mathematics leaders from a variety of boards in the province. These individuals have direct experience in working with a variety of schools to support student and teacher learning. The second phase involved the study of four case schools that have had notable success with the provincial Grade 9 Applied Mathematics assessment. The case studies gave me the opportunity to visit high performing schools and learn about their approaches to supporting student success in Grade 9 Applied Mathematics. This approach is often used in effective schools research (see, for example, the work of Chenoweth and Lezotte) in order to articulate the characteristics that are common to effective schools (Downer, 1991). Figure 14 below highlights the data collection tools that were used.

**Figure 14.** Data collection methods and tools.

There are numerous examples in the Ontario mathematics education literature where this combination of methods has been used. For example, the CIIM researchers
used both focus groups and case studies to determine how the intermediate mathematics curriculum was being understood and implemented by Ontario educators (Suurtamm and Graves, 2007). Similarly, focus groups and case studies were used to determine effective implementation strategies for online learning objects (Ross, Bruce, Scoffin, & Sibbald, 2008).

The data was collected over a ten-month period from September 2012 through to June 2013. The data collection for phase 1 was mostly completed (i.e., two of three focus group interviews were conducted) before the visits to the case study schools began in phase 2. The insights gathered from the focus groups provided some fodder for additional and probing questions for the case study interviews and observations. For example the questions, “What happens on test day at your school?” and “Can you tell me a little about a typical student in the Grade 9 Applied Mathematics classroom?” were added to the interview protocol after reviewing the focus group data.

**Data Management**

As illustrated in Figure 14, multiple data collections methods were used in this study. This included interviews, observations, field notes, artifacts, and external data (EQAO and ministry reports). This allowed me to triangulate through the use of multiple types of data (observations, interviews, field notes, artifacts, student achievement data), multiple sources (teachers, administrators, math department heads, consultants, coaches, and the EQAO) and multiple schools.

Qualitative research amasses huge amounts of raw data. Therefore, it is important to maintain and organize the data in a timely fashion (Merriam, 1998). To assist with this task, I kept a research journal from the outset of the research process. In it, I kept notes
on the data collection process as it unfolded. This included field notes from focus groups and case study school visits, a log of artifacts that were collected, and memos on new insights about the research questions as they emerged. I also kept notes on relevant things that I had read, as well as sources that I wanted to follow up on.

All of the focus group and case study interviews were recorded with a digital voice recorder. The digital recordings were transferred to my personal computer for transcription and back-ups of them were stored on an external hard drive. All of these digital recordings were password-protected.

All of the electronic data created during this study including word-processed documents, such as transcriptions, were encrypted and stored on my personal home computer and all were password-protected. The project files were backed up on an external hard drive that remained in a secure location in my home for the duration of the data analysis and report writing period. This hard drive was password-protected.

**Use of NVivo**

For my EdD internship, I worked on a project that involved the analysis of survey data on the OME’s Coaching for MathGains initiative. My task was to analyze the responses to the open-ended questions on the survey. To accomplish this, I was introduced to NVivo, a computer software package designed for qualitative research. This application allowed me to store, organize, code, and analyze the large collection of data consisting of 740 survey responses. This was my first experience in using this software and I learned a lot about using such a program to manage, code, and analyze data. I found that the tool made it very easy to engage in open coding, a process of starting from the responses to build codes (called nodes in NVivo). As I was working, I
found myself quite naturally organizing these nodes into categories in order to manage them. For example, one of the things that teachers spoke about in the survey was how they had been introduced to this or that resource, e.g., TIPS or CLIPS. When a teacher first mentioned TIPS, I created a node for TIPS, or similarly when a teacher first mentioned CLIPS, I created a node for CLIPS. Whenever I came across another response that referred to these resources, I could add to this code by highlighting the new and relevant portion of text, and then dragging and dropping on to the appropriate node.

As I continued working my way through the data, I realized that it made sense to organize these two nodes under the general theme of “resources” and so I aggregated them under a new “parent” node called resources as illustrated in Figure 15.

![Figure 15. Creating and organizing nodes in NVivo.](image)

As I worked my way through the data, I found that the categories and themes continued to emerge and change. For example, a lot of teachers began to mention *Gizmos*, another web-based resource. I put this code under the resources node. Upon reflection, I realized that both CLIPS and Gizmos were web-based tools, whereas TIPS was a print resource. And so, I created two new classifications: “Print” and “Web-based applications” under the parent node of “Resources,” as illustrated in Figure 16. In this way, it was easy to see developing and emerging themes from and patterns across the data. The software also has features that allow the researcher to explore the relationships between the various codes that emerge from the data.
I had found it quite easy to use the NVivo software for my internship project and I was impressed with the efficiency it afforded in dealing with the number of survey responses that I had. Furthermore, it had been quite supportive to the data analysis. Bazeley (2007) stated that using computer technology helps to remove much of the drudgery from coding (cutting, labeling and filing) as well as the boundaries which limit paper-based marking and sorting of texts. Put another way, when recoding data involves laborious collection of cut-up slips and creation of new hanging folders, there is little temptation to play with ideas, and much inducement to organize a tight set of codes into which data are shoved without regard to nuance. When an obediently stupid machine cuts and pastes, it is easier to approach data with curiosity, asking, “What if I cut it this way?” Knowing that changes can be made quickly. (Marshall, 2002, p. 67)

Another feature of NVivo that I discovered in working on my internship project is that it allowed me to assign attributes to the survey respondents. So I was able to run queries that would allow me to differentiate the responses that an experienced versus a new teacher might give, for instance. Or the responses that a principal versus a math department head might give, and so on.
I also found out that NVivo allows you to import many different kinds of data formats such as audio files, videos, digital photos, Word documents, PDFs, spreadsheets, and web sites. Therefore, it can be an effective mechanism in helping to manage large amounts of various data.

Once I had decided upon the methodology for my research project, I decided that for all of these reasons, NVivo would be a good tool for me to use. It is also worth mentioning that, after making this decision, I attended two courses on NVivo offered by the Education Commons at OISE (Fall 2012 / Winter 2013). The first course introduced the fundamentals of NVivo and refreshed my memory about how the software worked. It also introduced me to aspects of the software, such as importing audio files, which I had not used when working with the software for my internship project. The second course covered data analysis techniques, such as running queries on the data. Again, I learned some features of the software that I had not explored during my internship. These courses proved very worthwhile for me because they encouraged me to think about the best way to organize and manage my data before I had even collected it. I created the shell for my project in NVivo and simply populated it as I went along. Having said that, the beauty of NVivo is that it is very flexible; making changes to the organizational structure was a simple matter of click and drag. For example, when working with nodes, it was easy to move them, collapse them, expand them, rename them, or move them again. This made my work with managing and analyzing the data malleable and responsive to my insights as they emerged through the process.

From the outset I used NVivo to manage my data. It allowed me to store all of the data in one central project file (the “project file”). For example, I created a folder
within the project file called “Focus Groups” and within this folder, I created three additional files: Focus Group A, Focus Group B, and Focus Group C. As soon as a focus group interview was completed, I immediately imported the audio file into my NVivo project and filed it appropriately. Similarly, when the transcription of the interview was completed, I imported and filed it. In this way, I organized all of my data as I went along, including, photos and artifacts (in PDF format). For instance, the pictures that were taken during classroom visits could be imported into the project file, appropriately linked to the correct source, and coded. Other important sources of data that were shared with me, such as class blogs, could also be added to the project file using hyperlinks. This made all of the data records easily accessed, queried, or explored. Additionally, if new insights or thoughts came to me as I was working with the data, I could instantly create a linked memo in NVivo that could quickly be recalled during the later stages of the data analysis process.

In short, NVivo was a crucial tool during both the data collection and analysis stages of my research. In the following sections, I describe the two phases of data collection in more detail.

**Phase 1: Focus Groups**

Focus groups are defined as a “carefully planned series of discussions designed to obtain perceptions, on a defined area of interest in a permissive, non-threatening environment” (Krueger and Casey, 2000, p. 5). Three key features characterize focus groups:

- A clear plan for a controlled process and environment in which interactions among participants will take place;
• Use of a structured process to collect and interpret data; and

• Participants selected based on characteristics they share, as opposed to differences among them. (Larson, Grudens-Schuck, & Allen, 2004)

Focus groups are an efficient tool for the researcher because they provide a fast and efficient way to collect data from multiple participants (Krueger & Casey, 2000). Another important benefit of focus groups is their environment, which is socially constructed (Krueger, 2000). A synergistic effect often emerges in a focus group setting because participants share a mutual interest and/or identity and this can actually stimulate ideas that might not emerge were the same interview conducted on an individual basis (Larson et al., 2004). Finally, focus groups have the potential to produce more detailed responses than a paper and pencil survey (Bromley & Fischer, 2000) because researchers have the opportunity to interact with the participants and ask clarifying questions.

The intent of this phase of data collection was to determine the resources, professional learning, departmental, leadership, and teaching practices identified by mathematics leaders as being important to support student achievement in Grade 9 Applied Mathematics. Mathematics education and other researchers will often distinguish and seek out the perspective of mathematics leaders in their research. For example, the CIIM researchers included mathematics consultants and coordinators in their research on the implementation of The Ontario Curriculum: Mathematics (revised). The researchers stated that this group made an important contribution to their understanding of the multiple perspectives towards the curriculum and its implementation because they were “actively engaged in the curriculum implementation process and have
worked extensively with teachers, administrators, and other leaders in the mathematics education community” (Suurtamm & Graves, 2007, p. 7).

Sample

In this study, three focus group interviews were conducted with individuals that were currently involved with and/or supporting Grade 9 Applied Mathematics, including consultants, coaches, and math department heads. I initiated participation in the focus groups through the provincial mathematics education associations.

First, I sent the request to conduct a focus group (see Appendix A) via e-mail to the executive of Ontario Mathematics Coordinators Association (OMCA). The OMCA website describes its membership as follows:

OMCA members support the effective teaching and learning of mathematics in K–12 classrooms across Ontario. Our members are coordinators and consultants at public and Catholic school boards. We work closely with the Ontario Association of Mathematics Education (OAME), Ministry of Education, Education Quality and Accountability Office (EQAO), and the Fields Institute. (OMCA, 2013)

The OMCA holds monthly meetings, the purpose of which is “to provide a framework for the sharing of ideas, professional development, and an avenue for a collective impact on the direction of education, particularly in the area of mathematics in the province of Ontario” (OMCA, 2012, p. 1).

The OMCA Executive agreed to let me host a focus group at their October 2012 monthly meeting, during the lunch hour. The secretary distributed the Letter of Introduction / Consent Form: Focus Groups (see Appendix B) to the entire membership with the e-mail distribution of the October meeting agenda. The focus group interview was also noted on the meeting agenda itself. Three individuals attended this focus group: one OMCA member (a consultant) and two associate OMCA members (a math coach and
a publisher representative). This focus group will be referred to as Focus Group A. The math consultant and math coach worked in different boards, neither of which was involved in the case study phase of the research.

After the first focus group had taken place, an OMCA member (a math consultant) contacted me by e-mail. She wrote to let me know that she had been unable to attend the October 2012 OMCA meeting, but was very interested in participating in my research. She also informed me that she had mentioned my study to members of her board’s Leading Math Success Team (a central committee) and some of them had expressed an interest to her about participating in the research as well. As a next step, I e-mailed her the Letter of Introduction / Consent Form: Focus Groups (Appendix B) so that she could distribute it to the interested parties in order to determine if there was bona fide interest in participating in a focus group. She determined that there was, so we proceeded to organize a meeting at a central location in the district. Four individuals (the board math consultant, two math department heads, and one math teacher) attended this meeting and will be referred to as Focus Group B. These individuals were employed by CDSB3, a catholic district school board. This board was not represented in the subsequent case study phase of the research.

The request to conduct a focus group (Appendix A) was also sent to the executive of the Ontario Association of Mathematics Education (OAME). On its website, OAME is described as “… the professional organization for everyone interested in Mathematics Education in Ontario. Our mission is to promote excellence in mathematics education throughout the province of Ontario.” My original intent was to host a focus group during the downtime of the OAME Leadership Conference that was held in November 2012.
The annual Leadership Conference is attended by a diverse sample of the OAME membership, as well as others (non-members) that are interested in mathematics education leadership. The OAME directors replied that the executive was hesitant to wade into research of any kind and so my request was denied. This might in part be attributable to the fact that there were labour disruptions in the sector at the time. This was particularly true of public school teachers who had been directed by their federation to withdraw from all “voluntary activities”. As it turns out, the conference was later cancelled due to poor registration, presumably because of the labour unrest.

Though it is a provincial association, OAME primarily operates at a grassroots level. There are a total of 15 chapters that organize events at a regional level throughout the school year. I had played an active role on the executive of my local chapter and had often discussed my research project with my chapter colleagues when we had met as a group. Several individuals had stated an interest in participating in my research and to accommodate them, I organized a focus group to coincide with one of our major chapter events, the local play-downs of the Ontario Mathematics Olympics. The Letter of Introduction / Consent Form: Focus Groups (see Appendix B) was distributed via e-mail to local chapter members and in the end, five members of this subset of OAME participated. This included three consultants from one district school board and one consultant and one math coach from a second district school board. This focus group will be referred to as Focus Group C.

Table 5 provides a summary of the focus group meetings. It should be noted that DSB D (Focus Group C) is the same board in which Case Study School D (discussed later) is situated.
Table 5

Summary of Focus Group Meetings

<table>
<thead>
<tr>
<th>Focus Group</th>
<th>Date of Interview</th>
<th>Number of Participants</th>
<th>Boards Represented</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>October 12, 2012</td>
<td>3</td>
<td>CDSB 1 CDSB 2</td>
</tr>
<tr>
<td>B</td>
<td>October 26, 2012</td>
<td>4</td>
<td>CDSB 3</td>
</tr>
<tr>
<td>C</td>
<td>April 26, 2013</td>
<td>5</td>
<td>CDSB 4 DSB D</td>
</tr>
</tbody>
</table>

*Note. CDSB refers to a catholic district school board and DSB refers to a (public) district school board*

Procedure

Interviews

All of the focus group interviews were conducted in a private meeting space. In an effort to create a comfortable environment, I welcomed the participants individually to the space and invited them to partake in the refreshments that I had brought. As some of the participants did not know each other, I engaged the participants in a brief period of casual conversation to establish a comfortable climate before proceeding with the interview. I began by reading a script to inform the participants about the purpose of my research and their role in it. I then asked for and collected their written consent before beginning the interview questions.

Each participant was asked to consent that the group interview be digitally recorded so that a transcript of the discussion could be prepared. The participants were advised that I would provide each of them with a copy of the interview transcript by e-mail so that they could make any additions, deletions, or clarifications to their contributions if they so desired. I reminded the participants that they were under no obligation to answer any questions that they did not want to. I then asked the participants if they had any questions or needed any clarification about the research or their
participation in it. Participants were given the opportunity to sign the consent forms that I then collected. Before proceeding with the formal interview protocol, I asked the participants to introduce themselves to the other participants by stating their name, their role, their years of teaching experience, and their experience with Grade 9 Applied Mathematics.

Table 6 outlines the focus group participants, as well as their association affiliation, board (if applicable), role, and years of total teaching experience. In total there were 12 participants in three different focus groups. Six participants were board consultants, two were board math coaches, two were math department heads, one was a math teacher, and one was a publisher consultant. In order to preserve the anonymity, privacy, and confidentiality of the participants, pseudonyms have been used. These pseudonyms will continue to be used for the remainder of this paper. The names of the school boards have also been changed, again to protect the identity of the focus group participants.

The focus group interviews allowed me to access the expertise of several mathematics leaders across the province. Each of them had worked in their boards and its schools to support student achievement in mathematics and collectively they brought a wide-range of experience and expertise to the discussion.

Although each focus group interview was held independent of the others, the same semi-structured interview guide was used for all of them. This approach allowed me to ask the same key questions of all groups, but afforded me the flexibility to ask follow-up and probing questions as appropriate. The interview guide was designed to elicit information about practices that are perceived by mathematics leaders as being
important to support student achievement in Grade 9 Applied Mathematics. The questions were open-ended in nature and broad enough to accommodate several of the elements outlined in the conceptual framework. In total, there were five key questions that are included in Appendix C along with links to the conceptual framework.

Table 6

*Focus Group Participants*

<table>
<thead>
<tr>
<th>Group</th>
<th>Name</th>
<th>Subject Association</th>
<th>Board</th>
<th>Role</th>
<th>Years of Teaching Experience (In Total)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Kathy</td>
<td>OMCA</td>
<td>CDSB 1</td>
<td>Math Consultant</td>
<td>19</td>
</tr>
<tr>
<td>A</td>
<td>Christopher</td>
<td>OMCA</td>
<td>NA</td>
<td>Consultant (Publisher)</td>
<td>NA</td>
</tr>
<tr>
<td>A</td>
<td>Ethan</td>
<td>OMCA</td>
<td>CDSB 2</td>
<td>Math Coach</td>
<td>7</td>
</tr>
<tr>
<td>B</td>
<td>Gilbert</td>
<td>OMCA</td>
<td>CDSB 3</td>
<td>Math Department Head</td>
<td>21</td>
</tr>
<tr>
<td>B</td>
<td>Nadine</td>
<td>OMCA</td>
<td>CDSB 3</td>
<td>Math Consultant</td>
<td>20</td>
</tr>
<tr>
<td>B</td>
<td>Cindy</td>
<td>OMCA</td>
<td>CDSB 3</td>
<td>Math Department Head</td>
<td>22</td>
</tr>
<tr>
<td>B</td>
<td>Malcolm</td>
<td>OMCA</td>
<td>CDSB 3</td>
<td>Math / Student Success Teacher</td>
<td>10</td>
</tr>
<tr>
<td>C</td>
<td>Susan</td>
<td>OAME</td>
<td>CDSB 4</td>
<td>Math Consultant</td>
<td>20</td>
</tr>
<tr>
<td>C</td>
<td>Nancy</td>
<td>OAME</td>
<td>CDSB 4</td>
<td>Math Consultant</td>
<td>25</td>
</tr>
<tr>
<td>C</td>
<td>Don</td>
<td>OAME</td>
<td>DSB D</td>
<td>Math Coach</td>
<td>22</td>
</tr>
<tr>
<td>C</td>
<td>Lynda</td>
<td>OAME</td>
<td>DSB D</td>
<td>Math Consultant</td>
<td>15</td>
</tr>
<tr>
<td>C</td>
<td>Megan</td>
<td>OAME</td>
<td>CDSB 4</td>
<td>Math Consultant</td>
<td>15</td>
</tr>
</tbody>
</table>

*Note.* DSB stands for District School Board and CDSB stands for Catholic District School Board.
Each of the focus group sessions ran smoothly and resulted in attentive, lively, and engaged conversation around Grade 9 Applied Mathematics. The interviews took from sixty to ninety minutes each. I found that an easy rapport developed quickly in each group and the participants seemed passionate about the topic at hand. All of the participants in each group contributed to the discussion and in no case did a single voice dominate the talk. Each of the three focus group interviews ended on a positive note with widespread comments made about enjoying the dialogue, appreciating the opportunity to reflect on what works, and looking forward to reading the research findings.

All of the focus group participants were sent electronic and verbatim transcripts of their group’s interview and were extended the opportunity to confirm the content and make any additions, deletions, or revisions. None of the participants requested any changes to their contributions in the transcript. The transcripts were imported into my project file in NVivo.

**Field Notes**

During each of the focus group interviews, I kept notes in a research journal. As the conversations were unfolding, I wrote the main themes that were being voiced by the participants. I also took some time after the interviews had concluded to reflect on what I had heard and experienced and recorded that in my journal. Ary, Jacobs, and Razavieh (2002) discussed the fact that field notes should have two components:

- The descriptive part, which includes a complete description of the setting, the people and their reactions and interpersonal relationships, and accounts of events (who, when, what was done); and
- The reflective part, which includes the observer’s personal feelings or
impressions about the events, comments on the research method, decisions and problems, records of ethical issues, and speculations about data analysis. (p. 431)

In this sense, the researcher is engaging in some preliminary meaning-making or data analysis (Merriam, 1998) in the preparation of field notes. For example, Bruce and Flynn (2013) discuss how such documentation helped them to capture and describe “in a thicker descriptive manner” the overall elements of a successful collaborative inquiry-based professional learning program and its impact on teacher efficacy. Similarly, Kajander and Zuke (2007) used their collection of documented anecdotes and examples from their classroom observations to build the narrative around factors they found were important in supporting mathematics success for at-risk Intermediate students.

All of my field notes were word processed and imported into my project file in NVivo.

**Phase 2: Case Studies**

Case studies at one rapidly improving and three consistently high performing schools were conducted in phase 2 of the data collection for this study. Case studies are “intensive descriptions and analyses of a single unit or bounded system” used “to gain an in-depth understanding of the situation and meaning for those involved” (Merriam, 1998, p. 19). A case study is “conducted in great detail and often relies on the use of several data sources” (Orum, Feagin, & Sjoberg, 1991, p. 2).

The intent of this phase of data collection was to determine if there were any resources, professional learning, department, leadership, and teaching practices that are common to a sample of successful schools across the province. In addition to this, I was also trying to understand if there were specific practices that had been adopted by the
successful schools, which had been identified in the mathematics and general reform literature as being related to better mathematics achievement.

**Sample**

EQAO data was used to identify the case study schools. EQAO cautions that in assessing the results on its tests over time, small increases or decreases from one year to the next are less important than the general trend (Kozlow, 2008). Therefore, in order to discern the schools to be included in the research sample, EQAO trend data over five years was examined.

The following criteria were used to delineate “consistently high performing” schools:

1. Over the past five years, the overall trend for student achievement in Grade 9 Applied Mathematics is improving.
2. The school was at or above the provincial average for Grade 9 Applied Mathematics for each of the past five years.
3. The score for the academic course also improved over the past five years and is currently at or above the provincial average.
4. The gap between students in applied and academic courses for each of the last five years is smaller than the same gap provincially.

Figure 17 illustrates how the selection criteria were successively applied to the population of 718 Ontario Grade 9 Applied Mathematics classrooms, resulting in a sample of 46 schools meeting the criteria for “consistently high performing schools.” Schools A, B, and C in this study are “consistently high performing schools.”
Figure 17. Applying selection criteria to determine consistently high performing schools.

Given that the sample size of schools that could be characterized, as “consistently high performing” was quite small, a second set of criteria was established to identify “rapidly improving” schools. Schleicher (Schleicher & Fullan, 2012) suggested that student achievement alone is not the only benchmark for measuring success and that there is merit in studying systems that improve faster than others. These systems, he argued, are often more innovative in their approach to improvement. The criteria used to identify such schools in this study were that the school’s results on the Grade 9 EQAO Mathematics Assessment at the applied level:

1. Moved from being below the provincial average five years ago to meeting or exceeding the provincial average for the past two years, or

\begin{align*}
\text{Number of schools with Grade 9 Applied (9P) Mathematics} & \quad 718 \\
\text{Schools with improving trend for 9P results over the past 5 years} & \quad 452 \\
\text{AND} & \\
9P \text{ results at or above provincial average for each of last 5 years} & \quad 94 \\
\text{AND} & \\
\text{improved Grade 9 Academic (9D) results over five years and currently at provincial average} & \quad 82 \\
\text{AND} & \\
\text{gap between 9P and 9D lower than provincial gap for past five years} & \quad 46 \\
\end{align*}
2. Improved by a minimum of 25 percentage points over the past five years.
3. Additionally, the provincial average on the Grade 9 Academic assessment was also improving.

As of the 2011/12 administration of the Grade 9 EQAO Mathematics Assessment, a total of 117 schools across the province met these criteria. School D included in this study is an example of a “rapidly improving” school.

Once the EQAO results for 2011/12 were released in September 2012, I compiled two lists of schools: one for “consistently high performing” and another for “rapidly improving” schools. I then used these lists to identify a total of four district school boards that each had a minimum of two schools on the lists, at least one of which was “consistently high performing.” I looked for a mix of boards in terms of size, public and Catholic designations, and reasonable proximity to my home (within a day’s drive as I knew I would be travelling to each school on more than one occasion). I proceeded to make application to these boards to conduct my research in the identified schools, using the appropriate board protocols. Two of the four boards granted permission for the research within a reasonable timeframe of three months.

As mentioned previously, there were labour disruptions in the field during the time that I was collecting my data. Teacher Federations were encouraging their members not to engage in any activity outside of normal teaching duties. This made it difficult for some boards (and schools) to commit to the research in a timely fashion. I would also discover that not everyone valued research related to the Grade 9 EQAO Mathematics Assessment. In order to get the full complement of four case study schools, therefore, I needed to make application to another three boards on my list to conduct my research in
their schools. All three of these boards granted me permission to do the research and I ended up conducting the research in two of them.

In every instance, once a board granted me approval to conduct the research, I had to go through another level of approval with the school principal. To accomplish this, I contacted the school principals by phone, or e-mail, as directed by my board contact. To introduce the study, I used a prepared script and followed up either by phone or e-mail, whatever the principal’s preference. If the principal subsequently agreed to participate, I asked him or her to forward an e-mail containing the Letter of Information / Consent Form to the appropriate individuals: a vice-principal (if necessary), the math department head, and teachers with experience teaching Grade 9 Applied Mathematics at the school (see Appendix D for the e-mail sent to “consistently high performing” schools and Appendix E for the e-mail sent to “rapidly improving” schools).

The process of establishing case studies proved to be quite challenging. For starters, teachers are reluctant to engage in research; it involves opening up their practice and classroom to a complete stranger. I would discover that boards and principals are quite likely to shield teachers from even the proposition of research. I also found that many hours of work go into completing the applications that boards require in order to approve proposed research in its schools. To complicate matters, each board has their own protocol, so I had to start from scratch every time. Some boards even required that you include a criminal reference check in your application package if you intended to step foot in one of their schools—at considerable expense, I might add. The added twist for this study is that teachers were caught up in a dispute between their federation and the government and many of them were not participating in any activity other than teaching.
Despite these complications, staff from four schools in four different district school boards agreed to participate in the case studies. As an added bonus, there was a Grade 9 Applied Mathematics teacher in each case study school that also agreed to a classroom observation. Case Study Schools A, B, and C qualified as “consistently high performing” schools while Case Study School D was a “rapid improver.” Case Study Schools A and B were situated in Catholic district school boards and Case Study Schools C and D were situated in public district school boards. I feel that despite all of the challenges to establish the case studies, these four schools represent a nice cross-section from across the province with a good mix of large, small, urban, rural, Catholic and public schools. Figure 18 plots each of these schools on a graph showing their EQAO Grade 9 Applied Mathematics scores over the past five years.

![Figure 18](image-url)

*Figure 18.* EQAO five-year trend data for province and case study schools in Grade 9 Applied Mathematics, 2007-2012.
In the following sections, each of the case study schools is described in more detail. Information about the school and the population that it serves is included in order to provide some context. In doing so, I have used the following parameters to classify the schools by size: small (0 to 500 students), medium (500 to 1000 students), and large (over 1000 students). I also outline whom I met with during my initial visit to the schools, again to provide background information for the reader.

**Case Study School A**

School A is a small Catholic secondary school situated in a residential neighbourhood of a small rural community. The school is attended by a mix of urban and rural students, with about 50% of them being bused. Thirteen percent of students who attend this school live in lower-income households, compared to 16.5% provincially. A striking 41% of the students receive special education services. This might account for the fact that over the previous five years, an average 45% of the students taking the Grade 9 EQAO Mathematics Assessments were in the applied course, as compared to 31% provincially. That being said, this school has a very high participation rate in the Grade 9 EQAO Mathematics Assessment. For example, in all but one of the preceding five years, 100% of the students enrolled in the applied course wrote the assessment.

Approximately 85% of the special needs students that wrote the EQAO Grade 9 Mathematics Assessment during the previous five years had been enrolled in the applied course, compared to 75% provincially. There had been no English Language Learners taking the applied assessment at the school in the preceding five years whereas provincially, on average, 6% of the students that wrote the applied assessment were English Language Learners.
When looking at the EQAO cohort data for students that were in Grade 9 Applied Mathematics at School A in the 2011/12 school year, 73% of them continued to meet the standard in Grade 9 after meeting it in Grade 6. Seventeen percent of the students actually rose to standard in Grade 9 Applied Mathematics after not meeting it in Grade 6. Seven percent dropped from being at standard in Grade 6 to not meeting standard in Grade 9. Three percent of the students did not meet the standard either in Grade 6 or Grade 9.

