AN HISTORICAL EXAMINATION OF THE SECONDARY MATHEMATICS CURRICULUM IN ONTARIO THROUGH TWO LENSES: CURRICULUM POLICY DOCUMENTS AND REFLECTIONS OF LEADERS IN THE FIELD

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ABSTRACT

The secondary mathematics curriculum in Ontario has gone through many revisions and renewals during the past 60 years. Current curriculum and policy documents are readily available, yet previous documents are not easily accessible. There is a dearth of literature on historical changes to the Ontario secondary math curriculum, especially from the perspective of the mathematics education leaders. By performing a document analysis of historical secondary mathematics curriculum in Ontario and then interviewing mathematics leaders who have been involved in several change/revision processes, this descriptive study seeks to document the changes to and influences on the Ontario secondary mathematics curriculum since the 1960s.

This study identified keys trends in changes to Ontario mathematics curriculum documents. These trends include an increased focus on teaching methodologies within the document, removal of topics such as conics and proofs with the reduction of the secondary program to four years and an overall increased focus on calculus. By contrasting document changes to both previous literature and interviews conducted in this study, possible triggering events, such as mathematical movements or new political parties elected, were identified for each curriculum revision. By comparing and contrasting experiences of leaders with existing literature suggestions for future curriculum revisions processes are proposed such as a provincial scoping survey prior to the start of the writing process and sufficient time for field testing and implementation.

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GLOSSARY OF TERMS

CMS – *Canadian Mathematics Society* is an association of professional mathematicians dedicated to mathematical research, outreach, scholarship and education in Canada

CMESG – *Canadian Math Education Study Group* was created by the Science Council in Canada in 1978 for mathematicians and math educators to discuss mathematics education. This group meets at an annual conference.

EQAO - *Education Quality and Accountability Office* is a crown agency of the Government of Ontario. Its purpose is to maintain accountability in the public-school system and uses standardized provincial tests. The mathematics tests occur in grades 3, 6 and 9.

HS1 – Formally known as *Circular H.S.1, 1974 -1984* this document outlined the requirements for students in Ontario to complete the Secondary School Graduation Diploma from 1974-1984

Field's Institute Mathematics Education Forum – hosted by *The Field's Institute for Research in Mathematical Sciences,* the forum promotes discussion of issues in mathematics education at all levels, with special emphasis on education in the Province of Ontario.

NCTM – Founded in 1920, the *National Council of Teachers of Mathematics* is the world's largest mathematics education organization throughout the United States and Canada.

OAC – *Ontario Academic Credits* were courses designed to prepare students for post-secondary. These were fifth year secondary course that replaced Grade 13 starting in 1985. OAC courses were discontinued as of the 2000 curriculum document

OAME – The *Ontario Association for Mathematics Education* is a professional organization for everyone interested in Mathematics Education in Ontario. Their mission is to promote excellence in mathematics education throughout the Province of Ontario.

OMCA – *Ontario Mathematics Coordinators Association* exists to provide a framework for 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.

OSSTF – *Ontario Secondary School Teachers Federation* is the provincial trade union that represents all public secondary school teachers

RFP – *Request for Proposal* solicits proposals for the services of an agency or company. In the context of this study, the Ontario government used an RFP to acquire the services of an outside agency or company to create new curriculum documents after the election of a new Conservative government in 1995.

Profiles – The Ministry of Education commissioned the development of "Course Profiles" with the release of the 1999/2000 documents. The contents of these resource documents included a "scope and sequence" by clustering expectations and providing a lesson plan with a student activity. Full profiles were written for the Grade 9 Applied and Academic mathematics, but only partial profiles were provided for other courses.

TIPS – *Targeted Implementation and Planning Supports* were documents created after the release of the most recent curriculum documents to support the implementation of the curriculum across the province. They provide examples and lessons for teachers to follow.

STEM – a term used to group together the subjects of *science, technology, engineering and mathematics*

CHAPTER 1: INTRODUCTION

The history and development of the secondary mathematics curriculum in Ontario is of great interest to me due to professional and personal reasons. I grew up in Ontario with an interest in mathematics, so I enrolled in all the high school university level math classes. This interest eventually led to my completion of a Bachelor of Science focused on mathematics and physics which I followed up with a Bachelor of Education to become certified to teach both mathematics and physics. Professionally, I have worked in the secondary education system in Ontario teaching mathematics and science for nine years now.

Throughout my time as a student in secondary school, I rarely struggled with new mathematics concepts and was consistently able to achieve high marks. Thus, having completed the highest level of mathematics courses available in Ontario, I felt confident I had mastered the mathematical skills, content and strategies needed to pursue mathematic courses in a post-secondary setting. It was a shock the subsequent year when I failed the first midterm in my first-year calculus class and then faced subsequent struggles. In conversation with the professor while obtaining help, he mentioned that the struggles I had were a common issue with Ontario students who did not take IB[1] or AP[2] courses. He went on to explain that since the elimination of the Grade 13 year in Ontario, many students in my position were similarly challenged. In order for the high school mathematics program to be condensed from five to four years, many important topics were excluded or highly abbreviated; however, according to this particular university professor the universities did not adapt their courses to accommodate the removal of critical Grade 13 material from the curriculum.