Table 7 highlights the EQAO Grade 9 Mathematics Assessment trend data for School A over the previous five years, in comparison to the same results provincially.

Table 7

*School A Trend Data, 2007-2012*

<table>
<thead>
<tr>
<th>Course</th>
<th>2007/08</th>
<th>2008/09</th>
<th>2009/10</th>
<th>2010/11</th>
<th>2011/12</th>
<th>Δ over 5 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applied</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>School A</td>
<td>61</td>
<td>66</td>
<td>81</td>
<td>71</td>
<td>90</td>
<td>+29</td>
</tr>
<tr>
<td>Province</td>
<td>34</td>
<td>38</td>
<td>40</td>
<td>42</td>
<td>44</td>
<td>+10</td>
</tr>
<tr>
<td>Academic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>School A</td>
<td>65</td>
<td>81</td>
<td>84</td>
<td>86</td>
<td>93</td>
<td>+28</td>
</tr>
<tr>
<td>Province</td>
<td>75</td>
<td>77</td>
<td>82</td>
<td>83</td>
<td>84</td>
<td>+9</td>
</tr>
<tr>
<td>Gap between</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Applied/Academic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>School A</td>
<td>4</td>
<td>15</td>
<td>3</td>
<td>15</td>
<td>3</td>
<td>-1</td>
</tr>
<tr>
<td>Province</td>
<td>41</td>
<td>39</td>
<td>42</td>
<td>41</td>
<td>40</td>
<td>-1</td>
</tr>
</tbody>
</table>

Over a five-year period, the Grade 9 EQAO Applied Mathematics scores had improved by 29 percentage points at Case Study School A, virtually keeping pace with
the improvement in academic mathematics results. This is especially compelling given
the fact that the school already had 61% of its students at level 3 and 4 five years
previous and that the average applied score was 34 percentage points higher than the
province. Also impressive is the fact that for the previous two years, no students had
scored below a Level 2, at either the applied or academic levels, and the fact that an
average 20% of students in the applied classes had reached Level 4, compared to 6%
provincially. It is also worth noting that the gap between the applied and academic scores
was very small compared to the same gap provincially.

I met with Brad, the principal of School A, on my initial visit to the school. He
was in his second year in this role. Previously, he had served as Vice Principal (two
years) and Acting Principal (one year) at the school. Brad had a history of teaching
mathematics in the secondary panel, including the Grade 9 Applied course. It is also
important to note that Brad had assumed the math department head responsibilities, as the
individual assigned this role did not have a mathematics specialist.

In terms of the teaching staff, Steve usually taught Grade 9 Applied Mathematics
at the school, and Bill taught Grade 10 Applied Mathematics. I interviewed both of them.
In addition, I met with Mark; he was assigned additional sections of Grade 9 Applied
Math when necessary. Mark had attended School A as a student.

I also met with Jayne and Tammy, two of the board’s math consultants. Although
they had not worked to provide direct support to School A, they had provided
professional learning sessions for mathematics teachers and principals across the board
and this included both the administrators and teachers from School A.
Case Study School B

School B is a medium-sized catholic secondary school located in a rapidly growing, large rural town. It is also situated in the heart of one of Ontario’s year-round recreation and tourist destinations. Students from this town, another town within close proximity, and the surrounding rural area attend School B. Seven percent of the students that attend this school live in low-income households, compared to 16% provincially. Interestingly 14% of the parents have some university education, which is less than half of the provincial average of 37%.

Nineteen percent of the students at this school receive special education services, compared to 14% provincially. Even so, about 10% of students receive accommodations on the Grade 9 assessment, compared to 27% provincially. Approximately 85% of the students with special needs that wrote the assessment during the past five years have been in the applied course. This is higher than the provincial average of 75%. There have been no English Language Learners taking the applied assessment at the school in the past five years whereas provincially, on average, 6% of the students that have written the applied assessment were English Language Learners.

The rate of participation in the Grade 9 EQAO Applied Mathematics Assessment was virtually the same as the province over the previous five years, averaging 95%. Over the same timeframe, an average 39% of the students taking the Grade 9 EQAO Mathematics Assessments were enrolled in the applied course, as compared to 31% provincially.

When looking at the EQAO cohort data for students that were in Grade 9 Applied Mathematics at School B in the 2011/12 school year, an impressive 47% of them rose to
standard, i.e., they went from not meeting to standard in Grade 6 to meeting it in Grade 9. Twenty-six percent of the students maintained the standard in Grade 9 after meeting it in Grade 6. Four percent of the students dropped from being at standard in Grade 6 to not meeting the standard in Grade 9. Twenty-two percent of the students did not meet the standard in Grade 9, nor did they meet it in Grade 6.

Table 8 highlights the EQAO Grade 9 Mathematics trend data for School B over the previous five years, in comparison to the same results provincially.

Table 8

*School B EQAO Trend Data, 2007-2012*

<table>
<thead>
<tr>
<th>Course</th>
<th>2007/08</th>
<th>2008/09</th>
<th>2009/10</th>
<th>2010/11</th>
<th>2011/12</th>
<th>Δ over 5 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applied</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>School B</td>
<td>63</td>
<td>62</td>
<td>73</td>
<td>67</td>
<td>76</td>
<td>13</td>
</tr>
<tr>
<td>Province</td>
<td>34</td>
<td>38</td>
<td>40</td>
<td>42</td>
<td>44</td>
<td>10</td>
</tr>
<tr>
<td>Academic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>School B</td>
<td>77</td>
<td>95</td>
<td>93</td>
<td>81</td>
<td>92</td>
<td>15</td>
</tr>
<tr>
<td>Province</td>
<td>75</td>
<td>77</td>
<td>82</td>
<td>83</td>
<td>84</td>
<td>9</td>
</tr>
<tr>
<td>Gap between</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Applied /</td>
<td>School B</td>
<td>14</td>
<td>33</td>
<td>20</td>
<td>14</td>
<td>16</td>
</tr>
<tr>
<td>Academic</td>
<td>Province</td>
<td>41</td>
<td>39</td>
<td>42</td>
<td>41</td>
<td>40</td>
</tr>
</tbody>
</table>

Over a five-year period, the Grade 9 EQAO Applied Mathematics scores had improved by 13 percentage points at Case Study School B, slightly less than the improvement realized in the academic mathematics results. During this time, the Grade 9 Applied Mathematics results were at least 24, and at most 33, percentage points higher.
than the provincial average. Of particular note is the fact that School B consistently had a much higher number of students at Level 4 than was the case provincially, by as much as 5 times as many. In the previous five years, the average number of students in Level 4 at School B was 21% compared to 6% provincially. Furthermore, there had been no students scoring below Level 1 in the previous five years, except for four students in the 2008/09 school year.

I met with Gilbert, the principal of School B, on my initial visit to the school. It was his second year in this role at the school. He had started his career as an elementary teacher and then moved into Guidance at the secondary level before moving into administration. Gilbert did not have a history of teaching mathematics, either in elementary or secondary school.

Sam was the mathematics department head at School B. He had been in this role for 2 years, and prior to that he had been a math teacher for eleven years at the school. Sam made it a point to teach at least one section of Grade 9 Applied Mathematics every year.

Finally, I met with Sandra. She was the only other teacher that taught Grade 9 Applied Mathematics at the school, other than Sam. She had been teaching at School B for eight years—her career to date. She was also a graduate of School B and was once a student of Sam’s. She mentioned that she did all of her teaching placements at the school and that “it is all I know.”

**Case Study School C**

School C is a large secondary school located in a medium-sized, manufacturing-based city. It is also home to one of Ontario’s universities. Six percent of the students
that attend this school live in low-income households, compared to 16% provincially. Fifty-five percent of the parents have some university education, which is quite high compared to the provincial average of 37%. Fifty-two percent of the students that wrote the Grade 9 Applied Mathematics assessment in 2011/12 had attended three or more schools from kindergarten through Grade 8, which is somewhat higher than the provincial average of 41%, indicating a slightly more transient population than the norm.

The rate of participation in the EQAO Grade 9 Applied Mathematics assessment was virtually the same as the province over the preceding five years, averaging 95%. Eleven percent of the students at this school receive special education services, compared to 14% provincially. An average of 31% of students who wrote the EQAO Grade 9 Applied Mathematics assessment had received accommodations compared to the provincial average of 27%. None of the students that had written the assessment over the previous five years had been English Language Learners.

Over the past five years, an average 17% of the students taking the Grade 9 EQAO Mathematics assessments were enrolled in the applied course, which is considerably lower than the 31% province average. Part of the reason for this might be the fact that there is a vocational school in the immediate neighbourhood and many students who otherwise might have taken the applied courses had attended this school instead of School C.

When looking at the EQAO cohort data for students that were in Grade 9 at School C in the 2011/12 school year, an impressive 45% of them rose to standard in Grade 9 Applied Mathematics, i.e., they went from not meeting the standard in Grade 6 to meeting it in Grade 9. Twenty-nine percent of the students maintained the standard in
Grade 9 after meeting it in Grade 6. Two percent of the students dropped from being at standard in Grade 6 to not meeting standard in Grade 9. Twenty-four percent of the students did not meet the standard in Grade 9, nor did they meet it in Grade 6.

Table 9 highlights student achievement trend data in EQAO Grade 9 Mathematics for School C, in comparison to the same results provincially.

Table 9

*School C EQAO Trend Data, 2007-2012*

<table>
<thead>
<tr>
<th>Course</th>
<th>2007/08</th>
<th>2008/09</th>
<th>2009/10</th>
<th>2010/11</th>
<th>2011/12</th>
<th>Δ over 5 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applied</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>School C</td>
<td>48</td>
<td>53</td>
<td>43</td>
<td>52</td>
<td>68</td>
<td>20</td>
</tr>
<tr>
<td>Province</td>
<td>34</td>
<td>38</td>
<td>40</td>
<td>42</td>
<td>44</td>
<td>10</td>
</tr>
<tr>
<td>Academic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>School C</td>
<td>84</td>
<td>90</td>
<td>85</td>
<td>88</td>
<td>85</td>
<td>1</td>
</tr>
<tr>
<td>Province</td>
<td>75</td>
<td>77</td>
<td>82</td>
<td>83</td>
<td>84</td>
<td>9</td>
</tr>
<tr>
<td>Gap between</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>School C</td>
<td>36</td>
<td>37</td>
<td>42</td>
<td>36</td>
<td>17</td>
<td>-19</td>
</tr>
<tr>
<td>Province</td>
<td>41</td>
<td>39</td>
<td>42</td>
<td>41</td>
<td>40</td>
<td>-1</td>
</tr>
</tbody>
</table>

Over a five-year period, the Grade 9 EQAO Applied Mathematics scores had improved by 20 percentage points at Case Study School C. For the previous two years, 10% of the students in the Grade 9 Applied Mathematics course had reached Level 4 on the EQAO assessment, compared to the 7% provincial average during the same timeframe. The number of students in the applied course at Level 1 had been steadily declining over the previous five years and had been 5% or less for the preceding two years. This compares to the provincial average of 13.5% percent of students at Level 1 in
the applied course. This same trend was apparent at the academic level where virtually no students were below Level 2.

On my initial visit to the school, I met with Kobe, one of the school’s two Vice- Principals (VPs). He had been in this position for two and a half years. Kobe had responsibility for the numeracy pillar of the school’s improvement plan, and so he worked quite extensively with the mathematics department. He was also the chair of the board’s Numeracy Committee. Prior to coming to School C, Kobe had been a VP at one of the board’s other secondary schools. He also had a background as a mathematics teacher (eight years) that included four years as a math department head.

In terms of teachers, I met with Ivan, the school’s Student Success Coordinator. For half of his day, Ivan coordinated the credit recovery program at the school, including interventions for students that were at risk and struggling. For the other half of his day, Ivan taught mathematics, including Grade 9 Applied Mathematics. In fact, he had taught this course every year since it was introduced in 1999. It is also important to note that Ivan was the mathematics department head before assuming his current role. I also met with Emma. She had been teaching at the school since she began teaching five years ago. Emma taught mostly applied courses. She also had sections of Special Education resource every year.

On my second visit to the school, I had the opportunity to meet with Laura, the mathematics department head. She had been a mathematics teacher at the school for four years, the last three of which she had also been the math department head. Although she had not taught the Grade 9 Applied Mathematics course for eight years, she had taught the Grade 10 Applied Mathematics course every year.
Case Study School D

School D is a large secondary school located in a medium-sized manufacturing-based city. The school is situated on a busy street in a commercial area. Housing in the area ranges from single-family dwellings to high-density apartment rentals. Nine percent of the students live in low-income households, compared to the provincial average of 16%. Nineteen percent of the parents had some university-level education compared to the provincial average of 37%.

Seventeen percent of the students at this school receive special education services, slightly higher than the provincial average of 14%. An average of 14% of students who wrote the EQAO Grade 9 Applied Mathematics assessment received accommodations compared to the provincial average of 27%. The rate of participation in the EQAO Grade 9 Applied Mathematics assessment averaged 98% over the previous five years, slightly higher than the provincial average of 95%.

Over the preceding five years, an average of 29% of the students taking the EQAO Grade 9 Mathematics assessment were enrolled in the applied course which is slightly less than the provincial average of 31%. Virtually none of the students were English Language Learners.

When looking at the EQAO cohort data for students that were in Grade 9 Applied Mathematics at School D in the 2011/12 school year, a notable 40% of them rose to standard, i.e., they went from not meeting to standard in Grade 6 to meeting it in Grade 9. Twenty-three percent of the students maintained the standard in Grade 9 after meeting it in Grade 6. Six percent of the students dropped from being at standard in Grade 6 to not
meeting standard in Grade 9. Thirty-one percent of the students did not meet the standard in Grade 9, nor did they meet it in Grade 6.

School D is the only school in the research sample that qualified for the study by meeting the criteria for “rapidly improving schools.” Applied scores on the provincial assessment had moved from being below the provincial average to being at or above the provincial average for the preceding two years.

Table 10 highlights student achievement trend data in EQAO Grade 9 Mathematics for School D, in comparison to the same results provincially.

Table 10

*School D EQAO Trend Data, 2007-2012*

<table>
<thead>
<tr>
<th>Course</th>
<th>2007/08</th>
<th>2008/09</th>
<th>2009/10</th>
<th>2010/11</th>
<th>2011/12</th>
<th>Δ over 5 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applied</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>School D</td>
<td>16</td>
<td>29</td>
<td>41</td>
<td>60</td>
<td>61</td>
<td>45</td>
</tr>
<tr>
<td>Province</td>
<td>34</td>
<td>38</td>
<td>40</td>
<td>42</td>
<td>44</td>
<td>10</td>
</tr>
<tr>
<td>Academic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>School D</td>
<td>59</td>
<td>57</td>
<td>77</td>
<td>78</td>
<td>89</td>
<td>30</td>
</tr>
<tr>
<td>Province</td>
<td>75</td>
<td>77</td>
<td>82</td>
<td>83</td>
<td>84</td>
<td>9</td>
</tr>
<tr>
<td>Gap between Applied/Academic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>School D</td>
<td>43</td>
<td>28</td>
<td>36</td>
<td>18</td>
<td>28</td>
<td>-15</td>
</tr>
<tr>
<td>Province</td>
<td>41</td>
<td>39</td>
<td>42</td>
<td>41</td>
<td>40</td>
<td>-1</td>
</tr>
</tbody>
</table>

Over a five-year period, the Grade 9 EQAO Applied Mathematics scores had improved by 45 percentage points at Case Study School D. It is also worth noting that the academic level scores also improved by 30 percentage points during this same timeframe. Though the gap between the applied and academic scores was not considered
in the selection process, this school managed to close this gap by 15 percentage points over the previous five years—where the gap between applied and academic performance was 43 percentage points five years ago, it was now 28 percentage points. In comparison, the province closed the same gap by only one percentage point. Furthermore, where five years ago the applied-academic gap was bigger at this school than it was for the province, it had closed considerably (by 12 percentage points). It can be said, therefore, that not only did this school raise the bar of student achievement in applied mathematics; it also managed to make significant progress in closing the achievement gap between applied and academic course takers.

On my initial visit to the school, I met with Carol, one of the school’s two Vice- Principals. Carol had been a VP at the school for three years and during that time had worked to support the Math Department. Before moving into administration, she taught physical education, science, and mathematics at the secondary level.

Kate was the mathematics department head at School D. She had been in this position for the past three years. Prior to that, she had served as a system-level Grade 7 and 8 Math Coach for two and a half years. Kate taught at least one section of Grade 9 Applied Mathematics every year. She had been teaching for 22 years and had taught mathematics since the days before The Common Curriculum.

I also met with two other Grade 9 Applied Mathematics teachers. Millie had been teaching for 23 years, with equal parts in the secondary and elementary panels. She had also worked with Kate as a Grade 7 and 8 Math Coach. Millie regularly taught Grade 9 Applied Mathematics. Debbie was also one of the regular teachers of Grade 9 Applied Mathematics. She had been teaching for 20 years, originally as a physical education
teacher. She taught mostly applied mathematics courses, and occasionally the Grade 11
workplace course.

For comparison purposes, Table 11 presents Grade 9 Mathematics EQAO trend
data from all of the case study schools, including both the applied and academic courses.
It also includes demographic data, i.e., number of students and average family income.

Procedure

In order to strengthen the reliability and internal validity of the case studies
(Merriam, 1998) and to better develop an enlightened sense of the context of the school
and its classrooms, multiple sources of data were used during the case study phase.

Table 11

*Case Study Schools and EQAO Trend Data for Grade 9 Mathematics*

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>School A</td>
<td>358</td>
<td>61 200</td>
<td>61</td>
<td>66</td>
<td>81</td>
<td>71</td>
<td>90</td>
<td>Applied</td>
</tr>
<tr>
<td>CDSB A</td>
<td></td>
<td></td>
<td>65</td>
<td>81</td>
<td>84</td>
<td>86</td>
<td>93</td>
<td>Academic</td>
</tr>
<tr>
<td>School B</td>
<td>738</td>
<td>68 200</td>
<td>63</td>
<td>62</td>
<td>73</td>
<td>67</td>
<td>76</td>
<td>Applied</td>
</tr>
<tr>
<td>CDSB B</td>
<td></td>
<td></td>
<td>77</td>
<td>95</td>
<td>93</td>
<td>81</td>
<td>92</td>
<td>Academic</td>
</tr>
<tr>
<td>School C</td>
<td>1539</td>
<td>111 500</td>
<td>48</td>
<td>53</td>
<td>43</td>
<td>52</td>
<td>68</td>
<td>Applied</td>
</tr>
<tr>
<td>DSB C</td>
<td></td>
<td></td>
<td>84</td>
<td>90</td>
<td>85</td>
<td>88</td>
<td>85</td>
<td>Academic</td>
</tr>
<tr>
<td>School D</td>
<td>1065</td>
<td>73 700</td>
<td>16</td>
<td>29</td>
<td>41</td>
<td>60</td>
<td>61</td>
<td>Applied</td>
</tr>
<tr>
<td>DSB D</td>
<td></td>
<td></td>
<td>59</td>
<td>57</td>
<td>77</td>
<td>78</td>
<td>89</td>
<td>Academic</td>
</tr>
<tr>
<td>Province</td>
<td>74 890</td>
<td></td>
<td>34</td>
<td>38</td>
<td>40</td>
<td>42</td>
<td>44</td>
<td>Applied</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>75</td>
<td>77</td>
<td>82</td>
<td>83</td>
<td>84</td>
<td>Academic</td>
</tr>
</tbody>
</table>

*Note.* DSB stands for District School Board and CDSB stands for Catholic District School Board.
Each school was visited twice. At the initial visit, I conducted individual interviews with designated staff that included an administrator, the math department head, and one or two teachers that had taught Grade 9 Applied Mathematics at the school. My thinking was that each of these individuals would be able to offer different perspectives as to what may have contributed to the student achievement on the EQAO Grade Mathematics assessment. In some cases, additional staff was included, at the principal’s discretion. At the follow-up visit, I observed a Grade 9 Applied Mathematics classroom in action. All of the school visits are summarized on Table 12.

Table 12

<table>
<thead>
<tr>
<th>Visits to Case Study Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>School</td>
</tr>
</tbody>
</table>
| School A | 10 Jan 2013 | Interviews
• Brad, Steve, Bill, Mark, Tammy, Jayne |
| | 7 Jun 2013 | Observation in Steve’s Classroom |
| School B | 17 Apr 2013 | Interviews
• Gilbert, Sam, Sandra |
| | 30 May 2013 | Observation in Sandra’s Classroom |
| School C | 23 May 2013 | Interviews
• Kobe, Laura, Ivan, Emma |
| | 5 Jun 2013 | Observation in Emma’s Classroom
Interview with Laura |
| School D | 10 May 2013 | Interviews
• Carol, Kate, Millie, Debbie |
| | 27 May 2013 | Observation in Millie’s Classroom |

The primary source of data for the case studies is considered to be the interviews that were conducted at the first school visit. Upon the advice of my committee, I selected this as the primary method because it was felt that interviews could provide deeper and richer insights about the schools than would surveys. Being able to engage in conversation with the participants allowed them to speak to their experience, thoughts,
and opinions about effective practices in Grade 9 Applied Mathematics classrooms. This interview data was triangulated with:

- EQAO school reports;
- Ministry of Education demographic and student achievement data;
- Observations at the follow-up classroom visit (one 75-minute classroom based observation at each school);
- Field notes; and
- School and classroom artifacts.

**EQAO School Reports**

Prior to visiting the case study schools, I reviewed their EQAO school reports that are available on the EQAO website. These reports include student achievement data for the past five years, contextual data such as the number of students that wrote each version of the test, and student questionnaire data. This gave me some interesting insights about the student experience at each school and in their Grade 9 Applied Mathematics classrooms. These insights were recorded in my field notes and later transcribed so that they could be coded during the data analysis.

Reviewing the school reports also provided me with additional questions to ask at the individual school visits. For example, I noticed that, at three of the four case study schools, the number of students at Level 4—the highest level of performance—surpassed the same number provincially. I was therefore able to ask individuals at these schools to comment on this phenomenon. The data found in the EQAO school reports was also used to build a thick description of each case study school for this report. It was also used to generate the tables found in this report.
Ministry Data

Another source of data for the case study schools came from the Ministry of Education website. The “School Information Finder” provides student achievement, contextual, and demographic data for all publicly funded Ontario schools. This information was helpful in developing a rich, thick description for each case study school. The data was also used in generating Tables 7 through 11 above. Merriam (1998) suggested that this is important to enhance the possibility of the results of a qualitative study generalizing in any sense: “Provide enough description so that readers will be able to determine how closely their situations match the research situation, and hence, whether findings can be transferred” (p. 211).

Interviews

I worked with either the principal (in one case) or math department head (in three cases) to determine the date for my initial school visits. This same individual coordinated the interview schedule and also disseminated the appropriate interview guide to each of the would-be participants so that they had an opportunity to see and reflect on the questions prior to our meeting.

On the day of the school visit, I met with each of the participants individually. A private space in the school was made available to conduct the interviews. I felt that it was important to establish trust and rapport with the participants prior to beginning the interview. Therefore before asking any questions, I read through an introductory script that reminded the participants that they could elect to refrain from answering any question that they did not want to, and that they were free to withdraw from the process at any time. I explained that their responses would not be reported to anyone that had
authority over them. I asked permission to audio-record the interview and take notes.

I also reminded the participants that all of the interview data would remain anonymous and that their names, their school name, and their school location would not be used in the reports emanating from the research. I explained to each participant that I would e-mail them a transcribed copy of the interview and that they would be free to make any additions, deletions, or clarifications to the transcript. After ensuring that there were no questions, I asked the participants to give me their informed consent by signing two copies of the consent form—one for me, and one for their own records. I then proceeded to ask the interview questions, differentiated by role, from the semi-structured interview guide that I had prepared (see Appendix F for the Case Study Interview Guide with links to the Conceptual Framework).

The interview guide was designed to elicit information about practices that are perceived by educators in successful schools as being important to support student achievement in Grade 9 Applied Mathematics, as measured by performance on the EQAO Grade 9 Mathematics assessment. The questions were open-ended in nature and broad enough to accommodate several of the elements outlined in the conceptual framework. I had also prepared some prompts to kindle the conversation, if necessary. I was also able to ask questions pertinent to the individual school context.

It should be noted that, in order to determine the validity of the interview questions, i.e., that they measured what it was intended they measure (Gay, Mills, & Airasian, 2006), a field pilot test of the interview guides was conducted in my own school board. This helped me to ensure that the questions were clear and that they produced the kind of information that I was looking for. After completing the field test interviews, I
elicited feedback on the questions from the field-test participants and they worked with me to modify the questions as necessary. The field-test process also gave me an indication as to how long each interview would take. This was important information for the schools to have in order to set up the interview schedule.

There were no issues with any of the interviews that were conducted in the case study schools. All of the participants appeared to be willing to participate, at ease and comfortable with sharing their thoughts about their school’s success with Grade 9 Applied Mathematics. They were sent electronic and verbatim transcripts of their interview and extended the opportunity to confirm the contents and make any additions, deletions, or revisions. None of the participants requested any changes to their interview transcript.

In total, there were 17 participants from the four case study schools that participated in the interviews. An administrator, the mathematics department head, and the Grade 9 Applied Mathematics teacher(s) from each school participated in the case study interviews. Table 13 provides specific information regarding the case study participants, including their role, background, and teaching experience.

Field Notes

I continued to add field notes to my research journal during the second phase of data collection, both for the case study interviews and the classroom observations. These notes contained my personal observations and reflections related to what I had seen and heard at the school. This included descriptions of the people, the setting, and the activities that I observed. At each of the classroom visits, the classroom teachers were very receptive to answering my questions about the lesson and the classroom in general.
### Table 13

**Case Study Participants**

<table>
<thead>
<tr>
<th>School</th>
<th>Name</th>
<th>Role</th>
<th>Math Qualifications</th>
<th>Teaching Background</th>
<th>Years of Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Brad</td>
<td>Principal</td>
<td>2 years @ School A</td>
<td>Elementary Teacher Secondary Teacher (including Math) Administrator</td>
<td>7.5</td>
</tr>
<tr>
<td>A</td>
<td>Steve</td>
<td>9 Applied Math Teacher</td>
<td></td>
<td>Elementary Teacher Secondary Teacher 3 years @ School A</td>
<td>14</td>
</tr>
<tr>
<td>A</td>
<td>Bill</td>
<td>10 Applied Math Teacher</td>
<td>Has taught 9 Applied Math Bachelor of Science Also teaches Science</td>
<td>Elementary Teacher Secondary Teacher 6 years @ School A</td>
<td>10</td>
</tr>
<tr>
<td>A</td>
<td>Mark</td>
<td>Co-op Teacher</td>
<td>Bachelor of Business Admin. Int./Sr. Math Qualifications</td>
<td>Elementary Teacher Secondary Teacher 6 years @ School A</td>
<td>2</td>
</tr>
<tr>
<td>A</td>
<td>Jayne</td>
<td>Board SWST</td>
<td>Primary/Junior Math Specialist</td>
<td>Elementary Teacher</td>
<td>6</td>
</tr>
<tr>
<td>A</td>
<td>Tammy</td>
<td>Board Consultant</td>
<td></td>
<td>Elementary Teacher (Grades 7 and 8)</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Gilbert</td>
<td>Principal</td>
<td>2 years @ School B</td>
<td>Elementary/Secondary Teacher experience Administrator</td>
<td>22</td>
</tr>
<tr>
<td>B</td>
<td>Sam</td>
<td>Math Department Head</td>
<td>BSc (Math) MA (Math) Jr./Int./Sr. Math Qualifications Honours Specialist, Math</td>
<td>Elementary Teacher Secondary Teacher 11 years @ School B 2 years as Math Department Head</td>
<td>2 22</td>
</tr>
<tr>
<td>B</td>
<td>Sandra</td>
<td>Grade 9 Applied Teacher</td>
<td>Bachelor of Applied Science Math Minor Int./Sr. Math Qualifications</td>
<td>Secondary Teacher 8 years @ School B</td>
<td>8</td>
</tr>
</tbody>
</table>
I also recorded this additional information in my research journal. All of my field notes were word-processed and imported into the appropriate folder in my NVivo project file and coded during the analysis stage.
Observations in case study school Grade 9 Applied Mathematics classrooms

A second follow-up visit to each case study school was arranged at which time I visited a Grade 9 Applied Mathematics classroom and observed an entire 75-minute period. Merriam (1998) stated that “observational data represents a firsthand encounter with the phenomenon of interest, rather than a secondhand account of the world obtained in an interview,” (p. 94). In this sense, the observational visits were intended to verify what the teachers had reported to me in the interviews. The interviews also gave me the chance to observe the classroom community and dynamics, and gave me a sense of the Grade 9 Applied Mathematics classrooms in action.

To ensure consistency of the data collected during the classroom visits, an observation guide was used to focus and guide my observations (see Appendix G for an example of the Classroom Observation Guide from School D). This guide was developed using the categories in the conceptual framework that are directly related to classroom practice: resources and reform-based teaching practices (collaborative learning, student tasks, constructivism, manipulatives and instructional technology, classroom discourse, assessment for learning, and fostering positive attitudes and dispositions towards mathematics). I was also able to collect artifacts of classroom practice, including handouts and pictures of student work and the classroom itself. While the students were at work, I circulated around the room and listened in to how they were approaching the assigned tasks and interacting with one another. As I did not have permission to work with students directly, I did not conduct any focus groups or interviews with them.

The observation guides were word processed and imported into my NVivo project file and coded during the analysis stage.
Artifacts

In some cases, participants at the case study schools shared artifacts with me, such as sample assessments and departmental websites that illuminated and illustrated their practices. Each of these contributions was catalogued in my field research journal; I created a simple numerical index in the journal that listed the name of the artifact, along with whom had given it to me (using the assigned pseudonym), and the context for its use. I then numbered the artifact to match my field journal. All artifacts were scanned, then imported into my NVivo project file and attached to the appropriate folder for the case study school. I also took pictures while conducting the classroom visits. These pictures were also imported into my NVivo project file and attached to the appropriate case study school folder. These artifacts were coded during the data analysis stage.

Summary of Data Collection

Table 14 provides a summary of the types and quantity of data collected from the two phases of data collection.

Data Coding and Analysis

In order to immerse myself in the data, I personally transcribed all of the focus group and case study interviews. This was done verbatim and in full. Once the transcriptions were done, I began to code the data. The coding process was carried out using an inductive method that began “with specific observations and built towards general patterns” (Patton, 2002, p. 56). Harry, Sturges, and Klinger (2005) defined the first step in this process as “open coding.” To accomplish this, I coded the focus group interview and case study data by the common topics that emerged from the data. These are referred to as nodes within NVIVO.
Table 14

*Documents Collected During Phases 1 and 2*

<table>
<thead>
<tr>
<th>Type</th>
<th>Number of Documents</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>EQAO Reports</td>
<td>4</td>
<td>136</td>
</tr>
<tr>
<td>Interview transcripts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Focus Group A</td>
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<td>24</td>
</tr>
<tr>
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<tr>
<td>Case Study School D</td>
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</tr>
<tr>
<td>Field Notes</td>
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<td>Classroom Observations</td>
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<tr>
<td>Artifacts, photos</td>
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<td></td>
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<td>School A:</td>
<td>1 artifact</td>
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</tr>
<tr>
<td>Steve’s classroom</td>
<td>10 artifacts</td>
<td>16 photos</td>
</tr>
<tr>
<td>School B: Sandra’s classroom</td>
<td>3 artifacts</td>
<td>10 photos</td>
</tr>
<tr>
<td>School C:</td>
<td>2 artifacts</td>
<td>3 photos</td>
</tr>
<tr>
<td>Emma’s classroom</td>
<td>1 artifact</td>
<td>15 photos</td>
</tr>
<tr>
<td>School D: Millie’s classroom</td>
<td>4 artifacts</td>
<td>21 photos</td>
</tr>
</tbody>
</table>

Once this initial coding was completed, I then organized the nodes according to the categories of my conceptual framework (see Appendix H for a detailed list of initial nodes that emerged). To do so, I looked at all of the codes/nodes that had emerged from the data and selected those that were common to the focus group and case study schools. Once these nodes were so organized, I could then look for themes within the codes/nodes
(and patterns across the themes and categories). By way of example, the first category in my conceptual framework was “Resources” and specifically “Material.” As I was sorting the initial codes/nodes, I found that the most frequently cited resources were:

- TIPS4RM
- Gizmos
- GSP
- CLIPS
- Gap Closing
- Manipulatives
- Interactive whiteboards
- EQAO website, and
- Calculators.

In looking at and thinking about these codes/nodes, themes began to emerge. For example, there were a large variety of resources being used, many of them from the ministry. All of the schools were using the TIPS4RM and the EQAO website. The teachers had spoken about how important it was to co-plan with new resources. All of the case study teachers talked about the importance of their whiteboard and manipulatives and I had seen these things in the classroom during my visits.

Finally, in looking more deeply at the themes and in thinking about the context behind them coming from the interviews, clear patterns began to emerge. For example, a textbook was not used in the case study classrooms. Instead, the teachers and math department head had developed a program that used a variety of resources. The teachers had talked about the importance of engaging students and it was clear that the favoured
resources were hands-on and contextual. The teachers had positioned manipulatives and calculators as tools for learning and doing mathematics and so they were always available to the students. The teachers had also valued EQAO as a reflection of the curriculum and so integrated EQAO questions into their everyday teaching. Another commonality between the resources that teachers tended to use is that they had somehow been involved in co-planning for their use. Appendix H illustrates how the patterns emerged from the codes/nodes.

**Ethical Considerations**

Through participation in this study, participants were given the opportunity to think about and express their opinions about how to best support student success and achievement in Grade 9 Applied Mathematics. Participation in such studies is usually seen as a rich form of professional development for those involved (Gall, Gall, & Borg, 2005) because it gets teachers to reflect on practice. Osterman (1990) wrote that reflection is an essential part of the learning process because it results in making sense of and extracting meaning from experiences. Furthermore, this kind of reflection is a skill that is best fostered with colleagues (Danielson, 2009).

As the research involved human participants, ethical protocols were submitted and approved by the University of Toronto prior to collecting data. The ethics certificate was extended so that data analysis could be completed. All data for this research was collected with the explicit permission of the participants and in full compliance of the Social Sciences and Humanities Research Ethics Board (REB) of the University of Toronto.

For the case study schools, application was made to the appropriate district school
boards to carry out the research in their schools. Only after the boards granted permission for the research were schools contacted. In each case, permission also had to be obtained from the school principal to conduct the research in his or her school. District protocols were observed with diligence. For example, some of the districts requested written assurance that their identity and the identity of their schools and teachers remained anonymous.

This study was low risk to the participants. No mental, physical, physiological, or social harm was likely to result from this research. Participation was voluntary and the research did not revolve around a topic that would cause emotional stress to the participants. Participants were assured that no evaluations of them would be made and their responses would be held in the strictest of confidence.

Informed consent was obtained from all participants with a Letter of Information / Consent Form (Appendix B for focus groups and Appendices D and E for case studies) that I reviewed with them prior to beginning the formal interviews. All participants read and signed the form indicating that they understood the objectives and parameters of the research and that they were willing participants. Participants were also informed that they could withdraw from the research at any time without penalty.

The data collection, analysis, and storage processes ensured the confidentiality and anonymity of participants. Alphanumeric codes were assigned to all boards and schools. Pseudonyms have been used in this report to protect the identities of the research participants and to ensure their privacy and confidentiality. All research data will be destroyed within five years of the completion of this research; paper data will be shredded, and digital data will be deleted.
As part of my agreement with the participating school boards, I will be providing them with an executive summary of the research findings. I will also be sharing the findings with the executive of the OMCA, as well as with any research participant that requested receipt of the findings.

**Chapter Summary**

This chapter has introduced and discussed the choice of focus groups and case studies as a suitable research methodology for this study. It has provided an outline of the tools that were used to gather the data from both the focus group participants and the case study schools. The chapter also highlights how the data was both managed and analyzed using the conceptual framework for the study, along with the qualitative software, NVivo.
CHAPTER FOUR: PRESENTATION OF FINDINGS

Overview

This study attempts to discern effective practices in Grade 9 Applied Mathematics. The methodology for this research, described in the previous chapter, has guided the two phases of data collection. In the first phase, focus group interviews were conducted with district- and school-level mathematics leaders from across the province. In the second phase, interview, observation, and school report data were collected for four case study schools that have had outstanding success on the provincial Grade 9 Applied Mathematics assessment. The focus of this chapter is to present and discuss the findings from these two phases of data collection.

To answer the research questions, the themes that emerged from the analysis of the data have been mapped to the study’s conceptual framework. This framework identifies elements that emerged from the literature review as being important to effective mathematics teaching, namely: resources, professional learning, math departments, leadership, and reform-based teaching practices. The practices that are outlined in the ensuing discussion are common to the case study schools and were also alluded to and supported by the focus group participants.

The data sources that are referred to in the discussion are outlined in Table 15. By way of example, references to Focus Group B are referred to as FGB and references to an interview at Case Study School C are referred to as IntC. An observation in a classroom at the same school is referred to as ObsC. Pseudonyms have been used in order to protect the identity of participants, their schools, and their boards. Background information for the study participants can be found by referring back to
Table 6: Focus Group Participants on page 140 for focus groups and Table 13: Case Study Participants on pages 166 and 167 for case studies.

Table 15

_Coding of Data Sources for the Study_

<table>
<thead>
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<tr>
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<tr>
<td>Researcher’s Field Notes</td>
<td>FN</td>
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</table>

**Findings**

This research study set out to answer the following key questions:

- What practices are being used by high performing schools in Grade 9 Applied Mathematics?
• Which of the specific practices identified in the mathematics and general reform literature as being related to better mathematics achievement have been adopted by the most successful schools?

After completing a review of the literature related to effective practices in secondary school mathematics, I devised a conceptual framework that outlined some of the important elements for effective mathematics teaching that emerged, namely: resources, teacher professional learning, math departments, leadership, and reform-based teaching practices. The data collection involved gathering insights related to practices around these elements. Data was collected from mathematics leaders and educators at some of the province’s most successful schools, as measured by student achievement on the EQAO Grade 9 Applied Mathematics assessment. The following sections outline the patterns that emerged from the data.

Resources

Material Resources

There were some common themes that emerged from the data regarding the types of material resources that are most beneficial to the Grade 9 Applied Mathematics classroom. These were the importance of: using a variety of resources versus a core resource; using resources that engage students in hands-on, experiential, and active learning; using ministry and EQAO resources that are specific to the Grade 9 Applied Mathematics course; and, using technological resources that help to visually represent mathematical ideas and illuminate the connections between them. It was also apparent that teachers are most likely to implement new resources into their teaching repertoire when they have the opportunity to co-plan their use in the classroom with other teachers.
One thing that was evident from the case study schools is the fact that none of them relied upon a commercially published textbook as their exclusive, or even primary, resource. Instead, the Grade 9 Applied Mathematics teachers selected from a variety of resources that helped them to address the learning needs of their students. In three of the four case study schools, the mathematics department head had worked with other mathematics teachers to develop a program for the Grade 9 Applied Mathematics course. (In the fourth school, there was one primary Grade 9 Applied Mathematics teacher and he had developed a program in a similar style). These programs were in no way static; they were adjusted to meet the needs of the current student cohort and in response to the acquisition of new resources. All of the case study schools relied heavily on the ministry’s TIPS4M materials and sample questions from EQAO in their programming.

The math department heads had developed some mechanism for sharing the course program electronically, through a shared network folder, wiki, or other type of web page that all teachers could easily access. School B had evolved to the point where the course materials were also available online to students on a class wiki, as illustrated in Figure 19. This wiki included all handouts, PowerPoint materials, and smartbook files that were used in the classroom, as well as hyperlinks to web-based resources such as Gizmos that were used in class. Information about this wikipage was shared with parents so that they could be apprised of what was happening in the class. Note, for example, that the April 23 entry in Figure 19 has a statement that a mark update is being sent home for signature.

The teachers spoke to the importance of having resources in the applied classroom that promote hands-on, active, and experiential learning. These include interactive
whiteboards, web-based learning objects, concrete manipulatives, calculators, graphing
calculators, and less sophisticated, but still necessary materials such as pencils and
calculators. Also worth mentioning here is the fact that not coming prepared to class with
the necessary “tools” for learning (e.g., pencils and calculators) did not become a barrier
to participation and learning for students. In virtually all of my classroom visits, at least
one student arrived without a pencil or other required tool for learning, such as a
calculator. In all cases, the teacher simply provided it, without making a fuss or big deal
about it (ObsA, ObsB, ObsC, ObsD: FN).

**Figure 19.** Screenshot of Grade 9 Applied Mathematics class wiki. (ObsB, FN)

All of the case study schools relied heavily on the ministry’s TIPS4M materials in
their program. In fact, I saw TIPS4M resources, or adaptations of them being used in all
of the case study classrooms. The teachers liked these resources because they were
directly linked to *The Ontario Curriculum, Grades 9 and 10: Mathematics (revised).* All
of the case study teachers also used questions from the EQAO Sample Assessment
booklets that are posted on the EQAO website. There was a strong sentiment expressed amongst the teachers that EQAO assessments are a reflection of the curriculum and therefore provide excellent examples of good learning tasks.

Most of the case study teachers commented that they really liked the EQAO sample questions and that their students enjoyed working on them as well; they often were just really interesting and had appropriate contexts to engage students. The teacher practice was to integrate these questions into their ongoing classroom lessons, as opposed to setting time aside to “practice for EQAO” at the end of the semester. They used the sample questions in a variety of ways, including as “minds-on” activities and “action” problems for lessons. The teachers also revamped questions, for example, by changing a multiple-choice question into an open response question, or by adapting an original worksheet to better suit their particular students’ needs. The teachers also spoke about incorporating “EQAO-style” questions into their own assessment practices:

You make tests that are kind of summative, or formative assessments that look like EQAO and at the same time, once you start doing that, it almost forces you in some cases to get the kids the think more. They have to think more critically. Anyone can follow the, “Move x over here, do this, square this, do this and you’ve got your answer.” But as soon as you ask them something out of the box where they have the skill but there is no algorithm to follow, they can’t do it, right? So the more questions that you can introduce that are problem-based questions that get them to think critically, the better they become at them and the less afraid they are of those types of question. (IntC: Ivan)

Another resource common across the schools was the interactive whiteboard. In fact, the case study teachers spoke about how they “couldn’t live without it” (IntA: Bill; IntD: Millie) to teach the Grade 9 Applied Mathematics course. True to this, I witnessed the case study teachers using interactive whiteboards in all of my classroom visits. For example, I witnessed students using the interactive whiteboard to prove that the sum of
the angles in a triangle is always $180^\circ$ (ObsB: FN). The general sentiment of the teachers was that the tool was especially helpful in the applied classroom because of its interactive and dynamic nature. This feature enables the teachers to design lessons that better engage students in mathematical tasks and ideas. In addition to allowing them to present mathematical concepts in dynamically visual and exciting ways, the interactive whiteboard also enables teachers to design learning experiences that animate mathematical ideas and illuminate the connections between them. Sam put it this way:

> I use it as a dynamic board. The fact that I can draw things quickly. I can measure angles. I can show things. I mean, the other day—this was Grade 10, not Grade 9—it was transformation of quadratics. The fact that I can write $y = x^2$ as an equation, drag it, and get an instant graph. Drag it and get an instant table. You know, it’s just so dynamic and quick when you know how to use it. (IntB: Sam)

This theme was underscored in two of the three focus group interviews where mathematics leaders lamented the fact that interactive whiteboards were having minimal impact in many mathematics classrooms because teachers did not realize their potential as a teaching tool. In their experience, many teachers had simply integrated the tool into the teaching schema that they already had, with little added value in changing established practice. This resulted in them using the interactive whiteboard as little more than a glorified chalkboard, instead of taking advantage of the interactive environment. This had the effect that many teachers continued to present traditional lecture-style lessons, but in “Technicolor.”

This leads to another important discovery about the use of resources that emerged from both the focus groups and the case study schools: teachers are unlikely to implement a new resource in the absence of professional learning that helps them to understand why and how to use said resource. Simply put, a resource that lands in a teacher’s mailbox is
more likely to find its way to the teacher’s shelf than to the teacher’s daybook. Even in cases where teachers might have integrated a new resource, it is quite likely that it will have been used superficially and not as intended, such as when the interactive whiteboard was used as little more than a colourful chalkboard. This finding agrees with a bounty of research that has gone before it. It is not enough to introduce a resource and leave it to teachers to implement it on their own. To truly take advantage of a resource, teachers need to see and understand its potential to enhance student mathematical learning and thinking.

Perhaps even more importantly, however, is that the data from this study suggests that, for maximum impact, professional learning about a new resource needs to involve teachers in co-planning with that resource. Teachers need and benefit from the opportunity to “group think” with others about how a new resource can best be used to support student learning and in order to better understand what effective implementation of the resource will look like in the classroom. This step is often given short shrift, or skipped over altogether, when new resources are adopted and the case study teachers lamented this fact. Yet, in cases where teachers were given the opportunity to co-plan, their work together had a profound impact on what actually transpired in the classroom. As a case in point, Board D had funded School D’s Grade 9 Applied Mathematics teaching team to meet as a professional learning community for a total of three days during the semester. As part of their work, the teachers reviewed activities for interactive whiteboards that would fit with their Grade 9 Applied Mathematics program. For example, they reviewed the bank of available “Gizmos,” a set of OME-licensed online
learning objects. As a group, they decided which Gizmos would fit into their program and how they would use them.

Similarly, they reviewed the ministry’s Gap Closing resource to decide how it could best be used in their Grade 9 program. As a consequence, they decided upon the practice of administering diagnostics for integers and rational numbers at the beginning of each semester in all Grade 9 classrooms. They felt that this would help them to understand which students were likely to need intensive support and which students were likely to require enrichment opportunities. This, in turn, would support the teachers in better preparing for and meeting all student learning needs.

Each of the members in this team acknowledged that this work together was crucial in determining how they would implement and use new resources and ultimately, the way in which these resources supported and impacted their classroom practices. The need for this kind of meaning-making emerged as a persistent pattern across all of the focus groups and case study schools. In a very real way, teachers can serve as important resources to one another during the adoption and implementation of new resources.

A couple of trends also emerged as to what kind of resources teachers tended not to use. The case study teachers alluded to the fact that, if a resource was complicated to use or understand, they probably would not use it. For example, the only school that systematically used the ministry’s *Gap Closing* resource was School D and as discussed above, they had the opportunity to collaboratively work out how to use and implement it. When asked about the *Gap Closing* resource, many of the teachers in the other schools said that it was just too complicated to implement and they did not have the time to figure it out.
Other resources that teachers were not using were found to be “more trouble than they were worth” (IntB: Sam). For example, the web-based CLIPS resource was not widely embraced in the case study schools because the computer labs were too difficult to access. Even when the labs were accessible, the application often did not run smoothly because the school simply did not have the required infrastructure (Internet bandwidth). For this reason, teachers tended to use web-based applications in large group (whole class) settings or small group scenarios where a number of students would share a computer or tablet to solve a problem together.

**Human**

It is important to point out that at all of the case study schools, the staffing of the Grade 9 Applied Mathematics classroom was treated with import and careful attention was paid to who taught the course. Furthermore, the math department head had some influence in this staffing decision and in most cases, taught at least one section of Grade 9 Applied Mathematics each year. Some clear patterns emerged across the case study schools concerning who taught the Grade 9 Applied Mathematics course. This included teachers that were comfortable with the mathematical content being taught and had a willingness to teach the applied course.

The case study teachers expressed comfort with teaching the content of the Grade 9 Applied Mathematics course. Eight of eleven of them had formal mathematics teaching qualifications: one teacher was qualified to teach Intermediate Mathematics, six teachers were qualified to teach Intermediate and Senior Mathematics and one teacher was qualified to teach Junior, Intermediate, and Senior Mathematics. It is worth re-iterating
here that in order to acquire these qualifications, teachers need to have at least three university mathematics credits, or equivalent.

Another notable fact is that almost two-thirds of the case study teachers (7 of 11) had previously taught in the elementary panel. Curiously, two of the three teachers that did not have formal qualifications to teach Grade 9 (Intermediate Mathematics) belonged to this group. Steve, one of these teachers, discussed how his elementary teaching background was key to his success in the applied classroom:

Most of my teaching was at Grades 7 and 8. A neat experience was seeing where the math went to after Grade 8…. And I do believe that is what has improved my pedagogy… to have that wide range of experience of seeing where the math goes, how it sort of evolves, grade after grade. And especially where it goes from Grade 8 to Grade 9 to Grade 10. (Int: Steve)

Other case study teachers that had previously taught in the elementary panel also spoke to the importance of having this understanding of the curriculum across grades. They felt that because they understood the progression of mathematics learning, they are quickly able to identify and remediate gaps in student learning. This suggests that, though formal training in mathematics is important for Grade 9 Applied Mathematics teachers, teaching experience might be equally important. It also speaks to the fact that it is important for Grade 9 Applied Mathematics teachers to deeply understand the curriculum at the Grade 7 and 8 levels so that they can better identify and remediate students learning gaps. Another factor to be considered here is the fact that, for the most part, students are not streamed or tracked at the Grade 7 and 8 levels. Therefore, teachers at these levels are perhaps more experienced with differentiating instruction in order to help all students to acquire the required learning; they have “to deal” with the students that are in their classroom, and their diverse learning needs.
In contrast, the culture in secondary schools seems to be that teachers will recommend a student switch streams if and when course content seems too difficult. In my experience, secondary teachers tend to default to this position. Even in the case study schools, there was a preoccupation with making sure that students were placed in the “right course.” Furthermore, according to the provincial EQAO data, the percentage of students with special needs is four times higher in applied courses compared to academic courses (Kozlow, 2012). This suggests that students with special needs have been streamed into the course that is perceived to be less difficult; when the going gets tough, students switch courses. It is not necessarily the teachers who do the switching (in terms of their own practice).

When these realities are taken into consideration, it appears as if having appropriate Grade 7 and 8 teaching experience might give Grade 9 Applied mathematics teachers a pedagogical edge. They might have a more robust instructional repertoire that will actually benefit struggling students. Furthermore, these teachers are perhaps better acclimated with trying a variety of strategies to support student learning. These two factors considered together imply that Grade 7 and 8 teaching experience can provide an effective avenue to understanding the content and delivery of the Grade 9 Applied Mathematics course and that teachers with this kind of experience are well equipped to support learners in Grade 9 Applied Mathematics classrooms.

As much as comfort with the course content was crucial, it became clear to me that there was more to it than just staffing a Grade 9 Applied Mathematics course with a “qualified” or experienced mathematics teacher. For example, when I asked the administrators and department heads at the case study schools, “Who teaches Grade 9
Applied Mathematics at your school?” they were more likely to say that it was their “best” math teachers rather than their “most highly qualified” math teachers. For example, Kobe said, “We put the right people in the right courses. Great teachers doing great things had the biggest impact on the results. I have no doubt of that” (IntC: Kobe). Sam, the department head at School B went so far as to say: “I’ve come to the distinct conclusion that qualifications amount to squat when it comes to good teaching” (IntB: Sam). Kobe and Sam were speaking about the need to pay attention to tactual personalities and teaching styles when staffing the Grade 9 Applied Mathematics classroom. These sentiments were echoed by the principals and department heads across all of the other case study schools where never was an individual “just dropped in” to a Grade 9 Applied Mathematics course in order to fill a teaching timetable.

In fact, at all of the schools, staffing had evolved to the point where there was a single individual, or core group of individuals—beyond the department head—who always taught the Grade 9 Applied Mathematics course. Ivan articulated the typical and strategic attention to staffing that was characteristic of the case study schools:

As I said, I teach the grade nine applied course almost every year. And, you know, there are only two or three teachers who really kind of focus on nine applied. We try to get, you know, our creative thinkers, our experienced, and willing to try new things, kind of teachers. That kind of staffing is important. The people who teach grade nine applied want to teach grade nine applied. Like they are not the ones that come in and say, “Oh I got 1P [Grade 9 Applied] again, darn it!!” Or, “I’ll trade you a 1P for two of your whatevers…” That doesn’t happen. (IntC: Ivan).

All of the administrators in the case study schools spoke to the importance of this kind of purposeful and strategic staffing for Grade 9 Applied Mathematics. The profile of the “right” people to teach the Grade 9 Applied Mathematics course that emerged included: teachers who are team players and open to trying and learning new things;
teachers who connect with the learners in applied courses; and, teachers who are comfortable in using approaches that are best suited to the applied context, such as cooperative learning. This involves a willingness to innovate that was confirmed by the case study teachers who spoke about how they were always on the look out for new ideas that would help them to engage the students in applied courses.

Furthermore, it can be stated that all of the case study teachers wanted to teach the course. They spoke about how much they enjoyed teaching the applied course and the learners in them. Emma’s sentiment that “they are great kids and you just learn how to work with them differently… with more tender loving care” (IntC: Emma) was reiterated by virtually all of the other case study teachers. For example, in describing the teaching team who taught Grade 9 Applied Mathematics at her school, Debbie expressed that:

You find a lot of other schools have all kinds of teachers. They’ll have eight or nine different teachers, especially in the bigger schools where they have a lot more sections. They’ll have eight or nine grade nine teachers because when the math teachers come in, they have to go to the senior grades. And so grade nine isn’t something that people want to teach. Grade nine is something we (emphasis) all want to teach. We want to teach it. And I prefer it. That’s my favourite course because I really like the Grade 9 Applied class. (IntD: Debbie)

I was struck by how the case study teachers unanimously spoke about the students in applied classrooms with great respect; not once did I hear these students spoken of in any insulting or disparaging way. This has not always been my experience when students in applied classes have been the topic of conversation amongst a group of secondary school teachers. I have often heard comments like, “What can you expect from these kids?” I have even heard teachers speak about being “punished” when they are assigned to teach applied courses. Not so with these teachers. Additionally, it is worth noting that about half of the case study teachers had either credit recovery or special education
resource slots on their timetables, confirming their affinity and inclination to work with students at risk.

In terms of experience, the Grade 9 Applied Mathematics teachers seemed to have either a lot (20 or more years) or relatively little (less than 8 years) teaching experience. It is interesting that the teachers with the lesser experience had been assigned to teach the Grade 9 Applied Mathematics course as a first teaching assignment. What is also significant, however, is that the math department head had played a key role in mentoring these new teachers. In fact, these teachers spoke about how the math head had taught another section of the course at the same time that they had first taught the course and that the math head had co-planned with them. This supports the idea that the department head can play an important instructional leadership role in preparing and developing teachers for dealing with the complexities of teaching applied courses.

**Professional Learning**

Patterns emerged from the data regarding the characteristics, or qualities, of professional learning that were expressed as being the most important for the study participants. As discussed previously, most of the teachers in the case study schools were qualified math teachers and the majority of them had some background in mathematics at the post-secondary level. Therefore, they all had a very good grasp of the mathematics content in the Grade 9 Applied Mathematics course. Perhaps it is not surprising that for them, the professional learning experiences that were most valuable did not focus on the mathematics content of the grade 9 applied course per se, but rather on instructional strategies that would best help their students to engage in and learn mathematics. The
teachers also spoke about how important it was to come to a clear understanding of what “successful learning looked like.”

Important to this work was developing an understanding of the curriculum as it transpired throughout the early Intermediate (Grades 7 to 9) grades. In three of the four case study schools, the Grade 9 Applied Mathematics teachers had been given the opportunity to meet and work with Grade 7 and 8 teachers. The express intent of this work had been to develop a better understanding of the continuum of learning from Grades 7 through 9, both in terms of content and content delivery. This work was important in two ways. First, it helped all of the teachers to better understand how the mathematics learning progressed through the grades: it helped the Grade 9 teachers to better understand what the students had been taught in Grade 7 and 8 and vice versa. For example, in Grade 9, students are expected to “construct table of values and graphs to represent linear relations derived from descriptions of realistic situations” (OME, 2005, p. 42). If a group of Grade 7 to 9 teachers were to engage in a conversation about the learning progression that leads up to this expectation, they might discover that students actually begin recording patterns on a table of values in Grade 5 and plotting them graphically using ordered pairs in Grade 6. By Grade 7, students begin representing and describing linear growing patterns algebraically and in Grade 8 they begin using algebraic equations to describe linear patterns.

When teachers develop this depth of understanding as to what their students have learned previously, they are in a much better position to activate prior knowledge and make connections to what students already know. This brings students to the new learning from a place of comfort. One of the schools went so far as to co-plan and co-
teach mathematics lessons together, literally opening up classrooms to one another. This helped the teachers to see what was really happening in the classrooms at the various grade levels. This led to some significant insights. Some of the case study teachers expressed, for example, that the Grade 7 and 8 teachers were surprised at how much work was done in groups in the Grade 9 classrooms. Many of the Grade 9 teachers were surprised at the actual content that was covered in Grade 7 and 8; this helped them to understand that they did not need to treat the curriculum as being brand new.

The second aspect of this cross-panel collaboration that was important is that it exposed the Grade 7 and 8 teachers to the kind of questions that are on the EQAO Grade 9 Mathematics Assessment. Some of them had never seen any of the test questions before, so this was a revelation for many:

The Grade 7 and 8 teachers were exposed to what an EQAO test really looked like…. And so part of our meetings that we had was encouraging the Grade 7 and 8 teachers to begin to do open response questions in their teaching on a weekly or daily basis…. Getting away from, you know, assigning thirty questions and realizing that maybe sometimes less is more. And instead of assigning a whole bunch of them where the students don’t put very much effort into their communication in answering the question, you know, saying, “Hey we’ll only assign two questions, but let’s do a fantastic job of answering them and let’s communicate really well.” (IntA: Steve)

Grade 7 and 8 teachers play an important role in preparing Intermediate students for the EQAO Grade 9 Mathematics assessment, so it seems important that they understand the end goal, particularly as the assessment is a reflection The Ontario Curriculum. Cross-panel collaboration can help teachers to develop a shared understanding of the intended learning strategies and outcomes articulated in the curriculum policy documents. Too often, teachers have misconceptions about what teaching “looks like” in grades that either precede or follow their own grade level. The
cross-panel collaborations allowed teachers to talk across grades and illuminate the actual learning that happens in their respective classrooms.

A characteristic of this work that was cited as being very important to all of the case study schools was its collaborative nature. In fact, the teachers spoke about how important collaborating with others was in supporting their own learning. The professional learning experiences that seemed to be most transformative to teachers were the ones that involved them in working and planning—co-learning—with others. This theme was also echoed in the focus group data. This kind of learning happened on a small scale where, for example, a new teacher and her department head collaborated on the Grade 9 applied course or where a pair of teachers met with a board consultant to work out how best to implement the Gap Closing resource. It also happened on a larger scale where, for example, teachers in the department met together or with teachers from other schools to discuss some aspect of teaching and learning mathematics. Key features of the work were that it was purposeful, and immediately relevant. In cases of the more formal collaborations, the work was focused on a particular problem of practice, as was the case when the 9P teaching team at School D collaborated in coming up with their Grade 9 Applied Mathematics program. In talking about this work, Debbie expressed:

It should be teams. When you, when you put three or four good minds together—let’s face it—everybody here has good ideas. Everybody’s got their things that they do in their classes. When you put that all together and you pull best practices from everybody and you put it together to get one program—over the course of several attempts, you develop a program eventually. You’re going to have some great success. A lot more success than all kinds of individuals doing their own thing, you know. I feel that I am definitely a better teacher for having taught with Kate and Millie. Us working together. Us sharing what works and what doesn’t. And each one of us has brought something to the table. Each one of us has offered a different way to try something. It makes it that much better. And that—that has to be better. (IntD: Debbie)
I would also add that many of the case study teachers seemed to be craving this kind of collaboration and felt that these opportunities just did not present themselves enough. Or when they did, the teachers felt that they were not in control of what they were learning. Even during professional activity days, teachers are not often provided with time to freely collaborate because there is always some laid on agenda. In keeping with this, Principal Brad spoke about how at the end of Professional Activity (PA) Days at his school, he always asks for three stars and a wish: teachers are asked to comment on three things that were done well at the session and additionally, to provide one wish for future events. He spoke about how teachers largely commented along these lines:

You guys, and our board staff—our board curriculum team as well—you always, always plan and plan and plan and give us so much information and say, “This is what you need to do” and then you carousel us for twenty minutes to talk about it. And then you give us another new strategy. You never just give us the opportunity to..., can’t we just be? Can we just have that time with our colleagues to try and plan? (IntA: Brad)

What should also be emphasized here is that teachers in the case study schools did find time to collaborate, but it was largely on their own time—over the lunch hour, in the hallways, and after school. Whether this is typical in other schools is another question. Furthermore, the principals in the case study schools seemed to understand the value of teacher collaboration and so they actively sought opportunities that would allow their teachers to do so, e.g., accessing targeted board funding for professional learning communities. This even extended to providing teachers with a shared preparation period, where possible.

It is also worth re-iterating here that professional learning that resulted in teachers co-planning for their own students seemed to have the most impact (as discussed in the resources section). This brought purpose, relevancy, and immediacy to the work.
Another area of professional learning that was cited by many of the case study teachers as being helpful involved the use of rich questions or tasks. The teachers spoke about how using these kinds of questions opened their eyes to the kinds of thinking and problem solving that students in applied classrooms were capable of. Furthermore, using these questions encouraged the teachers to use collaborative grouping structures and this in turn increased student engagement. For example, Emma spoke about how her experience in co-planning and co-teaching a problem-based lesson had impacted her:

> Just seeing them in action. And seeing the way they worked together. And seeing how they loved tackling a problem that was challenging and how they could really problem solve through it and work with each other was like, just awesome! (IntC: Emma)

This speaks to how professional learning that encourages teachers to embrace higher-order questions and rich tasks in applied classrooms has the potential to launch teachers into experimentation with other reform-based teaching practices.

**Math Department**

Both the focus group and case study data suggest that the math department can be an important structure for supporting success in Grade 9 Applied Mathematics classrooms. There are some key features that emerged from the case study data related to the mathematics department: instructional leadership was apparent in the department chair; the departments were professionally supportive in nature; and the teachers within them understood the benefits of strong performance in Grade 9 Applied Mathematics.

The general sentiment from the focus group participants was that most math departments in schools were more focused on operational details, than they were instruction. As Kathy said:

> My experience is that our math departments are still very, when they meet—if they ever do meet—it's very focused on operational stuff. We need batteries. The
textbooks are falling apart. You know. And it's not professional learning. It's not sharing. We are starting to see that, I think, in 7 and 8 divisional teams, but I'm finding that the teachers still at secondary have very closed doors…. But very closed doors, not really sharing the strategies they're using. And again our schools are really small so we have one section sometimes of Grade 9 Applied in one school. You know, two in another one. Two in another one. So the teachers are often very isolated. So there's no one in the building to collaborate with. And there's not that ownership of the 9 Applied. It's well, "You're the 9 Applied teacher so away you go." (FGA: Kathy)

Similarly, Lynda’s experience of working in math departments was that they were more congenial than they were collaborative:

I’ve worked in eight high schools. And I would be very friendly with everybody in the math department and when it came to the exams we would have a conversation and I’d say, “Where are you in your unit?” But I would never say, “Hey I’m thinking of trying out this lesson. Do you want to sit down and help me because it requires this manipulative and I have no idea how to use it? If you’ve used it, great. If you haven’t, can you help me?” Like we just—it just doesn’t—that community doesn’t work at that level. (FGC: Lynda)

The mathematics leaders in the focus groups spoke about how a lot of their work involved trying to bring teachers from a math department together in order to have these kinds of collaborative learning experiences.

My sense was that the math departments in the case study schools were characteristically different than those that were described as typical in the focus group interviews. To start, the mathematics departments in the case study schools were characterized as having very collaborative and professionally supportive and enriching cultures. For example, Steve commented that:

I think that we have a very sharing atmosphere. It’s not that we have many formal meetings, but the math teachers, on a daily basis, we talk about stuff. We share, you know. We throw ideas around. It’s a very cooperative environment. Nobody is an island in our school. Everybody is kind of there to help each other. (IntA: Steve)
One of the things that I noted during the school visits is that all of the math
departments had large work areas for the teachers that appeared to be hubs of activity. In
describing the work area in his school, Ivan mentioned:

We are in a nice big workspace together, so there’s just a lot of sort of incidental
sharing that goes on and, you know, almost professional talk, kind of thing. Like,
“I’d really like to do this. What do you think?” And that kind of sharing.
Informal sharing of ideas. (IntC: Ivan)

Schools C and D had not always had this kind of culture, according to their math heads.
In both of these schools, the mathematics teachers had once been dispersed amongst
smaller offices and so did not tend to collaborate and the result was that “cliques” had
begun to develop. It was not until the teachers were moved into the bigger and more
inclusive workspaces that the more collaborative cultures began to emerge. It appeared
that the math heads also played a key role in fostering the collaborative and
professionally supportive culture by encouraging teachers to share their “best practices,”
first at department meetings, and later around the lunch table as Laura described:

So we’re all together which is great. I try really hard to do very casual things to
encourage conversation. Like at lunch, I’ll say, “You guys, since we started this
CLIC thing [a PD network with Grade 7 and 8 teachers], I’m kind of driving
myself crazy. I’m re-thinking every lesson like, you know, I think about it, and
I’m like, “Oh my goodness, no. And I’m always rethinking. I could do it this
way now. Like, you guys, is that just me?” And then we’re talking about it. And
all of a sudden we’re having a conversation. And it’s strategic. (IntC: Laura)

I also had the sense that, when it came to the Grade 9 Applied Mathematics
course, the math department head knew exactly what was happening in the classroom.
As was discussed earlier, he or she was instrumental in developing the course program.
In addition, the math head played a key role in developing the teaching personnel by
mentoring new Grade 9 Applied Mathematics teachers. In the three case study schools
that had an active math head, the case study teachers spoke about how the math head was
an important influence on and support to their teaching in the Grade 9 Applied classroom; they talked about how they had not been left to fend on their own.

Another trend that was common amongst the four case study schools is that they had all developed policies whereby the EQAO Grade 9 Applied Mathematics assessment counted as a portion of the students’ final course marks. As Sam put it, “Well if you put a test in front of kids that aren’t motivated and the kid says ‘Is this worth anything?’ and you answer, ‘Nope,’ then they will be like ‘Okay, I’ll just randomly bubble things black and colour in the pages’” (IntB: Sam). Furthermore, towards the end of the semester, two of the four schools administered a sample assessment, mocking the conditions under which the actual EQAO assessment would be administered, i.e., using the same test format, time limits, etc. Though these assessments did not “count” towards a students’ grade, they were marked and returned. The schools then ran after school tutorial sessions and students were encouraged to attend sessions for those topics that they had difficulty with.

I would also say that there was recognition in most (three of four) schools that how the students did on the EQAO Grade 9 Mathematics assessment mattered. This went beyond simple test results. The teachers had come to realize that when students did well on the Grade 9 EQAO Mathematics assessment, they would invariably do better on their more senior courses. In other words, everyone won when the youngest students thrived. I heard in these case study schools that the whole department supported initiatives such as homework clubs, or lunchtime study hall, or after-school tutorial sessions. In other words, it was not just up to the Grade 9 teachers to prepare the students; there was a collective sense of responsibility. For example, Steve shared:
It’s the team thing, you know. One of my colleagues, he has his prep [preparation period] during my (grade 9 applied) math time. Well, even though it’s his prep time, he’ll periodically come to me and say, “Hey, can I help anybody—any of your kids—in math?” So he’ll give up his prep and I’ll send one or two away to work with him. (IntA: Steve)

In the fourth school, there was not value placed on the EQAO assessment per se, but there was still the recognition and a strong sentiment that it was important for the students to do well on the course.

I was somewhat surprised that there did not seem to be a strong focus in most of the school’s mathematics departments regarding specific instructional approaches for mathematics teaching and learning. In cases where the departments were working on new instructional approaches, it appeared as if these approaches were being pushed at the whole school level and were not specific to mathematics. For example, School B was working as a school to develop critical thinking skills, and all of the teachers in the school had received targeted professional learning on this topic, i.e., at school-based professional activity days and after school staff meetings. Similarly, Schools A, C, and D were focusing on Assessment for Learning strategies that were being pushed from the system-level.

**Leadership**

There were patterns related to leadership that emerged from the focus group and case study data. These included: signaling that the EQAO Grade 9 Mathematics assessment was important and the significance of instructional leadership in both the administrator and department heads.

The general sentiment of the focus group participants had been that, if the EQAO Grade 9 Mathematics Assessment was not positioned as being important in the school at
large, then the teachers and the students did not see it as being important either. Several of the focus group participants expressed frustration around their own experiences in administering the assessment. For example, it was not unusual for announcements to be made over the Public Announcement (PA) system while the test was going on, and for students to be called down to the office or allowed to go on field trips during the testing period. This stood in stark contrast to how the Grade 10 Literacy Assessment was viewed in the schools; every effort was made to have students complete that particular assessment on time and without interruption (given that there was a single prescribed time for its administration).

When I visited the case study schools, the administrators spoke to me about the importance of the EQAO Grade 9 Mathematics Assessment and communicating this to staff, students, and parents. Furthermore, celebrating success was also critical, as expressed by Principal Brad:

We celebrate good results here. There’s not a class in this school that doesn’t know that our math—our students—from last year, did really, really well in applied level math. And academic. Our academic results are 93% so they are actually higher than applied, but applied is so nice, compared to the rest of the province—it’s so much higher. But it’s the celebration of it. We’ve gone into—I’ve gone into—every classroom. We’ve cheered. I’ve gone into every classroom and said in front of all the students, “Thank you” to the teachers. And “Guys you need to know that you are with a teacher here who their guys got really great marks. I’m sure you guys will do really well. But you guys, all you need to do is spend some time and ask for lots of extra help. You’ve got a teacher who is really helping a lot of students.” And so the students are buying in. They see that, “Wow, that was them from last year!” They know all of the kids and they are not special kids; “If they can get that, we know we can!” Also, at Christmas assembly, I told the entire student body and the entire student body did a big huge cheer for them. So that’s important too. It’s sort of social acclamation, you know. (IntA: Brad)

There was not a lot of fanfare attached to the actual administration of the EQAO Grade 9 Mathematics assessment at the case study schools. For the most part, the
assessments were administered by the classroom teacher, with students writing them in their regular classrooms during the regular mathematics period. The exception to this was at School D where the school cafeteria was set up and the assessment proctored in the traditional exam format (rows of student desks). In all but School C, snacks were also provided to the students during the assessment period, at either the beginning or midpoint of the writing.

Another interesting trend that became apparent from the data is that three of the four case study school administrators had a background in mathematics, having taught secondary mathematics and specifically the Grade 9 Applied Mathematics course. This included Principal Brad at School A, as well as Vice-Principals Kobe (School C) and Carol (School D) who had responsibility for mathematics at their respective schools. Principal Gilbert at School B had never taught mathematics at the secondary level. Though he had taught at the Grade 7 and 8 levels, he had never taught mathematics. The teachers in his school, coincidentally, were the only ones that did not feel supported by their principal. This suggests that content and pedagogical expertise in mathematics might be important for a secondary administrative team. When one considers that administrators have responsibility for staffing applied classrooms and conducting teacher performance appraisals, it stands to reason that they need to be guided by a strong sense of what a mathematics classroom should look and sound like.

This finding also suggests that having experience in teaching Grade 9 Applied Mathematics might have equipped the administrators to better understand and support the challenges inherent in teaching the applied course. In the three schools that had administrators with a mathematics background, the teachers spoke about the level of
support that they had and felt from their administrator. This included, for instance, knowing that the administrator would be supportive of the purchase of resources, such as manipulatives.

Finally, the department head was viewed as being an instructional leader in the case study schools and he or she played an important role in developing the Grade 9 Applied Mathematics program. The department heads also played a significant role in mentoring new teachers to the Grade 9 Applied Mathematics course. This suggests that the administrator and mathematics department head shared leadership for mathematics and that both roles had a significant impact on supporting student achievement in Grade 9 Mathematics.

**Reform-based Teaching Strategies**

**Collaborative Learning (The Learning Environment)**

The focus group participants spoke a lot about how important it is for students in applied classrooms to work together. They also spoke about how a lot of their work involved co-planning such learning experiences with teachers.

It is worth noting that many Grade 9 Applied Mathematics students may not have much previous experience with cooperative learning in math class. Kathy put it this way:

A lot of them haven't been successful. Or they've been working in different books than other kids. You know, working out of workbooks is often the experience that they've had when they come in. So they haven't even been working on something that's similar to the other students. So they often feel that they are kind of pushed aside to work on their own and do something different. (FGA: Kathy)

Despite this, I saw students working together in each of the case study classrooms. In fact, the case study teachers spoke to me about the importance of using collaborative learning strategies to take the pressure off individual students to learn and work in isolation. There seemed to be an implicit awareness that students in the applied
classroom would benefit from thinking collectively and so the teachers provided learning experiences that engaged the students in working with their peers. This included working collaboratively to both investigate mathematical concepts and solve mathematical problems.

I also noticed that there was a strong sense of community in the case study classrooms and it was apparent that the students were used to working with one another. Upon my entry into each case study classroom, I found that the student desks were set up in rows. However, when the students were asked to get into groups or to partner up for an activity, they quickly moved to where they needed to be and arranged the furniture accordingly (ObsA, ObsB, ObsC, ObsD: FN). From my own personal experience, I know that this would be very difficult to simply “stage” for a visitor and so I believe that the students were used to working this way.

All of the case study teachers spoke about the need for developing a safe place where students felt that they could take intellectual risks. They spoke about how it is often difficult to get this atmosphere up and running in applied classrooms. Many of the students do not have a history of being called on, either in large or small group scenarios. Therefore, getting them comfortable to share their thinking publicly requires persistence and support on the part of the teacher. Many of the teachers had found discreet ways to have the students begin to share their thinking, such as by using portable whiteboards on which students would record their answers to a question. This required all of the students to commit their thinking to writing. This was also helpful for teachers in drawing students into subsequent discussions because they knew what the individual students were thinking without having to call on them first. Another strategy that I observed was
“Think–Pair–Share’’ where students had the opportunity to rehearse and refine the articulation of their thinking with a partner before entering into larger group discussions.

I noticed that there was a no-nonsense, down-to-business environment in all of the case study classrooms. Yet at the same time, the classroom atmospheres felt relaxed and comfortable. I did not hear a single put-down in any of the classrooms and on only one occasion was a student disrespectful to a teacher; he was immediately dismissed and sent to the office. This speaks to the development of classroom climates that were respectful and safe for all learners.

Another observation that I made in all of the classroom spaces was the fact that there was a clear account of the mathematics learning that had been covered in the course. There were a variety of teacher, student, and co-created visuals including charts and word walls, as illustrated in Figure 20. These provided both an anchor to and a record of student learning. This may seem to be a rather simplistic observation, but the reality is that because different courses will share the same classroom space in secondary schools, the classrooms often remain very sterile and “bare.” There is frequently very little in the way of content posted on secondary classroom walls. Therefore “marking” classroom space in this way needs to be negotiated amongst the teachers that use it. It would seem, therefore, that having a dedicated Grade 9 Applied Mathematics classroom space was a priority in the case study schools. This is important because Grade 9 students are used to this kind of environment in their Grade 7 and 8 classrooms. Having student work posted is also beneficial because it allows students to see the variety of ways in which others approached a problem. Finally, these records of learning can be extremely helpful to students that may have poor organizational and note taking skills.
because they can refer back to them. Many students in applied classrooms will fall into this camp.

![Figure 20. Examples of anchor charts in three case study classrooms.](image)

In summary, each of the case study classrooms had a strong sense of community and the students were positioned as important resources to one another’s learning.

**Student Tasks**

As was already established, the case study teachers preferred tasks that engaged students in active and hands-on learning. The kinds of tasks that students were assigned served as a site for the practice and application of skills. In addition, though, the tasks given to the students required them to engage in problem solving and critical thinking; in all of the classrooms, students were required to do more than parrot a technique given them by the teacher. They were required to use their knowledge and skills in mathematical applications that involved problem solving and critical thinking.
I would also say that although the lesson problems were rich in that they engaged students in problem solving and required them to represent and communicate their thinking, I found that the thinking itself was scaffolded by the preceding questions or activities. For example, in Classroom A, the students were asked to solve problems involving the use of tables and graphs before being given a problem that would require them to use both of these representations. On the other hand, in Classroom C, I observed students doing an investigation in which they explored the relationship between triangles, the number of sides in a polygon, and the sum of the interior angles in a given polygon. This element of exploration, in my mind, made the work “richer” because it required students to make, test, and follow up on their own conjectures.

My findings from the literature review indicated that one of the pitfalls of streaming was that low-level tasks often predominate the learning landscape in the lower streams. Therefore, I wanted to explore this element in the case study classrooms. To help me in analyzing the tasks that were used during my classroom observations, I turned to the taxonomy developed for the TIMSS framework. This taxonomy distinguishes the cognitive dimensions of test items by specifying the thinking processes that are assessed:

The first domain, knowing, covers the facts, concepts, and procedures students need to know, while the second, applying, focuses on the ability of students to apply knowledge and conceptual understanding to solve problems or answer questions. The third domain, reasoning, goes beyond the solution of routine problems to encompass unfamiliar situations, complex contexts, and multi-step problems. (Grønmo, Lindquist, Arora, & Mullis, 2013, p. 24)

In the framework, the dimensions are further articulated by the verbs that are associated with the mathematical tasks, as outlined in Figure 21. I used this particular framework for determining the level of cognitive demand that was required of students in the case study classrooms for the lessons that I observed. Through my analysis, I found
that in each of the classrooms that I visited, the highest level of cognitive skill—reasoning—was demanded of the students. (see Appendix I for an outline of the tasks that students were assigned, along with the requisite level of cognitive skill). The students were being asked to do more than carry out mathematical procedures; they were asked to apply them and reason about the results. This goes well beyond the typically low-level tasks that are often associated with the lower streams, as was highlighted in the literature review. In each of the classrooms that I visited, the students worked on a series of questions that led up to a concluding task or problem and there were elements that involved the practice of skills (knowing), application of procedures (applying), and problem solving (reasoning). This thinking is also required on many EQAO test items.

<table>
<thead>
<tr>
<th>Cognitive Skill</th>
<th>Associated Verbs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowing</td>
<td>Recall</td>
</tr>
<tr>
<td></td>
<td>Recognize</td>
</tr>
<tr>
<td></td>
<td>Classify/Order</td>
</tr>
<tr>
<td></td>
<td>Compute</td>
</tr>
<tr>
<td></td>
<td>Retrieve</td>
</tr>
<tr>
<td></td>
<td>Measure</td>
</tr>
<tr>
<td>Applying</td>
<td>Determine</td>
</tr>
<tr>
<td></td>
<td>Represent/Model</td>
</tr>
<tr>
<td></td>
<td>Implement</td>
</tr>
<tr>
<td>Reasoning</td>
<td>Analyze</td>
</tr>
<tr>
<td></td>
<td>Integrate/Synthesize</td>
</tr>
<tr>
<td></td>
<td>Evaluate</td>
</tr>
<tr>
<td></td>
<td>Draw Conclusions</td>
</tr>
<tr>
<td></td>
<td>Generalize</td>
</tr>
<tr>
<td></td>
<td>Justify</td>
</tr>
</tbody>
</table>

It is also worth re-iterating that the types of tasks that the case study teachers tended to use encouraged a process that went beyond simply using a formula. Students were expected to show their thinking and were therefore required to show different kinds of representations such as graphs, charts, diagrams, etc.: 

And I think also, you know, the critical thinking. Giving them some questions that don’t have one answer, you know. And saying that, “Guys don’t try to memorize formulas because it’s not always about a formula, you know. There isn’t always one right answer in math and helping them to see that as well. And giving them questions that can be solved different ways. So that they see you don’t have to memorize a formula because he solved it that way and I solved it that way, he solved it that way, and things like that. (IntC: Emma)

It is probably no coincidence that I found students in the case study schools were more likely to score a Level 4 on the EQAO assessment than were their counterparts across the province (see Table 16). Level 4 signifies “that the student has achieved all or almost all of the expectations for that course, and that he or she demonstrated the ability to use the knowledge and skills specified for that course in more sophisticated ways than a student achieving at Level 3” (EQAO, 2009, p. 14). Achieving at this level requires students to not only apply mathematical concepts, but to use relevant mathematical knowledge and skills to represent and explain their answers.

Table 16

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<thead>
<tr>
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<tbody>
<tr>
<td>Province</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>School A</td>
<td>28</td>
<td>16</td>
<td>21</td>
<td>14</td>
<td>23</td>
</tr>
<tr>
<td>School B</td>
<td>14</td>
<td>26</td>
<td>12</td>
<td>23</td>
<td>28</td>
</tr>
<tr>
<td>School C</td>
<td>0</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>School D</td>
<td>9</td>
<td>5</td>
<td>2</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>
Clearly, this data shows that the case study schools can hold their own where Level 4 performance is concerned. Schools A and B were particularly impressive in this regard with two or three times as many students at Level 4 than the provincial average.

**Constructivism**

As discussed previously, one of the biggest shifts with the introduction of the revised Ontario Curriculum: Mathematics, Grades 9 and 10 (2005) was the change from a theoretical to more practical, hands-on approach. The Grade 9 Applied Mathematics course description states that the course “enables students to develop an understanding of mathematical concepts related to introductory algebra, proportional reasoning, and measurement and geometry through investigation, the effective use of technology, and hands-on activities” and that “students will consolidate their mathematical skills as they solve problems and communicate their thinking” (OME, 1999, p. 38).

The general sentiment expressed by the mathematics leaders was that this approach or philosophy was not being realized in many applied classrooms that they knew of. For example, in his role as the chair for his board’s Numeracy Committee, Kobe expressed that:

> They are not being taught the way that was intended to be, right? Where they are doing more hands-on activities, you know? They are still in their seats. The teacher is still at the front and you are not getting much of that. And we have really tried to push away from that and get more activities … The biggest barrier to applied level students is that teachers who aren’t—some teachers aren’t—really aware of the teaching strategies those students need in their class, right? It’s not been implemented to the extent that we hoped for. So if you walk into an applied level classroom, we’re hoping to see these activities and it’s hard, I think, for some teachers to let go of that control. Let go of the control and let the kids do some work and see what they can do, right? And we talked about using manipulatives in classrooms and the teachers said, ‘Well, are we going to get the elastic bands out to do that?’ And it was like, “Well who is going to get shot first?” Right? But they brought them out and they were totally surprised that the
kids were totally engaged and not one elastic was chucked. So I think it’s still part of that learning process and having to let go of the control. (IntC: Kobe)

The case study teachers seemed to be somewhat of an exception to this rule; much of what was happening in their classrooms seemed reflective of the constructivist stance. Two of the tenets of constructivism that emerged from the literature review were that learning must be active and it must be social. As discussed previously, the case study teachers tended to use a lot of activities that engaged students in hands-on learning, rather than instructing them from the front of the room. They also allowed opportunities for students to explore, problem solve, reason, and process thinking with their peers. The third element of constructivism is that new learning must be created/constructed in the mind of the learner as opposed to being “transmitted” from teacher to student.

In his articulation of constructivism in the mathematics classroom, McDougall outlined a continuum of teaching practices, as illustrated in Figure 22.

<table>
<thead>
<tr>
<th>Instructional Approach</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>The teacher takes a…</td>
<td>… predominantly skills approach to learning mathematics</td>
<td>… skills approach and a conceptual approach to teaching mathematics</td>
<td>… predominantly conceptual approach to teaching mathematics, occasionally using a constructivist approach</td>
<td>… predominantly constructivist approach to teaching mathematics</td>
</tr>
</tbody>
</table>


Through my conversations with the case study teachers and my observations of what took place in their classrooms, I would speculate that all of them were at a minimum of Level 2 in this dimension of constructing knowledge. I think that all of the teachers were concerned with skill development and they also wanted the students to
understand the mathematical concepts. In terms of knowledge construction, however, the lessons were teacher-directed. With the exception of the lesson that I observed in Classroom C, the observed lessons did not start from a point of student inquiry or investigation. Although the teachers did not teach from the front of the room, the lesson was structured in such a way that it stepped students through a series of activities and questions from which they could draw upon to solve the culminating lesson problem. Although the students were learning by doing, the “doing” was highly structured.

All of the teachers provided activities that required students to engage in reasoning—by problem solving, making conjectures, reasoning, reflecting, and communicating their thinking. This put the students in the active role of mathematician. They had to do more than simply follow procedures; they had to apply them in new situations and then interpret the results. Furthermore, the students were engaged in meaning-making through the use of manipulatives, conversations, and collaborative problem solving with their peers. However, as pointed out above, the thinking of the students was scaffolded by the sequence of lesson activities. For example, in Classroom A, the students were led through a review of how to graph partial and direct variations before being assigned to work in groups to solve a problem scenario that involved graphing two such relationships in order to determine “the best deal.” This review included a check-in on the students’ conceptual understanding. For example, the teacher asked questions like, “What do you think this means?” And “Can anybody add meaning to that?” (ObsA: FN). As the lesson unfolded, the students were supported with the strategies that they could use to arrive at the graphical representation that would help them to solve the lesson problem. They were supported with the “skills” aspect of the
problem solving. However, to arrive at the final solution, the students had to employ their own thinking and reasoning.

In a similar way, the students in Classroom D were led through a review of how they could create a table of values and were then assigned a group task that involved them in graphing a system of linear equations, making use of this skill. They, too, had to interpret the resulting graph and draw conclusions related to the problem scenario to arrive at the final solution.

In Classroom B, the teacher and students worked through a demonstration on the interactive whiteboard to determine that the three angles in a triangle always add to 180° as illustrated in Figure 23:

![Figure 23](image-url)

*Figure 23.* Investigation of the sum of angles in a triangle.

After exploring and working with a variety of triangles, the students were able to generalize that the sum of the interior angles in a triangle is always 180°. As opposed to just telling the students this fact, the teacher helped the students come to realize it for themselves. This kind of work supports conceptual understanding of mathematical truths. It also gives students a visual or representation, that they can later draw on, or even reconstruct, to access the learned fact. After the teacher and students had worked through this demonstration, the students worked in pairs to find the missing angle in a variety of problems and contexts.
Finally, in Classroom C, the students worked in small groups to develop the formula for finding the sum of the interior angles in a polygon. This was an investigation in which the students determined the relationship between the number of triangles that could be formed in a regular polygon, the number of sides of the polygon, and the sum of the interior angles in the polygon. In this case, the students started with an investigation that was unchartered territory. They had to use their own strategies to arrive at the solution; they were not led there.

In all cases, once the students had worked together to solve the main lesson problem, the teacher brought the students back together in the whole group to discuss what they had learned and how they had solved the problem. New understandings were extracted from the student experience and the teacher formalized the learning where possible. For example, in Classroom A, the conversation focused on interpreting the graph of the two equations, e.g., at which point one option would be cheaper than the other. In Classroom C, the teacher helped the students to generalize the formula for the Sum of the Interior Angles of a Polygon as \( S = (n-2) \times 180^\circ \), where \( S \) is equal to the Sum of the Angles and \( n \) is equal to the number of sides of the polygon.

Another common theme that was expressed was a concern that many students in applied classrooms lacked basic skills, such as understanding the order of operations. The focus group teachers talked about how it was pretty commonplace for the applied course to start off with a big review unit. However, this did not seem to be a good approach as Kathy explained:

We did used to start off both our academic and our applied doing review of skills that we thought were important and we just in the last couple of years did away with that because we thought, "Why are we reviewing dividing fractions when they really don't even use dividing fractions?" And you didn't have the time to
even go deep enough with kids to help them understand how to divide fractions, you know. You ended up just reviewing a lot of procedural stuff. But we have kind of shifted it to looking at the beginning of the unit. So if we're doing measurement, what are those important skills? What do we need to review with the kids? And doing that as it comes. As opposed to starting out that way for two weeks at the beginning of a semester. (FGA: Kathy)

It is also interesting to note that all of the case study teachers spoke about how they embedded basic skills into their lessons on an on-needs basis. They had found this approach much more effective than taking time out at the beginning of the year for a big review. In the lesson that I observed in Classroom C, for example, the students began their lesson with a “Skill Builder” activity that involved them in using mental math to multiply by 18, e.g., $18 \times 6$ is the same as $2 \times 9 \times 6$ or $2 \times 54$ which is equal to 108. This was a skill that they would use later in the lesson.

**Use of Manipulatives and Technology**

The value of manipulatives and technology emerged as a theme for both the case study teachers and focus group participants. The talk around the use of manipulatives and technology positioned both as being tools for thinking—that they can actually help the students to think through a problem. In essence, these tools engage students in “doing mathematics” in the way that mathematicians “do mathematics.” The general sentiment was that these tools are especially important in applied classrooms because many students in them tend to be very “hands on” and kinesthetic learners and by definition learn by doing. In this sense, manipulatives act as a hook and support to doing the math. Besides engaging them, manipulatives are important for helping students to develop conceptual understandings. For example, Bill spoke about the value of using algebra tiles to help students understand operations with integers:

Just the integer operations are so much easier when you do it with algebra tiles. You can say, ‘I have positive 12 and negative 9, so these cancel these guys’
(gesturing). And there’s a website on line where they will actually disappear if you do that. So the kids get the concept of the zero principle really quickly. Like I have 12 (gesturing) here and there’s 19 of these guys (gesturing), so those 12 disappear and I’m left with 7 of these guys and they are all positive…. There’s one for balance too where you balance the equations as well… And the kids pick it up nice and see what the opposite operation means. I have a positive two (gesturing). I need to get rid of them, so I need a negative two. And you can also do division. I’ve got three x’s here (gesturing) and I have 9 over here (gesturing), so each x gets 3, or \( x = 3 \). (IntA: Bill)

Although I did not see any concrete manipulatives being used in any of the lessons that I observed in the case study classrooms, I did notice that they were available in all of the rooms and that the students had free access to them, as illustrated in Figure 24.

![Manipulative cart, Classroom A.](image)

*Figure 24. Manipulative cart, Classroom A.*

Another theme that emerged from the focus groups is that it is often difficult to get teachers of applied classrooms to embrace the use of manipulatives and technology. Lynda shared how one of the schools that she works with was audited by EQAO during the Grade 9 Mathematics assessment period:

And they came in and they said, ‘Do you guys have manipulatives out for your kids?’ And they were like, ‘Ya, they’re right here.’ And not one kid used them. And they’re like, ‘How come they are not using the manipulatives?’ And I’m thinking, ‘I’ll tell you why. Because the box hasn’t been cracked open since last EQAO. That’s why. It’s in the storage room until it gets brought out and put on the table for EQAO.’ (FGC: Lynda)
The fact is that manipulative use is relatively new in Ontario secondary schools. From my own experience, secondary schools in my district did not even start strategically thinking about using manipulatives until the release of *Leading Success: Leading Math Success* (2004), which recommended teachers use them to support student success in mathematics. With this OME initiative came funding that helped the board to begin to purchase manipulatives for secondary classrooms. Quite simply, therefore, there is a not a long history of manipulative use in secondary schools.

This speaks again to the need for teachers to have support in learning how to incorporate these resources into their practice. When you consider the case study teachers, many of them had a background in the elementary panel where manipulatives are more widely used. Two of the teachers at Case Study School D had been math coaches previously, and had actually helped other teachers in their board to develop a practice of working with manipulatives. In Case Study School C, the school had worked with its’ feeder schools and the teachers spoke about how they had learned to manage and implement manipulative use when they had visited these schools.

Technology was also used widely in the case study classrooms. Specifically, the teachers used graphing calculators, math specific software such as Geometer’s Sketchpad, and web-based applications such as virtual manipulatives. Again, these tools serve as a hook to engage students and are important for developing conceptual understanding of the mathematics. For example, Ivan spoke about how he used a class set of Inspire graphing calculators:

So I like to use those with my applieds for the algebra stuff, right? Just to let them experiment. So rather than trying to teach combining like terms, I just say, ‘What happens when you punch in $3a + 4a$?’ ‘$7a.’ ‘Why does it say that? Where do you think that’s coming from?’” So that sort of investigative—you
know—that tool allows me to put the investigation into their hands and let them experiment with it and let them muck about for a while. You know, I think it’s been great for solving equations because one of the issues for students is they know they have to, or they think they want to subtract three from both sides and so they just go and put down what they think the next line should be and it’s sometimes wrong. Whereas if you tell the Inspire to add 3 on both sides, it’s going to do it, and it’s going to do it correctly. And if it doesn’t match what you think it was supposed to be, then you know you need to go back and re-think that adding three. So I get that immediate feedback. So when I’m teaching solving equations we do it from that perspective. (IntC: Ivan)

OME-licensed software such as Geometers Sketchpad, Gizmos, and Fathom were discussed by many of the case study teachers and focus group participants as being important resources for teaching and learning. This is understandable because the curriculum actually makes reference to using dynamic geometry software and dynamic statistical software in investigations.

**Classroom Discourse**

The importance of getting students to talk together about the mathematics that they were engaged in emerged as a theme in both the focus groups and case study interviews. This strategy was helpful not only to the students, but to the teachers as well.

As already established, the case study teachers liked to assign partner and small group work, in part to get the students talking about the mathematics that they were exploring. The support of the others in a group or partnership was also important for students who might struggle otherwise. As Kate put it,

Yep we work in pairs and groups. A lot of times you would think in the applied classrooms that it wouldn’t work very effectively but the students really like that idea, ‘…if I’m working and I have a question, I can talk to that person next to me and they can help me out.’ And so, you know, we set our classrooms out so that it’s mixed abilities groups and then it will work. And, you know, if the student who has difficulty can actually help someone who is a stronger student, then they
feel so much better about themselves. So there’s tons of interaction. There’s conversation. (IntD: Kate)

During my classroom visits, I did indeed find students working in this way. As they were working, I noticed that the case study teachers walked around the room and engaged students in informal conversations about what they were doing and how they were approaching the problem. I also saw how the teachers would bring the students back together in the whole group to more formally share how they had completed the assigned task. These conversations were helpful for three reasons. First, they helped students to realize that there was more than one way to tackle a problem. Second, it created a shared understanding, which was sometimes documented on classroom anchor charts as illustrated in Figure 20. Third, teachers would get insight as to what students were thinking and who might be struggling. This is important to inform teaching:

We had a lot of conversation out in the room. The beauty of it was that we’d had just that. The kids were hearing math discussion or we were engaged in a math conversation and there were lots of ideas out there that they could take in. And I knew and they knew what one another were thinking without ever having written anything down. Or another way to say it, I didn’t have to wait until they had written something down and handed it to me to know what they were thinking. I knew right on the fly. You could make adjustments. You could ask for more information. There were lots of ways you could go. So in terms of just speaking to the engagement, ya, the engagement went way up. And since the engagement was up we had the opportunity to address misconceptions and extend topics and get a sense of where we wanted to go. (FGB: Gilbert)

I also noticed that the students were expected to explain their thinking in all of the case study classrooms. It was never enough for them to simply state an answer; they had to also explain why. This pushed the students to solidify and articulate their mathematical thinking
Assessment for Learning

There were a number of themes regarding Assessment for Learning that emerged from the data. These included the importance of frequent monitoring, the significance of conversations and observations, the need for timely and descriptive feedback, and the value of practicing for EQAO-style assessments.

One of the things that became very apparent to me in speaking to the case study teachers is that they all had means to check in on or monitor individual students on a regular basis. For example, Steve had daily multiple-choice quizzes in his class. These quizzes gave him the opportunity to see who was struggling with the recent content. The students completed the quiz as soon as they entered the class and as he marked it, they did a warm-up activity. On the day that I observed, the students had to copy a note from the board into their notebooks. This note outlined the learning goals and success criteria for the day’s lesson. Steve then returned the quizzes to the students and gave individual feedback to the students that were struggling. This whole process took nine minutes. For the main problem-solving task, Steve teamed up students who had done well on the quiz with students who had done poorly (ObsA: FN).

In Classroom C, the students had to complete an exit ticket before they left the classroom. This exit ticket had questions that reflected the work that the students had done during the last few lessons, namely finding the missing interior angles for a variety of triangles (ObsC: FN). They were given eight minutes to complete this task. I did not witness the use of exit tickets in either Classroom B or D, but the teachers had mentioned it is a strategy that they frequently used to make sure that all students were on track. Additionally, the teachers spoke about the importance of these kinds of strategies in
helping to group students for various tasks. For example, they might pair up students that were struggling with a concept with students that were doing really well with it.

Giving timely and descriptive feedback to the students came up as another theme for both the focus group participants and the case study teachers. The general sentiment was that students in applied classrooms cannot wait until the end of the unit to see how they are doing. They need teachers to check in on them more frequently than that and to intervene when necessary. Timely feedback is described as immediate and responsive to how students have met a particular learning or content goal. Descriptive feedback involves an explanation of what a student is doing well, as well as what needs to be improved and how. I observed all of the case study teachers circulating as the students were working on the main lesson problem. As they were doing so, they were engaging in observations and conversations with the students, and giving them this type of timely and descriptive feedback. Sandra described this as:

> While they are doing the work I’m just walking around giving them pointers, helping them out. All of the time. I don’t do a lot of, ah, I don’t do a lot of paper assessments. Just at the end of the unit. Or a lot of quizzes. I don’t really feel that I need to because I sort of know where they are at from that. (IntB: Sandra)

This kind of feedback is particularly important for students in applied classrooms, as Malcolm described:

> There are a few things that stuck with me from that old *Leading Math Success* book from 2004, right? You know there were a lot of good points. And one in particular working especially with applied students is that the best feedback is oral. You know, the very best feedback is oral. It is the best received. You know, to get down on a student’s level, tell them what they are doing well with what they are doing. Tell them, you know, where they need to improve and suggest what they’re going to be doing next. I mean this is, in an oral and individual basis, trying to make it and emphasizing doing that. It doesn’t show up on paper anywhere, it’s not anything that we are tracking, but doing that very intentionally it’s really important, and really, you know, useful. But anything that you take in, you know, I always find my very best ideas for what we’re going to
do in class come when I’m looking at student work and then you realize what we need to work on. (FGB: Malcolm)

As Malcolm alluded to, these conversations and observations are not only important to the student, they are important to the teacher because they help to inform the next teaching move. The math leaders also talked about how important it is to be responsive to learners in applied classrooms. In speaking about Steve, for example, Tammy said:

He is purposeful in his thinking and his planning and responding to where the kids are at and what they know. And I’m just thinking too, Steve probably talked to you about this too, but he, I think, has a very effective use of very timely feedback that he uses on a daily basis so he knows where they are. And so do they. (IntA: Tammy)

A final theme that emerged from the case study classroom was the teachers’ use of EQAO sample questions in their teaching. The teachers talked about how they would source questions from the student booklets that are available on EQAO’s public website. They would then integrate them into the bank of questions that they would use during a unit of study. In this way, the students would get used to the styles of question and not be intimidated by them. Emma described it this way:

Well, we all use the EQAO website. And we take the questions and we really incorporate them with our daily teaching with the students, so that’s something. The kids are very familiar with EQAO questions. My students would typically do a minimum of two open response questions a week, you know. So that’s something. They are just so used to them so that by the time the EQAO comes around they’ve done it a hundred times… And because they see EQAO on a regular basis, they go into it not feeling like, ‘Oh my God, this is the first time I’m seeing it.’ And I know that other teachers do that as well to try and expose the kids so that it takes away some of the anxiety. Test taking is a big source of anxiety for a lot of kids. (IntC: Emma)

The research participants also spoke about helping the students to develop test-taking skills, such as how to deal with multiple-choice questions. They felt this to be very important to students in applied classrooms because they have not necessarily
developed these skills before and as Emma mentioned, many of them are anxious about tests to begin with. As Ethan explained, this kind of critical thinking is actually important to foster:

And it's one of those things where, you know, if you're going through and two weeks before EQAO is happening and you're talking about "Well, how do we eliminate possibilities? You might not know what it is, but you know what it isn't. And you give them confidence to say, 'It's A or B. I'm not 100 per cent sure mathwise, but you know I'm going to take an educated guess.' That's an okay skill to teach kids. And do I think they are successful directly because of their math ability? I don't necessarily think so, but a combination of their math ability through open questions and their test taking skills through the multiple-choice, I think that that is a powerful combination. And it's okay to teach kids. (FGA: Ethan)

In addition to the test questions, the case study teachers would also make use of the EQAO anchor booklets that contain examples of student answers at different levels of performance. This helps the students to see what a good answer looks like. It also provides them the opportunity to think about their own work and what they need to do to improve it.

I'll say, 'Okay, here’s a question. Everybody do it….’ ‘Okay. Here’s a 10. Here’s a 20. Here’s a 30. Here’s a 40. Here’s why. What do you think yours is worth? How did yours compare to that?’ Then I’ll say, ‘Okay here’s another one. Don’t put your name on it.’ And we’ll trade papers. ‘Okay here are the four anchors. What do you think that one is worth? Trade again. ‘And what do you think that one is worth? Put a number at the top. Do you agree with what your peers said or not?’ Ah, you know that whole self-reflection. ‘Okay here’s your paper. Here’s a 30 or here’s a 40. What would you do to make yours look more like this? What more would you like to do? What will you remember next time,’ you know. Sometimes we’ll get out a question—we have a document camera in the classroom—so I’ll throw it down there. And I’ll say, ‘Okay let’s make up a code 40 answer. What should we include here? What do you think? And get the students give input.” (IntC: Ivan)

This self-reflection helps the students to build metacognitive strategies that they then take with them, not only into the testing situation, but also into their everyday work.
Fostering Positive Dispositions towards Mathematics

There were a number of patterns that emerged from the data that are related to fostering positive dispositions in Grade 9 Applied Mathematics. These were: fostering a love of and positive relationship with mathematics; counteracting the negative stigma associated with Grade 9 Applied Mathematics; demonstrating an ethic of care; building student confidence in mathematics; leveraging the social nature of adolescents, and establishing high standards and expectations.

A theme that emerged from all of the data sources is the fact that students in Grade 9 Applied classrooms have, by and large, become disenfranchised and even traumatized by their prior experience of mathematics. They express strong sentiments about not liking math, not being good at math, and not seeing how math matters to them. The fact that they have been channeled into the applied course exacerbates the problem; the focus group and case study participants unanimously spoke about there being a stigma attached to Grade 9 Applied Mathematics. As Emma put it:

There’s a stigma for sure. I think they hear things like, “He’s going to drop down from academic to applied.” I think we need to stop saying that. I don’t think it’s dropping down. I don’t think it’s, you know, a step below any other academic kid. It’s just a different course and a different style of learning. So I think for sure there is a stigma that is in, you know, the school and the community…. And I think we do it subconsciously and don’t even realize it, but I think we need to change that cause kids hear those things and they interpret them and internalize them and I think that the biggest thing that is standing in the way—is just the way that they believe they are interpreted. (IntC: Emma)

As Emma alluded to, this stigma extends to the teachers and parents. There are many mathematics teachers who simply do not want to teach this course and many parents will not place their child in the applied course. This was something that was brought up in the focus groups of math leaders as well, for example: “I would say from my experience, Grade 9 Applied comes with almost a stigma where teachers are like,
‘Ach, that’s not my favourite class. There are always behavioural issues,’ and ‘The math is not that fun,’ and ‘The kids are so weak’ (FGC: Lynda).

The case study teachers were sensitive to this stigma and recognized that it impacted their students’ relationship with mathematics. When I asked them about the typical student in the applied classroom, they spoke about how these students, as a rule, feel pretty beaten up by mathematics. Steve expressed it this way,

I would say, as a whole, most of them are there because of low self-esteem. They have told themselves they can’t do math. So it’s easier, rather than working hard, it’s easier just to give up. Well if you give up in Grade 4, when do you actually get it? So now they are behind because they failed math in Grade 4, and Grade 5, and Grade 6, and Grade 7, and Grade 8. They just keep getting poorer. Now they show up in Grade 9 and where is their self-esteem now? They’ve been told they are useless and stupid and can’t do math for multiple years. And now I’m saying, ‘Come on, try.’ And they are like, ‘What’s the point? I’m going to fail.’ (IntB: Steve)

As an antidote to this reality, the data from both the focus groups and the case study schools strongly suggests that it is important for teachers to quickly foster a feeling of success and comfort in the Grade 9 Applied Mathematics classroom. The following exchange between Bill and me is extremely typical of the response that I received when I asked the study participants about the biggest barriers to success in Grade 9 Applied Mathematics and what they did to help alleviate it:

Bill: The biggest barrier? I think just the fact that they’ve had eight or nine years of math already and they’ve decided they don’t like it that much. I think that’s the biggest barrier. They are afraid that they won’t do well.

Alison: Okay

Bill: Ya. I think that’s a big one

Alison: So what is important in getting them over that?

Bill: Just to have success. Find a way to get them successful. So that they can feel good about it…. find a way that they can go, ‘This is successful… I
can do this.’ Ya. I think that’s what I do, to find the ones that are struggling and say, ‘You can do this. You can be successful.’

Alison: Build them up?

Bill: Yep. I think it’s to find a way just to make them feel comfortable in school. That they are important. And they can do it. Try all you can to do that. To let them know, you are important to us. You are not going to be left at the wayside. It’s important and you’re important. (IntA: Bill)

This ethic of care permeated the classroom settings that I visited. It immediately struck me, for example, that the teachers made a point of greeting the students as they entered the classrooms. They were able to engage in easy banter with them by asking questions such as, “How did the hockey game go?” This suggested to me that they knew the students on an individual basis. I also felt a strong sense of relationship, not only between teachers and students, but also between the students themselves. In many cases, there were constructive messages posted in the classroom such as, “Just because something is difficult doesn't mean you shouldn’t try. It means you should just try harder” (ObsD) and the quote of the day, “Whatever you are, be a good one” (ObsC).

In a very real sense, the case study teachers recognized that they were in damage control. Not only do they need to help students repair their relationship with mathematics, but also the damage caused by the perceived stereotype of what it says about you if you are a student in Grade 9 Applied Mathematics.

The study participants also spoke about how important it is to value the learning and strengths that “applied-level” students bring to the classroom. Recognizing that the students are not blank slates is important, and so too is activating their prior knowledge so that they understand what they are learning now is simply building on what they already know. The case study teachers also spoke about how, as a whole, students in
applied classrooms are less formulaic in their thinking and approach problems more creatively. In fact, they argued that these students are more likely to engage in “common sense” thinking. The teachers felt that it is very important to play to this strength by accepting a wide variety of strategies and methods, even if they do not “look pretty” or follow conventional formats. For example, Malcolm expressed:

We have to be open to allow them to use reasoning and their reasoning will often look sloppy compared to what we want to see for good mathematical form. And I think we really have to embrace that instead of fight it. I’m thinking right now something as simple as solving equations, right? Let’s say—solve a linear equation. You know I can either beat you over the head with doing it with the same form as me, or I can talk to you and allow you to reason through it some and build some thinking. (Malcolm, FGB)

Besides building this sense of student success and confidence in mathematics, the case study teachers also felt that it is important to foster a love of math in the Grade 9 Applied Mathematics classroom. Furthermore, the teachers themselves seemed to share this passion and joy for all things mathematical:

We all have a love of math. And I think it’s just, it’s fun. Like I enjoy it. I enjoy being in the classroom because you get to see the kids in that. I love doing math. My grades might not have been the best, but I just love doing it. I love teaching it. Having students, you know, engaged in it. Like I think a lot of time (non-math) people have their qualifications in Intermediate and Senior, so we just give them Grade 9 Applied. Like you are just getting a bunch of kids who maybe don’t want to do math or whatever so it doesn’t matter. But our Grade 9 Applied teachers want to teach math and it’s not that they are just staying one day ahead… Like I find math to be the most useful and I can sit there and think about probability stuff all day. Like that’s my kind of brain. That’s the way my mind goes. I know a lot of people aren’t like that, but I’m always thinking in that mathematical sense. So like I try to bring that into the classroom as well. But that’s where some of the success might be. From the people that we’ve had here in the past few years. They share a love of math and you know, they want everyone to do well in it. (IntA: Mark)

Many of the teachers talked about how they brought interesting math puzzles, anecdotes, and stories of interest to the students so that they would develop a more robust
appreciation of what mathematics is and the often-compelling history behind it. This again speaks to the importance of staffing the Grade 9 Applied Mathematics classroom. To really fire up students about the subject and help them to care about it, you need teachers that are themselves passionate about mathematics and eager to share it, even with those who might struggle.

The case study teachers also leveraged the social nature of the young adolescent. During my classroom visits, I would say that the students worked with partners or small groups for the bulk of the period. The teacher would bring the whole group together in order to give direct instruction, engage in demonstration, consolidate findings and learning, or to introduce a new task, but this lasted for no more than ten or fifteen minutes. There was very little in the way of “sit and get.” Instead, the students were active and engaged in doing math; they were not sitting in isolation working on their own.

Another important characteristic of all of the case study classrooms was that the teachers had very high expectations for their students. Erin expressed it this way:

I don’t think we have enough expectations of our applied kids. Like I think you hear teachers sometimes say, “Well it’s just applied” or “It’s only applied” and again, these kids are the same kids. Like they could be fighting academic kids for jobs after high school. Like who knows? You know they are going to have responsibilities. They are going to have families. They are going to have bills to pay. They are going to have to manage their time. All of these things. And I think that we have to set some sort of bar for them. Because if we don’t have these expectations of them, we are doing a really lackluster job of preparing them for life after high school. And I think they sense when we don’t have expectations of them. I think they sense when it’s like, you know they come to you and say it’s applied and we won’t have any homework. Well you bet you’ll have homework. In my class you will. Because why would I not have the same expectations in terms of work ethic for my 1Ps (applied course) as I have for my 1Ds (academic course), you know? (Int Ė: Erin)
In keeping with this, I was also struck by the rigorous nature of the lessons as they unfolded in the case study classrooms; in every case there was a very fast pace and a lot of work was accomplished during the 75 minute period. In my interviews with the teachers, they had spoken to me about how they would typically “chunk” their lessons as illustrated by the lesson agenda for Classroom C in Figure 25.

![Lesson agenda for Classroom C observation.](image)

*Figure 25. Lesson agenda for Classroom C observation.*

It was typical during my classroom observations that the students would spend no more than ten to fifteen minutes on any single activity during the lesson. Furthermore, the teacher would be reminding the students constantly how much time was left for the activity and what was expected, e.g., “there are ten minutes left and then I want to hear from each group what you found out” (ObsB). Expectations were high, clear, and followed through on. To re-iterate, the tasks within a lesson were demanding and included high levels of cognitive demand. I would also say that the case study teachers also had a tenacious and “whatever it takes” attitude. They spoke about offering extra help sessions for students. Steve in Classroom A, for instance, spent his lunch hour in his Grade 9 Applied Mathematics classroom every day. This time period immediately
preceded the Grade 9 Applied course. At lunchtime, Steve was available for extra help; he even made fresh popcorn and had juice boxes on hand (ObsA: FN). In three of the four classrooms, I saw the teachers seek out students who had been absent the previous day to catch them up on what they had missed; they had a very strong pulse on each and every one of their students.

Summary

In this chapter, I have outlined the resources, professional learning, math department, leadership, and reform-based teaching practices that were common amongst the case study schools, and endorsed by the focus groups of mathematics leaders. In asking what leads to success in Grade 9 Applied Mathematics classrooms, I have been able to identify some common practices and collective wisdom from the study participants.
CHAPTER FIVE: DISCUSSION

Overview

This thesis was concerned with discerning the practices that appear to support student achievement in Grade 9 Applied Mathematics. It involved collecting interview data from three focus groups of mathematics leaders from across the province, as well as the case study of four high performing schools, as measured by the provincial assessment for Grade 9 Applied Mathematics. Through the analysis of interview and observation data, artifacts from the schools and classrooms, EQAO Reports, Ministry of Education demographic and student achievement data, and my field notes, I was able to identify certain practices that were common to the case study schools and endorsed by the focus group participants. It is important to point out that I did not visit any schools that have been low performing on the provincial Grade 9 assessment; I do not know if the practices common to the study schools are or are not being used in less successful schools.

The Research Questions

This study set out to answer two research questions that were posed in Chapter One. To review, these questions were:

• What practices are being used by high performing or rapidly improving schools, as measured by the Grade 9 EQAO Assessment for Mathematics?

• Which of the specific practices identified in the mathematics and general reform literature as being related to better mathematics achievement have been adopted by the most successful schools?

I will examine each of these in light of the findings (outlined in Figure 26) from my research.
Figure 26. Mind map of research findings
The literature outlined in Chapter Two established that in the province of Ontario, massive changes have been introduced to secondary mathematics classrooms over the past two decades, in part due to secondary school reform, and in part due to new curricular and assessment policies. The conceptual framework highlighted five areas from the literature that theoretically should support educators in making the kinds of transformations inherent in the reforms: resources, professional learning, math departments, leadership, and math-reform teaching practices. The questions asked of the participants reflected these elements. This research established that were indeed practices that were common to the case study schools.

Discussion of the Research Questions

1. What practices are being used by high performing or rapidly improving schools, as measured by the Grade 9 EQAO Assessment for Mathematics?

The first research question was concerned with discerning practices common to schools that are high performing or rapidly improving on the EQAO Grade 9 Applied Mathematics Assessment. Given that students in the applied course have consistently performed poorly on this assessment and given the mounting evidence that poor performance in this course can have a negative impact on secondary and post-secondary outcomes, this is an important question to address.

The literature review established that when it comes to resources, the lower level streams often take the backseat to the more academic courses. This is true both in terms of material (Applebee et al., 2003; Boaler et al., 2000; Callahan, 2005) and human resources (Berry et al., 2002; Crosby & Owens, 1993; Hanushek et al., 2003). The case study schools did not appear to suffer from any lack of material resources. In three of the
four case study schools, the teachers spoke about how supportive their administrators were. In fact, they expressed that if they felt their applied classroom would benefit from a given resource, all they had to do was ask. As a case in point, every applied classroom that I visited was equipped with an interactive whiteboard, an expensive piece of technology that also requires input from an additional electronic device, such as a laptop or iPad.

The case study teachers did not attribute their success to any one resource in particular. On the contrary, they spoke about how important it is to use a variety of resources in the applied classroom to meet the needs of their particular students. This included print resources, manipulatives, and technology. The case study teachers preferred activities that were hands on, experiential, and required students to be active in the learning process. In all of the lessons that I observed, students in the case study classrooms were engaged in tasks that required higher-level thinking skills and this practice was contrary to what typically happens in the lower stream classrooms, where students are usually given work that is less demanding (Applebee et al., 2003; Ayalon, 2006; Balfanz & Byrnes, 2006; Boaler et al. 2000; Callahan, 2005; Gamoran et al, 1995; Hanushek et al., 2003; Hattie, 2002; Oakes, 2005; Shanker, 1993).

The streaming literature also documented that the least qualified and senior teachers are often relegated to teaching the lower streams (Berry et al., 2002; Boaler et al., 2000; Crosby & Owens, 1993; Hanushek et al., 2003). In the Ontario context, this might well mean that the academic courses in Grade 9 take precedence over the applied course when it comes to teacher assignments. In the case study schools, careful consideration was given to who taught the Grade 9 Applied Mathematics course. Perhaps
most important was the fact that all of the teachers assigned to the applied classroom wanted to teach the course and the students in it; they were not randomly “dropped in” to teach the course. Furthermore, all of the case study teachers felt comfortable in teaching the content in the Grade 9 Applied Mathematics course. They all had a background in mathematics, acquired either through their university backgrounds and/or their previous teaching experience.

Although the more junior teachers often taught the Grade 9 Applied Mathematics course in the case study schools, the impact of this seemed to be mitigated by three things. First, the mathematics head took on the role of mentoring any new or rookie teachers assigned to the Grade 9 Applied Mathematics classroom. In three of the four schools, the math head actually went so far as to teach a section of the course alongside these new teachers. This mentorship provided the new teacher with support in navigating the complexities of teaching this course. Second, the math head had been involved in developing the program for the Grade 9 Applied Mathematics course. This helped to ensure “quality control” as to what would transpire in the classroom of any new teacher assigned to teach the course. Also, it meant that the math head knew what was, or should be, going on in the classroom. This also provided the math head with a vehicle to engage in conversation with the new teacher about what was happening in the applied classroom, thus giving a window to provide descriptive feedback. Third and lastly, a teaching corps for Grade 9 Applied Mathematics was established in all of the case study schools. Whenever anyone left the school, the remaining teachers were in place to support the incoming teacher who was assigned to teach the course.
This research has established that students in applied mathematics classrooms are a vulnerable population for mathematics teaching and learning. It has also illustrated that the teachers in the case study classrooms were attuned to not only the academic, but the emotional needs of the students in their classrooms. An important consideration here that bears repeating is that the case study teachers wanted to teach this particular course; they expressed an affinity for working with the students that tended to populate it and had a dogged determination to help these students realize their mathematical potential. These teachers also had exceptional mathematics pedagogy skills and a willingness to innovate their practices for the sake of their students. There is a lot of rhetoric now that the “best” mathematics teacher should be placed in the Grade 9 Applied Mathematics. At present, this definition is mostly determined by qualifications. This research has demonstrated that there is much more to it than that.

The literature also suggested that professional learning is important to helping teachers understand and implement changes to curricular and assessment policies (Handal & Harrington, 2003; Sherin et al., 2004; Watanabe, 2007). With respect to mathematics reform, teachers might not have actually learned mathematics in a reform-oriented way. Therefore, professional learning might require them to unlearn and learn again (Handal & Harrington, 2003). The literature also indicated that to change their practice, teachers need extended opportunities to learn, generous support from peers and mentors, and occasions to practice, reflect, critique, and practice again (Bruce et al., 2011; Cohen & Hill, 2000; Guskey & Yoon, 2009; Hill & Ball, 2004; Lave & Wenger, 1999; Puchner & Taylor, 2006; Spillane, 2000; Suurtamm, 2009).
When asked if they had participated in any particular professional learning that had supported them in teaching the Grade 9 Applied Mathematics course, the case study teachers were somewhat non-committal. Instead, what they cited as being important was the opportunity to collaborate and co-plan with others who were teaching the course. In all of the case study schools, the teachers of Grade 9 Applied Mathematics had found ways to collaborate, even if it was over the lunch table. This finding corroborates previous research findings linking teacher collaboration to higher student achievement (Boader, n.d.; Bruce & Flynn, 2013; Desimone et al., 2007; Egodawatte et al., 2011; Goddard et al., 2007) and suggests that more formal opportunities for teacher collaboration might support higher achievement in Grade 9 Applied Mathematics.

This finding also parallels some of the other research that is going on in the province. For example, the Teaching and Learning Leadership Program has provided a space for teachers to collaborate on shared areas of concern and the result has been the development of innovative practices that have “contributed to changes in pedagogy which benefited students’ engagement and learning” (Campbell et al., 2014, p. 66).

It is not as if the case study teachers had not ever participated in any professional learning at the district, or even school, levels. Many of the teachers spoke about having had these kinds of “workshop” opportunities. Although these events gave them food for thought, and maybe even inspired them to try something new in their classroom, this is not what they felt made the difference to their teaching. Instead, it was having the opportunity to process and make meaning of their learning with their colleagues—through collaboration—that impacted what they ultimately did with their students.
This idea has given me pause to reflect on the conceptual framework that I developed for this study because it did not capture this element of professional learning that was so important to the case study teachers. Specifically, teacher-led collaboration that involves teachers in planning for their own students is very powerful and influences classroom practice. This co-planning was rooted in what the students need to know and be able to do, i.e., the curricular expectations. This kind of co-planning was found to be imperative to the implementation of new resources as well.

Having more formal opportunities for teacher collaboration was cited as being important and beneficial in the case study schools that had been given such an opportunity. In the schools that had not been given these kinds of opportunities, the teachers spoke about a desire to have opportunities to do more collaboration with their colleagues.

Professional learning that helped teachers to better understand the continuum of learning from Grades 7 to 9 also emerged as a finding of this research. One of the repercussions of having a grade-based curriculum, such as The Ontario Curriculum, is that teachers tend to focus on the grade or course that they happen to be teaching. In so doing, they might well lose sight of the bigger picture, i.e., the mathematical ideas, concepts, and insights that students are developing and learning over time. Professional learning that forces teachers to step back and situate their particular curriculum into the bigger scheme can be important, as when the Grade 9 Applied Mathematics teachers met with their Grade 7 and 8 counterparts. This professional learning helped the secondary teachers to better understand the mathematics schema that students had developed in their experience as elementary students.
Finally, professional learning related to higher-level questions and open-ended / rich tasks was described as having impacted some of the case study teachers’ beliefs about what students in applied classrooms were capable of. This realization served as a springboard to exploration with other reform-based strategies. Professional learning in this area holds promise for transforming what transpires in the applied classroom setting.

2. **Which of the specific practices identified in the mathematics and general reform literature as being related to better mathematics achievement have been adopted by the most successful schools?**

The conceptual framework for this study included seven dimensions of reform-based teaching practices that were outlined by McDougall (2004). When asked about what works in Grade 9 Applied Mathematics classrooms, I found that the research participants spoke of and endorsed these mathematics teaching and learning practices. Again, there were practices that were common to all of the case study schools.

Social and collaborative learning whereby students work together to construct new knowledge is characteristic of reform-based teaching (Staples, 2007; Van de Walle et al., 2011). This strategy is at odds with what characteristically happens in lower stream classrooms where students are often relegated to working in isolation on drill-and-practice activities (Hanushek et al., 2003; Oakes 1982; 1986) to build their skills. In contrast, all of the case study teachers engaged their students in cooperative learning experiences that required them to investigate mathematical concepts and solve problems.

I found that the case study teachers structured what took place in their classrooms in a particular way: they planned a variety of learning episodes or activities that would take from ten to fifteen minutes each. They also had a mid-lesson break of two or three
minutes where students could literally “take a break.” This is in keeping with current brain research that posits the working memory has capacity limits and time limits. Typically, an adolescent can process an item in working memory for 10 to 20 minutes before boredom sets in; in order for the focus to continue, there must be some change in the way that the individual is dealing with the item, i.e., a change in activity (Sousa, 2008).

I learned that one of the biggest hurdles to establishing this kind of learning in the applied classroom is the fact that many of the students are neither comfortable, nor experienced, with being called upon to share their thinking. Therefore, the case study teachers had to make a deliberate and concerted effort to establish a safe environment in which students felt secure in taking intellectual risks. The teachers helped their students to realize and recognize that they were capable mathematics thinkers who could be resources to one another’s learning. They did this by carefully structuring the delivery of the course content and starting out the semester with content that students traditionally do well in, e.g., measurement or geometry. The case study teachers also scaffolded the activities within lessons and embedded “just-in-time” skills practice within the context of a lesson. This included the development of test-taking skills, such as strategies for answering multiple-choice and open response questions.

The kinds of tasks that were used in the case study classrooms required students to think and engage with mathematical ideas; they were much more than the low level and fill-in-the blank exercises that, according the literature, are characteristic of lower stream classrooms (Applebee et al., 2003; Boaler et al., 2000; Callahan, 2005; Gamoran et al, 1995; Hattie, 2002; Oakes, 2005; Shanker, 1993). In fact, the highest levels of
cognitive demand were required of the students in all of the lessons that I observed in my visits to the case study classrooms.

The case study teachers also recognized that understanding the math was important for the students in the applied classroom. Getting the right answer was not enough in these classrooms; the teachers insisted on explanations and justification of thinking. The research literature has established that manipulatives and technological tools are important for helping students to develop this kind of understanding. These resources help students to visualize mathematical relationships and make sense of mathematics (Anthony & Walshaw, 2009; Chappell & Strutchens, 2001; Grouws & Cebulla, 2009; Kilpatrick, et al., 2001). The interactive whiteboard was especially important to the case study teachers. They spoke to how it helped students to “see” the math and make connections. They also discussed that this was important for documenting and archiving the learning that took place in the classroom.

Research has also demonstrated that teachers will likely forgo the use of manipulatives in secondary school (Kajander and Zuke, 2007; Suurtamm & Graves, 2008). This could be attributed to the fact that secondary mathematics teachers have probably not used manipulatives in their own experience of school, either at the secondary or post-secondary level. An interesting discovery in the case study schools was that the majority of the case study teachers had experience in the elementary panel where there is a much longer history of manipulative use. This might explain why the case study teachers were more likely to use these tools than is typical of Grade 9 teachers as a whole; only 16% of Grade 9 and 10 teachers use manipulatives (Suurtamm & Graves, 2007). Coincidentally, the teachers that did not have experience in elementary
schools were the ones that commented upon how much they appreciated hearing from their Grade 7 and 8 colleagues about managing manipulative use. This speaks to a lack of support for secondary teachers when it comes to the implementation of manipulatives.

This study supports a growing research base that speaks to the power of Assessment for Learning (Fullan et al., 2006; Ontario Principals Council, 2009; Stobart, 2008; Sutton & Krueger, 2002) for both teaching and learning. This approach includes the provision of descriptive feedback that defines what a student should do next, or recommends strategies for improvement (Anthony & Walshaw, 2009). This study supports this contention. All of the case study teachers used very deliberate strategies to check in on their students’ learning; they did not wait until the end of the unit to find out how students were doing with the content. This kind of assessment allowed the teachers to intervene quickly when a student began to falter. This constant checking also signaled to the student that their teacher cared about their progress.

Furthermore, the case study teachers used a wide variety of strategies to assess their students, in keeping with the recommendation outlined in the Growing Success assessment policy to triangulate data through product, conversation, and observation. The case study teachers continuously monitored what was going on in the cooperative learning groups. They would wander around the room and observe the students at work, engaging them in conversations about what they were doing, and providing descriptive feedback. This monitoring helped to keep the students on task and ensured that all of the groups were moving forward productively with the task.

Finally, on the topic of reform-based strategies, the fostering of positive attitudes and dispositions towards mathematics was widely focused on in all of the case study
classrooms. This focus might well be one of the most profound reasons for their success. After all, Kilpatrick et al. (2001) determined that having productive dispositions towards mathematics is an integral ingredient for mathematical success. Historically, EQAO student questionnaire data reveals that students in applied level mathematics classrooms have less favorable attitudes towards mathematics than do their peers in the academic classroom. This is in keeping with the streaming literature where it has been established that students in the lowest streams typically become unmotivated and demoralized by their experience of school (Ayalon, 2006; Berry et al., Boaler et al., 2000; Callahan, 2005; Carbonaro, 2005; Rubin, 2008). The case study teachers recognized that their students had an especially fractured relationship with mathematics and they attended to this by helping their students to realize success and build confidence. They did this by engaging them in worthwhile group tasks, by having high expectations for them, by coaching them to achievement through frequent and descriptive feedback, and by sharing their love and joy of mathematics.

The very structure of mathematics teaching in Ontario Grade 9 mathematics classrooms suggests an underlying belief that there are those that can, and those that can not, do mathematics. The findings from this study ring true to what has been established in the literature about streaming. One of the primary rationales to stream in the first place is to teach students based on their so-called ability (Boaler et al., 2000). Presumably when students are taught according to their level, they will do better (Van Houtte, 2004). However, studies of streaming consistently demonstrate that students in the higher streams will have higher outcomes (Allensworth et al, 2009; Burris & Welner, 2005; Callahan, 2005; Gamoran, 2009). We now have a decade of EQAO data in Ontario
showing that typically twice as many students in the higher stream achieve the provincial standard.

And just as the streaming literature suggests, this study has found that students in the lower stream have low self-esteem in, interest of, and motivation to do well in mathematics. Many of them have been told that they are not good at math; they have most likely been funneled into the applied stream on advice of their Grade 8 teacher with the implicit messaging that, “You aren’t good enough for the academic course.”

The research literature also established that teaching the lower streams has typically low status; it is often pawned off on new or beginning teachers, or even to non-math teachers with a slot in their timetable that needs filling (Boaler et al., 2000; Hanushek et al, 2003). This was no different in the case study schools where the new or rookie teachers to the school were assigned to teach Grade 9 Applied Mathematics.

All of this has led to a very prevalent stigma around Grade 9 Applied Mathematics. There is no doubt that this kind of stigma exists in other applied courses as well. However, this stigma may well be intensified for Grade 9 Applied Mathematics. First of all, there is a prevalent belief in our culture that math is difficult and that only the best and brightest will survive it as they proceed through higher and higher levels of schooling. In other words, if you did not make it to the academic course, you are not good in mathematics. Second, the spotlight gets shone on the Grade 9 Applied Mathematics course with provincial testing. Students who take the course are constantly reminded by the media that their lot are not very good at mathematics.

These deeply held beliefs that swirl around Grade 9 Applied Mathematics have resulted in a negative stereotype that the weakest students take it and the weakest math
teachers teach it. My thinking on this was validated this school year when I had the pleasure of sitting in on a consultation with the Minister’s Student Advisory Council for which the topic was “Why are the province’s results in mathematics declining?” During the conversation that I was a party to, the students mentioned that nobody wants to take Grade 9 Applied Mathematics. When I asked them why that was so, one of the boys responded that it was because of the stigma. “Everybody knows that there is a stigma about the applied course. There just is. And nobody wants to be labelled with that,” he said (MSAC member, personal communication, February 13, 2015).

This negative stereotype around the applied course has been exacerbated by the provincial testing—the spin-off of which is even more negative “press.” The media is forever picking up on the poor student achievement in this course. Everyone knows about the “Applied Grade 9 problem,” including the students. The pressure for better results is relentless. The politicians take the heat, and then it gets passed down the system where ultimately it lands in the classroom where the teacher (and ultimately his or her students) feel pressure to get results that show we have fixed the “Applied Grade 9 problem.”

Aronson, Steele, and Spencer (1990) identified and described the phenomenon of stereotype threat. This refers to “socially premised psychological threat that arises when one is in a situation or doing something for which a negative stereotype about one's group applies” (Steele, 1997, p. 614). Consequences of stereotype threat can contribute to the educational and social inequity of some groups, for example, women in math (Stoessner & Good, n.d.). When one views oneself in terms of this kind of salient group
membership, performance can be undermined, e.g., “I am a woman and women are not expected to be good at mathematics.”

There is plenty of research that has demonstrated that in situations where a prevalent stereotype like this exists, the stigmatized group will underachieve on classroom exams and standardized exams (Stoessner & Good, n.d.). In fact, reminding a test-taker of their identity in such a group has been shown to decrease test performance. If we follow the above example through, if a woman has to identify that she is a woman at the outset of a test, her performance can actually decrease. The perceived threat that she is a woman who is not supposed to be good at mathematics may, and is quite likely to, undermine her performance.

The stigma that exists around Grade 9 Applied Mathematics has made students who take this course vulnerable to stereotype threat and consequently, a self-fulfilling prophecy that they will not do well. It can be argued that the case study teachers did a lot to mitigate the potential of stereotype threat impacting on their students’ performance. First and foremost, the teachers recognized that their students have been traumatized by their experience of mathematics in the past and they did a lot of work to foster productive dispositions around mathematics. They helped their students to understand that they are confident and competent mathematical thinkers. Second, the case study teachers held high expectations for their students and gave them assurances that they had the capability to meet them. The constant stream of feedback that they gave their students provided motivation and signalled to their students that they believed in them. Third, the teachers provided positive role models by sharing their love of all things mathematical. Fourth, the teachers changed the definition of what it means to do well in mathematics. Having
success in their classrooms did not mean that you had to memorize formulas and be quick about it. It meant that you had to engage in the thinking, in whatever way that made sense to you. Fifth, the teachers prepared students for threat situations, such as writing the provincial assessment.

Research has shown that, in threat situations, an individual’s working-memory can actually be taxed, undermining one’s ability to deal with complex intellectual tasks. Beilock (2010) likens working-memory to a mental scratch pad. It helps you to keep relevant information in mind when you preform a particular task. When worries and self-doubt flood the brain, they deplete the working-memory resources that would otherwise be available to think and reason. This, in turn, leads to the feeling of “brain freeze,” or “choking.” Beilock argues that mitigating the threatful situation will reduce this risk.

The case study teachers did a lot to minimize the potential that the provincial assessment would feel threatening to their students. I conducted my case study observations at a time when the EQAO assessment was approaching (within three weeks of the test date). In every case, I heard the teachers say to the students in their classes that they were well prepared for the test, that they were going to do well on it and that they had nothing to worry about it.

The case study teachers used sample EQAO assessment questions so that their students were used to them, and knew what to expect. The students knew, for example, what it means to justify one’s thinking. Furthermore, the students had studied examples of what “good” justification of thinking looked like, and they knew what it took to produce a good answer.
Perhaps most importantly, the teachers helped the students to understand that they should approach solving a problem in their own way. Through her research, Beilock has demonstrated that, in solving problems, if an individual relies on complex methods such as the use of algorithms, a lot of working memory is needed. In a threatening situation that is already taxing those resources, that individual will be at a distinct disadvantage. If, on the other hand, that same individual has learned to approach problems in his or her own way, then he or she will be more flexible and creative in the strategy or approach taken and will literally be in a position to think it through. Furthermore, when students understand that there is more than one way to solve a problem, they will be more resilient and persevere through to a solution.

An unfortunate consequence of streaming at the grade nine level is that it has resulted in two very different kinds of performances in the two streams. (And this isn’t even considering the third and “lowest” stream of the locally developed course). We have come to expect excellence from those in grade nine academic courses and have evolved to an unfortunate place where 44% of students achieving standard in the applied course is seen as good, simply because it is an improvement. The lessons learned from the case study schools demonstrate that the stereotype about students in Grade 9 Applied Mathematics can be shattered. Students in these classrooms are capable and competent mathematics learners.

The reform-based strategies that were used in the case study classrooms engaged the students intellectually in the enterprise of doing mathematics. These were places where students learned that there are a variety of ways to tackle a problem and that they should rely on and trust their own intuitions as a tool for thinking mathematically. There
is a growing literature base that supports the use of reform-based strategies with students that struggle (Kajander et al, 2008; Lubienski, 2006). This study has demonstrated how the students in four high performing schools have benefitted from reform-based approaches. It is also interesting to note that these classrooms are reflective of what the curriculum developers had in mind when they developed this course:

Applied courses focus on the essential concepts of a subject, and develop students’ knowledge and skills through practical applications and concrete examples. Familiar situations are used to illustrate ideas, and students are given more opportunities to experience hands-on applications of the concepts and theories they study (OME, 2005, p. 6).

On the teacher side of the equation, using reform-based strategies afforded the case study teachers an opportunity to see and understand their students as mathematical thinkers. They engaged in conversations with, and observations of, the students as they participated in and shared their mathematical thinking during problem solving activities and investigations. This provided a rich source of information about what students could and could not do. In turn, the teachers were in a position to give meaningful feedback that would support and move forward student learning in a precise and focused way. It also afforded the teachers an opportunity to intervene quickly, before a struggling student fell too far behind. This is vastly different than what would happen in a traditional mathematics classroom where the teacher directs from the front and students work in isolation in preparation for the end of unit test.

The general reform literature suggests that secondary schools are especially impervious to change (Hargreaves & Goodson, 2006; Stodolsky & Grossman, 2000), in part because of their departmental structure and the autonomy that teachers have in their own classrooms. At the same time, there is evidence that professional learning that is collective and collaborative in nature (Cohen & Hill, 2000; Guskey & Yoon, 2009; Hill
& Ball, 2004; McLaughlin & Talbert, 2007; Puchner & Taylor, 2006; Spillane, 2000) and embedded in schools and classrooms (Bruce et al., 2011; Egodawatte et al, 2011; Garet et al, 2007; Lave & Wenger, 1991; Penuel et al., 2007) is more likely to impact teacher practice. Therefore, math departments have potential to be a vehicle for change (Connolly, 2000; Gutiérrez, 1996; Harris, 2001; Melville, 2010; Ross & Gray, 2006; Sidkin, 1997; Stodolsky & Grossman, 2000). This evidence led me to hypothesize that perhaps the math departments at the successful schools had participated in some professional learning together. I discovered that this was not exactly the case. Instead, the teachers of the Grade 9 Applied Mathematics course had initiated their own informal collaboratives around teaching the course. These efforts had included the math head.

The reform literature also suggests that distributing leadership to the department head can impact change efforts (Harris, 2001). This teacher leader can help other teachers to embrace goals, to understand the changes that are needed to strengthen teaching and learning, and to work towards improvement (Aubrey-Hopkins & James, 2002; Campbell et al., 2014; Connolly et al., 2000; Leithwood & Riehl, 2003). The evidence from the case study schools shows that the Math Head had played a role in fostering a culture of change around the teaching and learning in Grade 9 Applied Mathematics classrooms.

The principals in three of the four secondary schools had strong instructional leadership in mathematics. These principals understood the challenges of the applied classroom and had themselves taught the Grade 9 Applied Mathematics in the past. This experience positioned them to understand the complexities of teaching the Grade 9 Applied Mathematics course. This in turn put them in a position to better support the
conditions for learning in the applied classrooms. For example, they made sure that the teachers had the resources that they needed, such as the interactive whiteboard.

In Ontario, there has been a lot of energy and effort in boosting the instructional leadership of principals. This is important because not all principals have a background in mathematics. At the same time, this study has demonstrated the importance of leveraging the instructional leadership in mathematics heads. In the case study schools, it was clear that the leadership around Grade 9 Applied Mathematics was not a solo effort. Fostering this leadership potential could prove to be a worthwhile investment.

One final note with respect to leadership is the fact that for the most part, the administrators and math heads signaled to the students and staff that the EQAO Grade 9 Mathematics assessment was important and they also celebrated success. There are important reasons that students should do well in the Grade 9 Applied Mathematics course. The College Math Project has firmly established that, when students come out of the secondary system with good grades, they will thrive in college. If they barely scrape through high school, students will be hard-pressed to succeed in a college. And when you consider that the applied pathway is meant to lead to college, that is a significant fact.

The yardstick for success in Grade 9 Applied Mathematics has become gaining the course credit and this may well be a part of the problem. As discussed earlier in the paper, I had considerable difficulty gaining access to schools to conduct my research. In part, this was because of the labour unrest at the time. The other contributing factor, however, was a lack of understanding about why success in Grade 9 Applied Mathematics matters. There is a serious disconnect about the meaning or significance of a Level 3 performance, i.e., achieving at provincial standard. To illustrate, I had to do
considerable “selling” of my research ideas to one of the school boards because the provincial Grade 9 EQAO Mathematics assessment was not valued as an important measure of success. Instead, this school board had come to define success by the graduation rate:

We use our 90% graduation factor as the level of success and everything we do is geared toward that 90% graduation rate… The EQAO score (as I know you are aware) is based on achieving level three, which is considerably higher than the graduation rate. The ministry says that a “failure” in grade 9 or “not achieving 16 credits by age 16” is the best predictor of high school graduation. In our board, credit attainment is more valuable than EQAO scores. (Online correspondence, January 7, 2013)

Credit attainment means passing a course, equivalent to a Level 1 or “D” performance. If this is the measure of success, it is no wonder that so few students are achieving at Level 3 or beyond.

There are conflicting messages at play from the very highest level. The ministry messaging has been concerned with improving graduation rates and this has led to a preoccupation with credit accumulation. That is probably not a bad thing; it has certainly helped to boost graduation rates. However, the attention must now shift to the quality of the credits earned. While graduating from secondary school is a worthy goal, we are living in an era where that increasingly is not enough. Many of our students will need to go on to post-secondary education if they want to make a decent living. And they need to be well prepared for that. The most recent College Math Project data (now called College Student Achievement Project) has found that roughly 40% of all students take math in college. Yet, not even half of the students that take Grade 9 Applied Mathematics—the course that is supposed to prepare them for college—reach the provincial standard. Another alarming statistic is that, today, 30% more students are
required to enroll in remedial courses at college than five years ago (CSAP Provincial Forum, October 24, 2014).

The case study schools, for the most part, changed the conversation around the EQAO Grade 9 Mathematics assessment. To start with, the principals made sure that not only the Grade 9 students, but all of the students, understood the importance of the test. The principals also made sure that not only the Grade 9 Mathematics teachers, but all of the teachers, understood the importance of the test. Success was made public, shared and celebrated by the whole school community. Pride in doing well was cultivated.

In the classroom, the teachers positioned the test as an opportunity to show mastery of the course content. The students understood that the test content and the course content were inexorably linked. The students were told that they could do great things on the test because they had done great things in the course. Even more importantly, they were told that they could do great things in mathematics because they had done great things in mathematics.

The teachers also positioned the test as an opportunity to learn about test-taking skills—something that would increasingly come into play as students moved on in their secondary and post secondary studies. Students can be well served by learning how to take a formal test like those administered by the EQAO.

In the schools that I studied, the Grade 9 Applied Mathematics assessment had been a stimulus to change. The teachers within the mathematics departments had come to understand that, at the very least, when students did well on the provincial assessment, they inevitably did better in their more senior courses. This mobilized the troops, so to speak, and all of the mathematics teachers became involved in the effort, e.g., by
assisting with additional extra help sessions. On some level, the teachers had developed a moral imperative that students do well on the assessment. It was not about the marks, but what the marks represented: students that were well prepared for further study in mathematics. This kind of understanding is important at all levels of the system.

**Summary of Major Findings**

There has not been a lot of specific research conducted into the practices of effective Grade 9 Applied Mathematics classrooms, as measured by EQAO assessments. This study set out to understand if there are things that we might learn from mathematics leaders and from schools that have had good success with the course. I discovered that there were indeed practices that were common to the case study schools.

There are important findings from this research. First, there are particular teaching and instructional strategies that support students in the applied classroom. I take away from this study a vision of classrooms that are humming with curiosity, active with engagement, and confident in knowing and doing.

Second, there are particular strategies that support teachers in the applied classroom. I take away from this study a vision of teachers as important resources to “solving the Grade 9 Applied Problem.” When given the space and opportunity to innovate, they will find ways to help their students thrive and be successful.

Third, there are lessons that we need to learn about our most vulnerable students and how to most effectively work with them. Some of the stories that I heard from the case study teachers about their students’ experience of school, and mathematics in particular, were truly heart wrenching. I am truly buoyed by the contribution that my study participants have made to my understanding of how we can help all Mathematics
classrooms, and classrooms in general, to be places of significant and inspired learning for all.

I have summarized the major findings of this study in the form of recommendations for both policy and practice:

**Recommendations for Policy: Ministry of Education**

- Signal the importance of the quality of the Grade 9 Applied Mathematics credit, i.e., doing well in this course sets students up for success in college, university, apprenticeship, and/or the workplace
- Foster and leverage the instructional leadership, including mentorship, of math department heads
- Provide opportunities for teacher-led and inspired professional learning focused on Applied Mathematics
- Recognize that co-planning is an important meaning-making process for teachers and is essential to implementation efforts
- Ground professional learning in *The Ontario Curriculum*
- Be mindful of and work towards mitigating the stereotypes associated with lower streams
- Investigate de-streaming mathematics in Grade 9

**Recommendations for Practice: School Boards**

- Offer opportunities for school-based teams to develop their Grade 9 Applied Mathematics program
- Provide capacity building for math department heads in order to develop their instructional leadership, including mentorship
• Recognize that co-planning is an important meaning-making process for teachers and is essential to implementation efforts, e.g., engage teachers in co-planning when implementing new resources

• Establish learning networks of Intermediate Mathematics teachers that focus on the continuum of learning from Grade 7 to 10 and evidence-based strategies, e.g., use of manipulatives and technological tools that build conceptual understanding

• Leverage the experience of secondary administrators who have a background in mathematics

• Be mindful of and work towards mitigating the stereotypes associated with lower streams

• Professional learning related to the use of rich tasks can be an excellent springboard into reform-based teaching

• Ground all professional learning in *The Ontario Curriculum*

• Recognize and celebrate success

**Recommendations for Practice: Administrators**

• Be mindful of who teaches applied courses: qualifications, experience, comfort with mathematics, and a willingness to teach the course are equally important considerations as to who should teach Grade 9 Applied Mathematics. Consider develop a teaching corps for the course

• Foster instructional leadership in the math department head, including mentorship

• Provide accessible, networked, and collaborative spaces for teacher dialoguing and planning
• Seek out opportunities for your Applied Mathematics team to collaborate

• Encourage cross-panel collaborations with Grade 7 and 8 teachers that focus on the continuum of learning throughout the Intermediate grades

• Provide shared planning time for Grade 9 Applied Mathematics teachers whenever possible

• Be mindful of and work towards mitigating the stereotypes associated with lower streams

• Recognize and celebrate success

Recommendations for Practice: Teachers

• Have and hold high expectations for students in applied classrooms

• Build confidence and efficacy for students by beginning the course with measurement or geometry—areas that students traditionally do well in

• Affirm your students at every opportunity and celebrate success

• Use a variety of resources that engage students in active and hands-on learning

• Engage students in learning through inquiry/problem solving (as opposed to for) and encourage them to develop their own unique solutions

• Capitalize on the social nature of adolescents by using cooperative groupings and encourage students to be resources for one another’s learning

• Provide students with frequent, oral, and descriptive feedback

• Chunk lessons into ten to fifteen-minute activities and allow students a short mid-lesson break where they can get up, move, and re-focus

• Offer open access to mathematical thinking tools such as manipulatives, calculators, and pencils, and expect students to use them
• Foster productive dispositions around mathematics by sharing the wonder, beauty, and your love of the discipline

• Help students to understand the long term consequences of doing well in Grade 9 mathematics, i.e., there is a better chance of graduating both secondary and post-secondary school

• Integrate EQAO sample questions into your regular teaching and help your students to understand this text genre, e.g., discuss strategies for answering multiple choice questions, talk about what it means to “Justify your thinking”

• Provide samples of what good work looks like and engage students in self- and peer-assessment

• Develop anchor charts with the students, post them in the classroom, and direct students to use them

• Use instructional technologies that help students to conceptualize and connect mathematical ideas

**Reflections of the Researcher**

There are several insights that I have gleaned from conducting this study that are applicable to my own professional practice.

One of the most profound influences to my thinking as a result of my doctoral journey has been Dr. Joseph Flessa, who both got me started on and helped me to finish the EdD marathon. He introduced my cohort to the notion that we need to be really mindful of approaching our work from an asset, not a deficit, orientation. I took that notion with me to my work as a consultant, then to my work in the classroom, and currently to my work at the Ministry of Education. My work on this thesis has made me
not only underscore, but bold this idea. I think that going in to it, I had a hunch that much of the under-performance of students in applied classrooms is tied up with the kind of deficit thinking that often accompanies them. I still do not know if that is true or not, but what I have learned for sure is that approaching students in Grade 9 Applied Mathematics classroom from an asset orientation is important; there is no doubt in my mind that the schools and teachers in the case study schools approached the students in their Grade 9 Applied Mathematics classroom from this perspective.

I loved my work on this particular study because for me, it represents hope. There are all kinds of reasons that a board, or a school, or a teacher might slough off a disappointing performance on EQAO—the test is too costly, the test is not a good fit for “applied” students, the test is too early in the semester, the test is too late in the semester—I have heard it all. What strikes me is that the teachers in the case study schools, for the most part, approached the assessment from an asset perspective. Instead of throwing their hands up in defeat about the whole thing, they asked, “What can we learn from it?” and “How might it help our students?”

Going in to this research, there was a part of me that wondered if I would discover that the teachers were just teaching to the test. I suppose that in a way they were. They embraced the fact that the EQAO assessment is, after all, a reflection of the curriculum. They integrated EQAO sample questions into their daily teaching. They helped their students to understand the demands inherent in the questions, such as what it means to justify one’s thinking. They also taught their students strategies for dealing with multiple-choice questions, a skill that will be continue to be important in their academic career. They also gave value to the assessment by including it in their student’s overall
course mark. All of these things are good things for students in applied classrooms, especially in light of some of the new research regarding negative stereotypes, how they can impact performance, and what can be done to mitigate their effect. I think that there are important messages here that can be shared.

I am sure that there will continue to be nay-sayers regarding the EQAO assessment, claiming that it does not measure some of the areas of the curriculum that are important and cannot be measured by a paper-and-pencil test, namely those expectations that are connected to doing investigations. Although the assessment can assess the knowledge gained through and from an investigation, it is not designed to assess how such investigations are designed or carried out (EQAO, 2007). EQAO contends that the teacher in the classroom setting best assesses this. With respect to the case study classrooms, I believe that I can put my mind to rest on this score because these were not places where students just “sat and got.” They were places where students engaged in doing the work of mathematicians. This will be an area to continue to watch in the future as EQAO follows the lead of other jurisdictions into the realm of online testing. This will open up the possibility of developing a more comprehensive tool that can measure student achievement in additional skills, such as investigating.

I believe that there is a real disconnect in the province when it comes to understanding the significance of reaching the provincial standard. This is critical not only on EQAO performance, but for course marks. Currently, there is a perception that the most important thing is that the student gets the credit. My contention is that one of these goals does not have to come at the expense of the other. We can work towards having students get the credit and good marks. The case study teachers demonstrated
what can happen when you put high expectations in place and couple that with appropriate support. Their students not only did better at reaching the standard; they did better at exceeding it. I believe that this is an important discussion to engage in.

I think that this research also demonstrates that school excellence is not a solo affair, but a collective endeavour. In every single one of my case study schools, there was a core group of determined individuals who worked together to impact student performance in Grade 9 Applied Mathematics. To do so, they took a long hard look at the curriculum to see what it is that students need to learn. They then set out to find out how they could best help students to achieve the expectations. There was a lot of trial and error, starting over, and fine-tuning. If there is a silver bullet that comes out of this research, I believe it is to that we must give teachers the time, the space, the confidence, and the support to do the work. I am happy to report that as a result of my work on this project, I am currently involved in a pilot project at the ministry where teachers are being released to do just that. School teams have identified their own problem of practice around the curriculum and are being supported by a researcher to delve into the literature and develop their own research-based strategies for addressing it. I am hopeful that this work will contribute to the dialogue on effective practices in Grade 9 Applied Mathematics.

Limitations

This study gathered insights from a variety of math leaders across Ontario, but admittedly the participants were located in central, eastern, southern and western Ontario. There was no voice that represented northern Ontario, and often this region of the province has its own particular issues to deal with. Similarly, this study gathered insights
from three consistently successful and one rapidly improving school with respect to Grade 9 Applied Mathematics, as measured by EQAO scores. These were located in southern, central, and eastern Ontario and again, the northern perspective is missing. Nevertheless, I do believe that the study provides insights that should be useful regardless of geography. I believe that, if nothing else, the results of the study can be used to engage a variety of players in the conversation about effective practices in mathematics, whether it is board or school administrator, department head, teacher, consultant, ministry official, or researcher.

Another voice that is noticeably absent from this research is that of the student and what they believe is important to learning Grade 9 Applied Mathematics. Although I would have loved to pursue that dimension, it was not something that I could have pursued in the scope of this study, especially when one considers the process of getting ethical approval alone. Nonetheless, I believe that this is an important area for future study.

Another limitation of this study is simply the amount of time that I was able to spend in each school. I think it would be really interesting if a researcher were able to study the work of the teacher and teacher teams as they go about implementing a curriculum document over time.

Finally, this study focused on schools that have had success with Grade 9 Applied Mathematics, as measured by the provincial EQAO assessment. It is quite possible that some of the practices that they use are also used in less successful schools. Again, this would be an area for future research.
I believe that these limitations can be addressed through future research. The thick description that has been included in this study, and the methodology that has been provided should assist with the replication of this study in these and other contexts.

**Additional Suggestions for Future Research**

The degree to which negative self-concepts were reported as being an issue for students in grade nine applied classrooms was quite disturbing to me. When you consider that this is the experience of students who are just entering secondary school, this is especially troubling. They have their whole life ahead of them, yet they are already feeling so bad about themselves and their prospects, at least where mathematics, or anything related to it, is concerned. I believe that this whole area could benefit from further study. For example, what has led to these perceptions? Why are many kids entering secondary school so turned off by mathematics? What might we do about it? All of these things, I think, are worthy of investigation.

This finding from my study also supports the growing concern around streaming students at the Grade 9 level. In 2013, People for Education released a discussion paper that called the practice into question, claiming that for a variety of reasons, it does not serve our children well to stream them at this point in their education. There are some school boards that have heeded this advice and are finding innovative ways to work around the current policy. For example, the Limestone District School Board is piloting an academic-only choice for Grade 9 Mathematics at one high school. This school has developed an innovative plan for supporting all students to succeed in this course. Other schools are experimenting with other models of helping all students to access and thrive in the academic course. When other provinces in the country do not stream students at
the Grade 9 level, it is hard to understand why Ontario continues with this practice that seems to dis-enfranchise so many students.

While gathering data for this research, I learned that an area of an equal concern in the field is the Grade 10 Applied Mathematics classroom. It is the next frontier, so to speak. From what I heard, students do not tend to do very well in this course either, and some of the research participants that I spoke to are even more worried about student achievement and performance in that course. Again, when you consider that students from the applied pathway are not achieving well when they follow it to its intended destination of college, this is something that we need to think and worry about. Given this, I think that an investigation of effective practices in Grade 10 Applied Mathematics classrooms would be a worthy undertaking.

**Conclusion**

From what I could determine, this thesis work was unique in the Ontario context and I found that quite surprising considering the longevity of “the Grade 9 Applied Mathematics problem.” Having pursued this research, I understand now that not everyone understands or considers the significance or ramifications of the issue of underachievement in Grade 9 Applied Mathematics. I am buoyed by the fact that there are new areas of literature that are contributing to the conversation, such as the importance of having a growth, versus a fixed mindset in mathematics. And there is much more push back towards the acceptance that there are some of us who can and some of us who cannot do math. I hope that this research can add fuel to that fire by demonstrating that there is a lot that we can do to help even the most resistant and disengaged math learners.
This thesis has determined some of the common resources, professional learning, math department, leadership, and math reform practices in some of the province’s most successful Grade 9 Applied Mathematics classrooms, as determined by EQAO scores. Through the process, I discovered that many of the practices in these schools were brought about in response to poor results on EQAO assessments. Like it or love it, the assessment was a stimulus to change. It gave pause to a group of professionals and provoked them to re-image the way that they might teach a course, from beginning to end, in order to make a difference for students.
REFERENCES


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Organization for Economic Development. (2010b). *PISA results: What students know and can do—Student performance in reading, mathematics and science (Volume


Appendix A:

Request to Conduct Focus Group

Dear (President):

I am a graduate student in the Leadership, Higher, and Adult Education Department at OISE/UT and am currently planning a research project that is concerned with discerning the effective practices in Grade 9 Applied Mathematics. There will be two phases in my study: focus group interviews and school case studies.

As part of my data collection efforts, I am hoping to be able to conduct a focus group interview with members of (name of organization) because I believe that the organization’s members will be able to offer valuable insights as to what practices support student achievement in Grade 9 Applied Mathematics.

Ideally, I would organize the focus group so that it would take place in conjunction with an already scheduled event, such as (name of event, e.g., conference or meeting). I would organize a venue on-site and provide light refreshments for the participants. I anticipate that the interview would take approximately 90 minutes and I would organize it so that it took place during “down time” of the (name of event), e.g., during the lunch break.

Participation in the focus group would be invitational and completely voluntary. Participants would be free to withdraw from the focus group at any time, without consequence. At no time will participants be judged or evaluated and at no time will there be any risk of harm. No value judgments will be placed on their responses to the questions posed in the interview. Participants will be advised that if they have any complaints or questions related to their participation in the study, they can contact the Office of Research Ethics, ethics.review@utoronto.ca or 416-946-3273.

Only my supervisor and I will have access to the data that results from the focus group interview. This data will be kept secure in my residence. The identity of all participants and (name of organization) will remain confidential.

I believe that the results of this research will be of interest to your membership. The research is an opportunity to both discern and articulate our best practices so that collectively we can add to the knowledge base related to how we can best support students in our Grade 9 Applied Mathematics classrooms.

Thank you for considering this request. If you have any questions about my research, please do not hesitate to contact me at 705-745-7662, or by e-mail at alison.macaulay@utoronto.ca. You may also contact my supervisor, Dr. Ben Levin at ben.levin@utoronto.ca. Finally, you may contact the U of T Office of Research Ethics for questions related to the rights of research participants at ethics.review@utoronto.ca or 416-946-3273.

If you are in agreement with me proceeding with the focus group, I would ask you to keep a copy of this letter for your records. I would also like to ask that you distribute an invitation to participate in the focus group through (name of organization)’s e-mail distribution list prior to the event. Please let me know who I should contact to do this.

I thank you for considering this request. I look forward to sharing my findings with the Executive, Board of Directors*, and the (name of Organization) membership-at-large.

Sincerely,

Alison Macaulay
Appendix B:

Letter of Information / Consent Form: Focus Group

EFFECTIVE PRACTICES IN GRADE 9 APPLIED MATHEMATICS

Date:

To the participants in this study,

The purpose of this study is to understand the kinds of professional learning, resources, organizational, leadership, and teaching practices that schools have put in place to support student achievement in Grade 9 Applied Mathematics.

This study will be carried out in Ontario under the supervision of Dr. Ben Levin, Department of Leadership, Higher and Adult Education, the Ontario Institute for Studies in Education/University of Toronto. The data is being collected for the purposes of my EdD thesis and perhaps for subsequent research articles.

As part of the research, focus group interviews will be conducted with individuals that are involved in teaching or supporting Grade 9 Applied Mathematics. This interview will take approximately 90 minutes. During the interview, you will be asked questions related to the kind of professional learning, resources, organizational, leadership, and teaching practices you perceive as being important to supporting Grade 9 Applied Mathematics classrooms. As the interview proceeds, I may ask questions for clarification or further understanding, but my part will be mainly to listen to you speak about your views, experiences, and the reasons for believing the things you do.

It is the intention that the interviews will be audiotaped, with your permission, and transcribed later to paper. You will be assigned a number that will correspond to your responses in the interview. Your transcript will be sent to you to read in order for you to add any further information or to correct any misinterpretations that could result. The information obtained in the interview will be kept in strict confidence and stored in a secure location at my home. All information will be reported in such a way that individual persons, schools, school districts, organizations, and communities, cannot be identified. All raw data (i.e. transcripts, field notes) will be destroyed five years after the completion of the study.

You may at any time refuse to answer a question or withdraw from the interview process. You may request that any information, whether in written form or audiotape, be eliminated from the project. At no time will value judgments be placed on your responses and at no time will you be at risk of harm. You are free to ask any questions about the research and your involvement with it and may request a summary of the findings of the study.
If you have any questions about the research itself, please contact me, Alison Macaulay at 705-745-7662 or alison.macaulay@utoronto.ca. You may also contact my supervisor, Dr. Ben Levin at ben.levin@utoronto.ca. Should you have further concerns about your rights as a participant in this study, please feel free to contact the Office of Research Ethics by e-mail at ethics.review@utoronto.ca, or by phone at 416-946-3273.

Thank you in advance for your participation.

Alison Macaulay
Ed. D. Candidate, Leadership, Higher and Adult Education
OISE/University of Toronto
e-mail: alison.macaulay@utoronto.ca

Dr. Ben Levin
Professor, Leadership, Higher and Adult Education
OISE/University of Toronto
e-mail: ben.levin@utoronto.ca

CONSENT FORM

By signing below, you are indicating that you are willing to participate in the study, you have received a copy of this letter, and you are fully aware of the conditions above.

Name: ___________________________ Date: ___________________________

Signed: ___________________________

Email*: ___________________________

Please initial if you would like a summary of the findings of the study upon completion: _____

Please initial if you agree to have your interview audiotaped: _____

*Please provide your e-mail address so that this summary can be sent to you electronically.

Please keep a copy of this letter for your records.
Appendix C:

Focus Group Interview Questions with Links to Conceptual Framework

1. What practices are you aware of, or have you engaged in, that support student achievement in Grade 9 Applied Mathematics? How do you know that these practices are successful? (Resources, Professional Learning, Math Department, Leadership, Reform-based Teaching)

2. What do you think are the barriers to student achievement in Grade 9 Applied Mathematics? (Resources, Leadership)

3. There are five areas that I have identified from the research literature that I think might be important to support teachers and students in Grade 9 Applied Mathematics. I am curious as to what you think. The areas that I have identified are: Resources (Human and Material); Professional Learning; Math Department; Leadership; and Use of Reform-based Teaching Approaches.
   • In your experience, which of these areas are important to supporting student success in Grade 9 Applied Mathematics. Why?
   • Are any of these areas particularly challenging? Why? (Resources, Professional Learning, Math Department, Leadership, Reform-based Teaching)

4. What do you think is the most important thing that schools can do to support student achievement in Grade 9 Applied Mathematics? (Resources, Math Department, Leadership)

5. What do you think is the most important thing that districts can do to support student achievement in Grade 9 Applied? (Resources, Professional Learning, Leadership)
Appendix D:

Letter of Information / Consent Form (Case Study: Highly Performing)

University of Toronto/OISE-UT
Leadership, Higher and Adult Education
252 Bloor Street West, Toronto
Ontario, Canada M5S 1V6

Fax: 416-926-4741
www.oise.utoronto.ca/lhae

EFFECTIVE PRACTICES IN GRADE 9 APPLIED MATHEMATICS

Date:

To the participants in this study,

The purpose of this study is to understand the kinds of professional learning, resources, organizational, leadership, and teaching practices that schools have put in place to support student achievement in Grade 9 Applied Mathematics.

This study will be carried out in Ontario under the supervision of Dr. Ben Levin, Department of Leadership, Higher and Adult Education, the Ontario Institute for Studies in Education/University of Toronto. The data is being collected for the purposes of my EdD thesis and perhaps for subsequent research articles. It has been approved by your school board.

Given that the student achievement in Grade 9 Applied Mathematics has been lackluster provincially, it is important to understand what our successful schools are doing to support student achievement. In order to determine which of our schools in the province are the “most consistently successful” I have reviewed EQAO data to find schools that have met the following criteria:

1. The overall trend for student achievement is improving for both applied and academic courses in each of the past five years.
2. The applied scores are at or above the provincial average for each of the past five years.
3. The gap between students in applied and academic courses is smaller than the provincial gap for each of the past five years.

Based on these criteria, I have identified your school as a potential site for my study. I am interested in learning more about what might have contributed to your success. Ideally, I would like to interview an administrator, the Math Department Head, and two teachers that have taught Grade 9 Applied Mathematics at your school.

From this study I hope to be able to offer some concrete steps—or starting points—that other schools and districts might take to better support student achievement in Grade 9 Applied Mathematics.

If you agree to participate in this study, you will be asked to participate in a 45 to 60 minute semi-structured interview. I will work with your principal to arrange a suitable date to visit your school. Areas that I plan to discuss include: resources that are available to you to teach Grade 9 Applied Mathematics; professional learning opportunities that you have participated in; and, initiatives that your math department has undertaken to support Grade 9 Applied Mathematics.
If you agree to participate in this study, I will send you the complete list of questions that I intend to ask during the interview so that you have time to think about and reflect on them. Examples of questions that might be asked are:

1. Have you been involved in any professional learning that has helped to support your teaching of Grade 9 Applied Mathematics?

2. Are there specific resources (human or material) that have been important to you in teaching Grade 9 Applied Mathematics?

Should you participate, and with your consent, the interview will audio-recorded. A transcript of the interview will be prepared and shared with you to comment on or correct. This should take no more than a half hour of your time. None of the data reported from this study will contain your name, or the name of your place of work. I will take the necessary measures e.g., use of pseudonyms, to ensure confidentiality in all written reports or presentations which might emanate from this study.

All data will be stored electronically in as secure location in the researcher’s home office. It will be password-protected, and destroyed at the end of one year. Only my supervisor and I will have access to the data. The data will be used for research purposes only and will not be used to evaluate you in any way.

I do not foresee any risks in your participation in this research. You are not obligated to answer any question that you find objectionable or are uncomfortable with, and you are assured that no information collected will be reported to anyone who is in authority over you. Participation is voluntary and you are free to withdraw from the study at any time without reason or consequence, and you may request removal of all or part of your data.

This research provides an opportunity to both discern and articulate the best practices around Grade 9 Applied Mathematics. I believe that your school can contribute to this conversation. It is important to document what has gone into your school’s success because it is imperative that we build the knowledge base related to effective Grade 9 Applied Mathematics classrooms. Ideally students across the province will experience the kind of success in Grade 9 Applied Mathematics that students at (name of school) consistently demonstrate.

Should you have further concerns about your rights as a participant in this study, please feel free to contact the Office of Research Ethics by e-mail at ethics.review@utoronto.ca, or by phone at 416-946-3273. If you have any questions about the research itself, please contact me, Alison Macaulay at 705-745-7662 or alison.macaulay@utoronto.ca or my supervisor, Dr. Ben Levin at ben.levin@utoronto.ca

Sincerely,

Alison Macaulay
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OISE/University of Toronto
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Dr. Ben Levin
Professor, Leadership, Higher and Adult Education
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EFFECTIVE PRACTICES IN GRADE 9 APPLIED LEVEL MATHEMATICS

Consent Form

I have read and received a copy of the letter of information, have had the nature of the study explained to me, and I agree to participate in the study. All questions have been answered to my satisfaction and I understand that I am free to withdraw my participation at any time.

Printed Name of Participant  

E-mail*

Participant’s Signature  

Date

Please initial if you would like a summary of the research findings upon completion:

Please initial if you agree to have you interview audio/video-taped:

*E-mail address will be used to send transcripts of interview for your review and to send a copy of the research findings if you request it.
Appendix E:

Letter of Information / Consent Form (Case Study: Rapidly Improving)

Date:

To the participants in this study,

The purpose of this study is to understand the kinds of professional learning, resources, organizational, leadership, and teaching practices that schools have put in place to support student achievement in Grade 9 Applied Mathematics.

This study will be carried out in Ontario under the supervision of Dr. Ben Levin, Department of Leadership, Higher and Adult Education, the Ontario Institute for Studies in Education/University of Toronto. The data is being collected for the purposes of my EdD thesis and perhaps for subsequent research articles. It has been approved by your school board.

Given that the student achievement in Grade 9 Applied Mathematics has been lackluster provincially, it is important to understand what our successful schools are doing to support student achievement. In order to determine which of our schools in the province are “rapidly improving” I have reviewed EQAO data to find schools that have met the following criteria:

1. The school has moved from being below the provincial average five years ago to meeting or exceeding the provincial average for the past two years, or

2. The school has improved by a minimum of 25 percentage points over the past five years.

Based on these criteria, I have identified your school as a potential site for my study. I am interested in learning more about what might have contributed to your success. Ideally, I would like to interview an administrator, the Math Department Head, and two teachers that have taught Grade 9 Applied Mathematics at your school.

From this study I hope to be able to offer some concrete steps—or starting points—that other schools and districts might take to better support student achievement in Grade 9 Applied Mathematics.

If you agree to participate in this study, you will be asked to participate in a 45 to 60 minute interview. I will work with your principal to arrange a suitable date to visit your school. Areas that I plan to discuss include: professional learning opportunities that you have participated in; resources that are available to you to teach Grade 9 Applied Mathematics; and, initiatives that your math department has undertaken to support Grade 9 Applied Mathematics.
If you agree to participate in this study, I will send you the complete list of questions that I intend to ask during the interview so that you have time to think about and reflect on them. Examples of questions that might be asked are:

1. Have you been involved in any professional learning that has helped to support your teaching of Grade 9 Applied Mathematics?

2. Are there specific resources (human or material) that have been important to you in teaching Grade 9 Applied Mathematics?

Should you participate, and with your consent, the interview will audio-recorded. A detailed summary of the interview will be prepared and shared with you to comment on or correct. This should take no more than a half hour of your time. None of the data reported from this study will contain your name, or the name of your place of work. I will take the necessary measures e.g., use of pseudonyms, to ensure confidentiality in all written reports or presentations which might emanate from this study.

All data will be stored electronically in as secure location in the researcher’s home office. It will be password-protected, and destroyed at the end of one year. Only my supervisor and I will have access to the data. The data will be used for research purposes only and will not be used to evaluate you in any way.

I do not foresee any risks in your participation in this research. You are not obligated to answer any question that you find objectionable or are uncomfortable with, and you are assured that no information collected will be reported to anyone who is in authority over you. Participation is voluntary and you are free to withdraw from the study at any time without reason or consequence, and you may request removal of all or part of your data.

This research provides an opportunity to both discern and articulate the best practices around Grade 9 Applied Mathematics. I believe that your school can contribute to this conversation. It is important to document what has gone into your school’s success because it is imperative that we build the knowledge base related to effective Grade 9 Applied Mathematics classrooms. Ideally students across the province will experience the kind of success in Grade 9 Applied Mathematics that students at (name of school) have demonstrated.

Should you have further concerns about your rights as a participant in this study, please feel free to contact the Office of Research Ethics by e-mail at ethics.review@utoronto.ca, or by phone at 416-946-3273. If you have any questions about the research itself, please contact me, Alison Macaulay at 705-745-7662 or alison.macaulay@utoronto.ca or my supervisor, Dr. Ben Levin at ben.levin@utoronto.ca

Sincerely,

Alison Macaulay
Ed. D. Candidate, Leadership, Higher and Adult Education
OISE/University of Toronto
email: alison.macaulay@utoronto.ca

Dr. Ben Levin
Professor, Leadership, Higher and Adult Education
OISE/University of Toronto
email: blevin@oise.utoronto.ca
EFFECTIVE PRACTICES IN GRADE 9 APPLIED LEVEL MATHEMATICS

Consent Form

I have read and received a copy of the letter of information, have had the nature of the study explained to me, and I agree to participate in the study. All questions have been answered to my satisfaction and I understand that I am free to withdraw my participation at any time.

Printed Name of Participant

E-mail*

Participant’s Signature

Date

Please initial if you would like a summary of the research findings upon completion:

Please initial if you agree to have you interview audio/video-taped:

*E-mail address will be used to send transcripts of interview for your review and to send a copy of the research findings if you request it.
Appendix F

Case Study Interview Questions with Links to Conceptual Framework

Administrator

1. Please tell me a little about your background.
   (Resources, Leadership)

2. Your school has had impressive student achievement on Grade 9 EQAO in Applied Math. To what do you attribute your success?
   (Resources, Professional Learning, Math Department, Leadership, Reform-based Teaching Practices)

3. Have you or your teachers been involved in any professional learning that has helped to support your school’s success in Grade 9 Applied Mathematics?
   (Resources, Professional Learning)

4. Do you or your board have any specific practices that you have adopted regarding Grade 9 Applied Mathematics?
   (Resources, Leadership, Reform-based Teaching Practices)

5. Does your math department have any specific practices or initiatives that have been important in supporting Grade 9 Applied Mathematics?
   (Math Department)

6. Are there specific resources (human or material) that have been important to your school’s success with Grade 9 Applied Mathematics?
   (Resources, Leadership)

7. How are the chairs/department heads in your school instructional leaders?
   (Math Department, Leadership)

8. Has your school adopted any specific practices to support Grade 9 Applied Mathematics on test day?
   (Leadership)

9. What instructional approaches do you see used by Grade 9 Applied Mathematics teachers that seem to support the learners in these classrooms?
   (Resources, Reform-based Teaching Practices)
10. How would you describe a typical student in Grade 9 Applied Mathematics?

11. What do you think are the biggest barriers to achievement in Grade 9 Applied Mathematics?  
   (Resources, Leadership, Reform-based Teaching Practices)

12. What advice would you share with other administrators that are working to improve their student success in Grade 9 Applied Mathematics?  
   (Resources, Leadership, Math Department)

13. What do you think is the most important thing a school can do to support student achievement in Grade 9 Applied Mathematics?  
   (Resources, Leadership)

14. What do you think is the most important thing that districts can do to support student achievement in Grade 9 Applied Mathematics?  
   (Resources, Leadership)

15. Do you have any other thoughts or comments that you think is important in the dialogue of support student success in Grade 9 Applied Mathematics?

**Math Department Head**

1. Please tell me a little about your background  
   (Resources, Leadership)

2. Your school has had impressive student achievement on Grade 9 EQAO in Applied Math. To what do you attribute your success?  
   (Resources, Professional Learning, Math Department, Leadership, Reform-based Teaching Practices)

3. Have you or your department been involved in any professional learning that has helped to support your school’s success in Grade 9 Applied Mathematics?  
   (Resources, Professional Learning)

4. Have you been involved in any professional learning with other Grade 9 Applied Math teachers specifically?  
   (Professional Learning)

5. Does your math department have any specific practices or initiatives that have been important in supporting Grade 9 Applied Mathematics?
6. Are there specific resources (human or material) that have been important to your school’s success with Grade 9 Applied Mathematics? (Resources)

7. Can you tell me a little about the department meetings at your school? (Math Department)

8. Has your school adopted any specific practices to support Grade 9 Applied Mathematics on test day? (Leadership)

9. What would a typical lesson in your Grade 9 Applied Mathematics classroom look like? (if applicable) (Reform-based Teaching Practices)

10. How would you describe a typical student in Grade 9 Applied Mathematics?

11. What do you think are the biggest barriers to achievement in Grade 9 Applied Mathematics? (Resources, Leadership, Reform-based Teaching Practices)

12. What advice would you share with other math department heads that are working to improve their student success in Grade 9 Applied Mathematics? (Resources, Math Department, Leadership)

13. What do you think is the most important thing a school can do to support student achievement in Grade 9 Applied Mathematics? (Resources, Leadership)

14. What do you think is the most important thing that districts can do to support student achievement in Grade 9 Applied Mathematics? (Resources, Leadership)

15. Do you have any other thoughts or comments that you think is important in the dialogue of support student success in Grade 9 Applied Mathematics?

**Grade 9 Applied Mathematics Teacher**

1. Please tell me a little about your background (Resources, Leadership)
2. Your school has had impressive student achievement on Grade 9 EQAO in Applied Math. To what do you attribute your success? (Resources, Professional Learning, Math Department, Leadership, Reform-based Teaching Practices)

3. Have you been involved in any professional learning that has helped to support your teaching of Grade 9 Applied Mathematics? (Resources, Professional Learning)

4. Does your math department have any specific practices or initiatives that have been important in supporting Grade 9 Applied Mathematics? (Math Department, Reform-based Teaching Practices)

5. Are there specific resources (human or material) that have been important to your school’s success with Grade 9 Applied Mathematics? (Resources)

6. Can you tell me a little about the department meetings at your school? (Math Department)

7. Has your school adopted any specific practices to support Grade 9 Applied Mathematics on test day? (Leadership)

8. What would a typical lesson in your Grade 9 Applied Mathematics classroom look like? (Reform-based Teaching Practices)

9. How would you describe a typical student in Grade 9 Applied Mathematics?

10. What do you think are the biggest barriers to achievement in Grade 9 Applied Mathematics? (Resources, Leadership, Reform-based Teaching Practices)

11. What advice would you share with other teachers that are working to improve their student success in Grade 9 Applied Mathematics? (Resources, Reform-based Teaching Practices)

12. What do you think is the most important thing a school can do to support student achievement in Grade 9 Applied Mathematics? (Resources, Leadership)
13. What do you think is the most important thing that districts can do to support student achievement in Grade 9 Applied Mathematics? (Resources, Professional Learning, Leadership)

14. Do you have any other thoughts or comments that you think is important in the dialogue of support student success in Grade 9 Applied Mathematics?
Appendix G:
Observation Guide: Case Study Classroom D

<table>
<thead>
<tr>
<th>School D</th>
<th>Date</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>May 27, 2013</td>
<td>1:30 PM – 2:45 PM</td>
</tr>
</tbody>
</table>

| Class Make-Up | 18 students | Girls | 8 | Boys | 10 |

**Learning Environment**

<table>
<thead>
<tr>
<th>Seating</th>
<th>Motivational posters:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single desks, organized on rows</td>
<td>Challenge yourself!</td>
</tr>
<tr>
<td>Students easily move into partner and group formation</td>
<td>Soar together!</td>
</tr>
<tr>
<td>Walls</td>
<td>Stay Focused!</td>
</tr>
<tr>
<td></td>
<td>Just because something is difficult doesn’t mean you shouldn’t try. It means you should just try harder.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Anchor Charts</th>
<th>Climate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiplication Tables</td>
<td>Teacher greets students personally as they enter the classroom</td>
</tr>
<tr>
<td>Number Line</td>
<td>Starting by talking about EQAO test that is coming up, i.e., logistics, how to prepare, what to do that way, everyone is prepared</td>
</tr>
<tr>
<td>The Equation of a line – teacher created with definition, example, various representations</td>
<td>Student comment that this is a “safe space”</td>
</tr>
<tr>
<td>Climate</td>
<td>Building confidence, e.g., “You don’t need a calculator” “No one is going to fail”</td>
</tr>
</tbody>
</table>

**Resources**

<table>
<thead>
<tr>
<th>Manipulatives</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manipulatives stored in in classroom</td>
<td>Smartboard</td>
</tr>
<tr>
<td></td>
<td>Calculators are available</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ministry Resources</th>
<th>EQAO pamphlet was distributed: <em>EQAO Tests in Secondary Schools. A Guide for Parents and Students</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>TIPS Questions</td>
<td></td>
</tr>
<tr>
<td><strong>Lesson – Constructivist / Transmission</strong></td>
<td></td>
</tr>
<tr>
<td>-----------------------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>Format</strong></td>
<td><strong>Questioning</strong></td>
</tr>
<tr>
<td>Three part lesson</td>
<td>Mostly teacher questioning in whole group</td>
</tr>
<tr>
<td>Minds on at smartboard (MP3 Problem)</td>
<td>Teacher asks, “Why,” “Show me,” “How do</td>
</tr>
<tr>
<td>Action in pairs, groups, by question</td>
<td>you know?” “Explain your thinking” when</td>
</tr>
<tr>
<td>Students prepare solution on chart</td>
<td>students are working in small groups</td>
</tr>
<tr>
<td>paper for consolidation next lesson</td>
<td>Teacher encourages students to ask questions of</td>
</tr>
<tr>
<td></td>
<td>other groups as they are working (ask a</td>
</tr>
<tr>
<td></td>
<td>neighbor before me)</td>
</tr>
<tr>
<td><strong>Student Work</strong></td>
<td><strong>Groupings</strong></td>
</tr>
<tr>
<td>• Previous to this, students had learned to graph one equation on a graph. This task required them to graph two equations, and then interpret them.</td>
<td>Pairs work</td>
</tr>
<tr>
<td>Differentiated Task from TIPS: students picked the group (task) that they wanted to work with</td>
<td>Group work</td>
</tr>
<tr>
<td>Cell Phone Problem</td>
<td>Whole group</td>
</tr>
<tr>
<td>Music Problem</td>
<td></td>
</tr>
<tr>
<td>Snowboard Problem</td>
<td></td>
</tr>
<tr>
<td>Athletic Banquet Problem</td>
<td></td>
</tr>
<tr>
<td>Yearbook Club Problem</td>
<td></td>
</tr>
<tr>
<td>• Task involved multiple representations of linear equations (table of values, graph, equation). Students had to determine which option was the best deal.</td>
<td></td>
</tr>
<tr>
<td>• Students were to solve problem on a large chart which would be eventually shared with the class</td>
<td></td>
</tr>
<tr>
<td><strong>Assessment for Learning</strong></td>
<td></td>
</tr>
<tr>
<td>Teacher gives descriptive feedback as students are working</td>
<td></td>
</tr>
<tr>
<td>Learning goal is posted: I can graph a linear equation.</td>
<td></td>
</tr>
<tr>
<td>Success Criteria:</td>
<td></td>
</tr>
<tr>
<td>My graph coincides with the equation.</td>
<td></td>
</tr>
<tr>
<td>I can determine if the graph is linear.</td>
<td></td>
</tr>
</tbody>
</table>
**Classroom Discourse Patterns / Math Talk**

- Strategies to include everyone in the conversation, e.g., “Clap if you agree”
- Mostly teacher-student-teacher during whole group instruction
- Q & A format

Students were free to discuss math problem when they were working in groups. Teacher also encouraged students to speak across groups.

**Sketch of classroom:**
**Action Problem:**

**Problem Solving Activity**

**Cell Phone Problem**
You are considering changing your cell phone plan. 
**Koodo** offers a monthly flat fee of $40 plus 10 cents for each additional minute of use. 
**Telus** offers a monthly flat fee of $20 plus 15 cents for each additional minute of use.

Which plan would you choose?

**Music Problem**
**MyRadioStore**

RadioAlot and MyRadioStore are two online music providers. RadioAlot charges a $10 monthly membership fee and $1 per song download rate. MyRadioStore charges $7 monthly membership fee and $1.50 per song download rate.

Which online music provider would you choose?

**Snowboard Problem.**
You are just learning how to snowboard. 
Alpine Valley charges $10/hour for lessons and $40 for the lift ticket and snowboard rental. Nubsnob charges $20/hour which includes lesson, lift ticket and rentals.

Which resort would you choose?

**Athletic Banquet Problem**
The school council is trying to determine where to hold the athletic banquet. The Algebra Ballroom charges an $800 flat fee and $60 per person for the meal. Linear Hall charges a $1000 flat fee and $55 per person for the meal.

Which location should the school council select for their athletic banquet?

**Yearbook Club Problem**
The yearbook club is considering two different companies to print the yearbook. Pascal Publishing charges a flat fee of $475 plus $4.50 per book. School Memories charges a flat fee of $550 plus $4.25 per book.

Which company should the yearbook club select to print this year’s yearbook?

Students will present solutions tomorrow.
Lesson Outline:

Other:

- Absent folder—names go on sheet for those that were away
- Classroom Management—count down for silence
- Discussion re: upcoming EQAO assessment
  - Distributes EQAO flyer
  - When? June 13, 8:40 AM to lunch
  - What do you need to bring?
    - Where? Cafeteria
    - What to do? Come to class like always, have a nutritional breakfast, get a good sleep
    - What to expect
    - No one is going to fail
    - Kinds of questions
    - Tutorials
    - Worth 5% of your work

Minds On

The MP3 Problem (on Smartboard)

Mark recently purchased an MP3 player. The player came with 1000 songs already loaded.

As part of the purchase agreement, Mark is able to download 50 additional songs per day at no charge. After 10 days, how many songs will he have?

*Use your calculator, or do it in your head. Share with a partner.*

*After 20 straight days, how many does he have? Talk to a neighbor.*

*“Clap if you agree”*

*The two variables of this problem are the Number of Days and the Number of Songs. Which is independent and which is dependent?*

*What is dependent on what? ➔ Songs on days, or days on songs?*
Numerical Model (Table of Values) – students were selected to come up and fill in values

<table>
<thead>
<tr>
<th>Number of Days</th>
<th>Number of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1000</td>
</tr>
<tr>
<td>5</td>
<td>1250</td>
</tr>
<tr>
<td>10</td>
<td>1500</td>
</tr>
<tr>
<td>15</td>
<td>1750</td>
</tr>
<tr>
<td>20</td>
<td>2000</td>
</tr>
<tr>
<td>22</td>
<td></td>
</tr>
<tr>
<td>34</td>
<td></td>
</tr>
</tbody>
</table>

“You don’t need your calculator”

“Do you understand all that? Are you good?”

Action: Problem Solving Activity

“It’s your special day. You get to choose.”

“There are four options. Pick one.”

“Find someone that is doing the same one and work with them.”

Some students work independently
Some students work in groups of 2 or 3
Teacher walks around and checks on progress, answering questions
EA in the room

Checking on progress, monitoring, what questions are you on?

Teacher personally delivers work to students that were absent

Teacher provides descriptive feedback

Personal connections
- Car exhaust test
- Wedding, rental hall + meals + dress

“That even tricked me”

Students solidly working on the questions

“You’ll be good at that”

2:15 PM. Small stretch break. Students go back to their original seats.
Consolidation: Graphing Activity (Smartboard)

*Number yourselves, one or two (creating teams)*

“Don’t do that. You’ll hurt yourself.”

- No nonsense

Jeopardy type activity – matching graphs to equations and interpreting them (about ten minutes)

Independent Follow-up Question
- Outfitters. What is the better deal? (students worked independently)

Played songs when students were working (10 mins.)
- Rock on Pythagoras
C. Outfitters*

Jaraad wants to rent a canoe for a day trip. He gathered information from two places and produced the following graphs.

1. What is the cost of each place if Jaraad cancels his reservation?

2. Write an equation to model the cost of each outfitter.

   **Big Pine** \[ C = \]

   **Hemlock Bluff** \[ C = \]

3. a) If Big Pine Outfitters decided to change its base fee to $50 and charge $10 per hour, what effect would this have on the graph?

   b) Draw the new line on the graph.

   c) Write an equation to model the new cost.

4. a) If Hemlock Bluff Adventure Store decided to change its hourly rate to $20 per hour, what effect would this have on the graph?

   b) Draw the new line on the graph.

   c) Write an equation to model the new cost.

*This activity is adapted from TIPS4RM.*
Appendix H:

Moving from Codes to Patterns in the Data Analysis

<table>
<thead>
<tr>
<th>Initial Nodes</th>
<th>Categories</th>
<th>Themes</th>
<th>Patterns</th>
</tr>
</thead>
</table>
| • TIPS4RM  
• Gizmos  
• GSP  
• CLIPS  
• Gap Closing  
• Manipulatives  
• Interactive whiteboards  
• EQAO website  
• Calculators  
• Teachers equip students | Resources  
• Material | • Variety of resources, many from the ministry  
• TIPS4RM (all)  
• Sample questions from EQAO website (all)  
• Manipulatives and calculators are housed in case study classrooms  
• Interactive whiteboards in all case study classroom  
• Dynamic nature is important  
• Professional learning is important for implementation | • No textbook. Teachers teams develop 9P program that changes and adapts over time to incorporate new resources  
• EQAO is seen as a reflection of the curriculum  
• Free access to learning tools, even pencils  
• Hands on, experiential and active  
• Shared meaning making through co-planning is required for uptake and purposeful use of resources |
| • Math Degree  
• Math Qualifications  
• Teaching Background  
• Years of Experience  
• Role  
• The “right” teachers in 9P | Human | • University background in math, but not necessarily math degree  
• Applied teacher experience: either 8 and under or over 20 years  
• Same teachers tend to teach 9P all of the time  
• Math Heads teach 9P  
• Many applied teachers have elementary experience  
• Team players  
• Willing to try new things | • Purposeful staffing  
• Teachers are comfortable with the math (background and/or experience matters)  
• Teachers want to teach this course  
• passionate about students in applied  
• enjoy this age/grade level  
• Innovative teachers |
| • Cross-panel with Grade 7 & 8 Teachers  
• PLCs/Teacher Teams  
• Open / Parallel questions  
• Problem-based learning | Professional Learning | • Understanding the learning continuum from Grades 7 to 9  
• Collaborative  
• Purposeful, with relevance to the classroom  
• Questioning strategies | • Curriculum-focused  
• Active, not passive  
• Planning for own students  
• Higher level questions can impact teacher beliefs about what students can do; supports adoption of collaborative learning and other reform-based strategies |
| • Sharing ideas is common  
• “Hang out” with other department members  
• EQAO counts in student marks  
• Practice assessments  
• Tutorial sessions | Math Department | • Collaborative spaces  
• Recognition that students do better in the long run if they do well in Grade 9  
• Team effort to prepare students for EQAO assessments | • Collaborative and professionally supportive cultures, nurtured by Math Head  
• Math Head knows what is happening in Grade 9 Applied classrooms  
• Math Department places value on EQAO assessment |
<table>
<thead>
<tr>
<th>Initial Nodes</th>
<th>Categories</th>
<th>Themes</th>
<th>Patterns</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Most principals are viewed as being extremely supportive</td>
<td>Leadership</td>
<td>• Administrators support Grade 9 Applied Math</td>
<td>• EQAO Grade 9 Mathematics assessment is treated with import</td>
</tr>
<tr>
<td>• Administrator communicates with students and parents about EQAO</td>
<td></td>
<td>• P (or VP's assigned numeracy portfolio) have a background in math</td>
<td>• Principals understand challenge of 9P classrooms</td>
</tr>
<tr>
<td>• EQAO writing time is protected, e.g., no announcements, field trips, etc.</td>
<td></td>
<td>• Math Department Heads know what is happening in the 9P course</td>
<td>• Math Department Head is instructional leader for Grade 9 Applied Mathematics</td>
</tr>
<tr>
<td>• Math Department Heads are highly regarded</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Heads act as mentors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Partner work</td>
<td>Reform-based</td>
<td>• Students work with others instead of in isolation</td>
<td>• Development of mathematical community of learners</td>
</tr>
<tr>
<td>• Group work</td>
<td>Teaching Strategies</td>
<td>• Respectful learning environment</td>
<td>• Students are resources to one another’s learning</td>
</tr>
<tr>
<td>• Problem solving</td>
<td></td>
<td>• Classroom space reflects student learning</td>
<td></td>
</tr>
<tr>
<td>• Investigations</td>
<td>Collaborative</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Established partner and group work protocols, e.g., Think–Pair–Share</td>
<td>Learning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Evidence of shared learning, e.g., charts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Hands on</td>
<td>Student Tasks</td>
<td>• Tasks are conduits to learning</td>
<td>• Learning comes from doing</td>
</tr>
<tr>
<td>• Active</td>
<td></td>
<td>• Cognitively demanding tasks</td>
<td></td>
</tr>
<tr>
<td>• Collaborative</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Practice of skills and application of skills</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Problem solving</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Investigations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Manipulatives</td>
<td>Use of Manipulatives</td>
<td>• All classrooms have interactive whiteboard</td>
<td>• Manipulatives and technology are learning/thinking tools</td>
</tr>
<tr>
<td>• Calculators</td>
<td>and Technology</td>
<td>• Used for use in investigations</td>
<td>• Manipulatives engage students in doing as “mathematicians” do</td>
</tr>
<tr>
<td>• Gizmos (demonstrations)</td>
<td>(intersects with Material</td>
<td>• Used as a hook to engage students</td>
<td>• Manipulatives and technology foster conceptual understanding</td>
</tr>
<tr>
<td>• GSP</td>
<td>resources)</td>
<td>• Manipulatives and calculators are in classroom</td>
<td>• Free access</td>
</tr>
<tr>
<td>• Interactive Whiteboards</td>
<td></td>
<td>• Computer technology is used mostly used in classroom (small group vs. individual)</td>
<td>• Models for manipulative use are important</td>
</tr>
<tr>
<td>• Worked with Grade 7/8 teachers</td>
<td></td>
<td>• Newer to secondary settings</td>
<td></td>
</tr>
<tr>
<td>• Manipulatives and technology are learning/thinking tools</td>
<td></td>
<td>• Teacher comfort is necessary</td>
<td></td>
</tr>
<tr>
<td>• Partner and group work to talk about the mathematics</td>
<td>Classroom Discourse</td>
<td>• Manipulatives engage students in doing as “mathematicians” do</td>
<td></td>
</tr>
<tr>
<td>• Whole group shares strategies and thinking</td>
<td></td>
<td>• Manipulatives and technology foster conceptual understanding</td>
<td></td>
</tr>
<tr>
<td>• Whole group shares strategies and thinking</td>
<td></td>
<td>• Free access</td>
<td></td>
</tr>
<tr>
<td>• Partner and group work to talk about the mathematics</td>
<td></td>
<td>• Models for manipulative use are important</td>
<td></td>
</tr>
<tr>
<td>• Whole group shares strategies and thinking</td>
<td></td>
<td>• Articulating mathematical thinking is expected</td>
<td></td>
</tr>
<tr>
<td>• Whole group shares strategies and thinking</td>
<td></td>
<td>• Shared meaning making</td>
<td></td>
</tr>
<tr>
<td>• Whole group shares strategies and thinking</td>
<td></td>
<td>• Informs teacher</td>
<td></td>
</tr>
<tr>
<td>Initial Nodes</td>
<td>Categories</td>
<td>Themes</td>
<td>Patterns</td>
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<tr>
<td>• Exit Slips</td>
<td>• Assessment for Learning</td>
<td>• On-going and frequent formative assessments</td>
<td>• Teachers are quick to identify when students struggle and respond</td>
</tr>
<tr>
<td>• Entry Slips</td>
<td></td>
<td>• Teacher engages in observations and conversations</td>
<td>• Oral, timely, descriptive feedback</td>
</tr>
<tr>
<td>• Quizzes</td>
<td></td>
<td>• Test-taking skills (multiple-choice and open response)</td>
<td>• Fostering metacognition</td>
</tr>
<tr>
<td>• Red light, green light</td>
<td></td>
<td>• Students reflect on the characteristics and quality of their own work</td>
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<tr>
<td>• Monitoring student work</td>
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<tr>
<td>• Use of EQAO sample questions and anchors</td>
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<tr>
<td></td>
<td>• Fostering Positive Dispositions towards Mathematics</td>
<td>• Build confidence</td>
<td>• Safe, responsive learning environment</td>
</tr>
<tr>
<td>• Low self-esteem</td>
<td>• Fostering Positive Dispositions towards Mathematics</td>
<td>• Start with a unit that student find easy, e.g., Measurement</td>
<td>• Help students to build a new identity and relationship with mathematics</td>
</tr>
<tr>
<td>• Don’t like math</td>
<td></td>
<td>• Make connections to previous math learning</td>
<td>• High expectations</td>
</tr>
<tr>
<td>• Quick success</td>
<td></td>
<td>• Rigorous</td>
<td></td>
</tr>
<tr>
<td>• Variety of solutions is celebrated</td>
<td></td>
<td>• Tenacious teachers</td>
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</tr>
</tbody>
</table>
## Appendix I

### Analysis of Cognitive Demand in Observed Tasks

<table>
<thead>
<tr>
<th>Knowing</th>
<th>Applying</th>
<th>Reasoning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classroom A</td>
<td>Complete the table of values</td>
<td>If the job took 6 hours, which company would you choose? Explain your answer.</td>
</tr>
<tr>
<td></td>
<td>At what point on the graph is the cost the same for both companies? (You need both time and cost.)</td>
<td>If the job took 12 hours, which company would you choose? Explain your answer.</td>
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<tr>
<td></td>
<td>Display this data on the grid below.</td>
<td>Complete each of the following sentences:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• I would choose Company A if...</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• I would choose Company B if...</td>
</tr>
<tr>
<td>Classroom B</td>
<td>For each set of angles, can a triangle be drawn? Justify your answer.</td>
<td>Can a triangle have two 90° angles? Explain.</td>
</tr>
<tr>
<td></td>
<td>a) 41°, 72°, 67°</td>
<td>Find the indicated angle measures. Give reasons for your answers.</td>
</tr>
<tr>
<td></td>
<td>b) 40°, 60°, 100°</td>
<td></td>
</tr>
<tr>
<td></td>
<td>c) 100°, 45°, 30°</td>
<td></td>
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<tr>
<td></td>
<td>Determine each unknown angle (diagram of triangle provided with two angles.)</td>
<td>Determine the angle measure indicated by each letter (diagram of triangle in a triangle, three known and two unknown angles).</td>
</tr>
<tr>
<td></td>
<td>An equilateral triangle has 3 equal sides and 3 equal angles. Use this information to determine the measure of each angle. Show your work.</td>
<td></td>
</tr>
<tr>
<td>Knowing</td>
<td>Applying</td>
<td>Reasoning</td>
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<td>------------------------------------------------------------------------</td>
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<tr>
<td>Classroom C</td>
<td>What is the value of $x$? ($x$ is outside of a triangle and corresponding angle is given.)</td>
<td>Can a triangle have 2 obtuse angles? Explain.</td>
</tr>
<tr>
<td></td>
<td>You have an isosceles triangle and one of the angles is 50°. Draw the triangle.</td>
<td>Investigation:</td>
</tr>
<tr>
<td></td>
<td>Determine the unknown angles for the following (triangles with one or two missing angles.)</td>
<td>• Determine the number of triangles in a square, pentagon, hexagon, and heptagon.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• How can this help you to determine the measure of the angle?</td>
</tr>
<tr>
<td>Classroom D</td>
<td>As part of the purchase agreement, Mark is able to download 50 additional songs per day at no charge. After 10 days, how many songs will he have?</td>
<td>The two variables of this problem are the Number of Days and the Number of Songs. Which is independent and which is dependent? How do you know?</td>
</tr>
<tr>
<td></td>
<td>After 20 straight days, how many does he have?</td>
<td>Student groups had the choice of problems that required them to decide which of two purchases would be the best deal and why. They had to represent their thinking on a chart to be presented and defended the next day.</td>
</tr>
<tr>
<td></td>
<td>Represent Mark’s purchase using a Table of Values. Include 22, 34, 100, and $n$ days. You shouldn’t need a calculator. Why?</td>
<td></td>
</tr>
</tbody>
</table>