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[1] International Baccalaureate (IB) courses are math courses developed by the International Baccalaureate for the completion of the IB diploma program

[2] Advanced Placement (AP) courses are courses developed by the College Board which offer university level examinations to high school students

Now, over a decade later, as a mathematics educator myself, I find myself teaching curriculum that has even fewer topics than those in the courses that I took just one decade ago. It is frustrating to me to teach a curriculum that appears to be continuously diminished over time, and I had questions about the alignment of content courses between grade levels as a result of the changes to the curriculum.

To further understand the changes that have taken place in the Ontario mathematics curriculum, I started asking around and looking for old documents. To my surprise, it was almost impossible to find old documents in schools or online, and many teachers could not tell me why or how changes were made to the curriculum. It is important that revisions to the curriculum over time be tracked and mapped in order to be communicated clearly to current instructors in both secondary and post-secondary environments. While the mathematics curriculum policy documents will tell their own objective story through text, what is absent is the record of the conversations and deliberations that occurred behind the scenes to bring the curriculum to fruition; thus, it is important to honour those individuals who were most closely involved in mathematics curriculum reform between 1960 and the present time by giving them an opportunity to share their first-hand experiences and reflections on those experiences.

In this study, I explored the historical changes made to the Ontario secondary mathematics curriculum with an emphasis on both curriculum alignment and how mathematics education leaders, such as university mathematics professors, mathematics education professors and secondary math department heads have perceived these changes. Specifically, mathematics leaders were interviewed to determine whether they felt the changes were necessary and to offer their rationales for making the changes. These changes and perceptions were then compared to wider trends and movements occurring within the North American mathematics education community.

Purpose and Research Questions

The purpose of this descriptive study was to document the changes to the Ontario secondary math curriculum and its alignment since the 1960s. Using historical secondary mathematics curriculum policy documents, I logged major changes to content and frameworks among the sequential curriculum iterations. I focused particularly on alignment between grades. To add context to the alignment analysis, I interviewed individuals who were responsible for the development and implementation of the Ontario curriculum documents to gather data about the rationale and process for revisions to content and concomitant changes to the underlying principles for the policy documents. The overall objective of this study was to provide a detailed record of the change cycles for the secondary mathematics curriculum in Ontario on the basis of official policy documents and from the perspective of members of the mathematics education community who were leaders in the change process.

To achieve the overall purpose of the study, the method was carried out in two distinct but interrelated phases. The focus of Phase One was the analysis of the curriculum documents to determine the overall strands in each individual course and the alignment of these strands to related historical courses. Using interviews, Phase Two focused on giving voice to leaders in the mathematics community about their contributions to the changing curriculum.

This overall purpose was achieved by:

1. recording changes to content in the Ontario secondary mathematics curriculum policy document between 1960 and 2017;
2. aligning these changes to particular historical events and educational movements; and,

3. providing contextual background for changes to the Ontario secondary mathematics curriculum policy document by giving voice to the leaders in the mathematics community to contributed to the change process(es).

Rationale

The mathematics curriculum has seen many revisions over the past 60 years. Curriculum renewal in Ontario has been in a continuous state of evolution stemming from the 1960s "new math" movement to the 1970s "back to basics" movement to the revolutionary release of NCTM's *Curriculum and Evaluation Standards for School Mathematics* in 1989 (Craven, 2003). In 1997, Dr. Geoff Roulet published a comprehensive research paper on the issues, choices and opinions that would drive the creation of the new mathematics curriculum in Ontario in the post NCTM Standards years. This new curriculum would coincide with a re-organization of the high school structure (Roulet, 1997). In 1998, an entirely new Grade 1-8 mathematics curriculum was introduced, along with the beginning of standards-based testing of students in Grade 3 and 6 mathematics (Craven, 2003). A new secondary mathematics curriculum was introduced for Grade 9 in 1999 followed by parallel documents for Grade 10 in 2000, Grade 11 in 2001 and finally Grade 12 in 2002 resulting in the elimination of the OAC[3] year from the Ontario high school program. Two documents were produced for these secondary mathematics courses: *Mathematics: The Ontario Curriculum, Grades 9 and 10 (1999)* and *Mathematics: The Ontario Curriculum, Grades 11 and 12 (2000)*. The most recent report on the state of mathematics education in Ontario was authored by Stewart Craven in 2003─a paper in which he reviewed the curriculum changes that had occurred up until that year. Since 2003, a revised secondary mathematics curriculum has been released with the Grade 9 and 10 document being updated in

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[3] Ontario Academic Credits, these courses compromised what was Grade 13 in the Ontario math curriculum

2005 and the Grade 11 and 12 document updated in 2007. In the last decade, mathematics education has seen an explosion of new technologies and recommendations for changes to instructional strategies, along with a Renewed Mathematics Strategy for Ontario in 2016. Research like this study may assist curriculum developers and Ministry of Education staff to prepare documents and policies to better serve secondary mathematics education. The alignment analysis may also allow educators to better understand why certain topics are challenging to students in different grades.

Overview of Thesis

The aim of the research was to document the changes to the Ontario secondary mathematics curriculum since the 1960s and to provide context to those changes by sharing the first-hand reflections of a small number of influential mathematics leaders involved at key stages in the curriculum revision process. Ontario secondary school mathematics curriculum documents from 1960s to 2007 were obtained and analyzed. Four participants were recruited for this study. All of the participants spent decades in mathematics education, held various local and provincial mathematics education leadership roles and played a part in a major curriculum revision process.

This chapter introduced the study. Chapter Two reviews the literature around the history of mathematics education in both North America and, more specifically, Ontario. Chapter Three details the research design, sampling procedures, recruitment process and participant selection, the role of the researcher, the method of data collection, and the method of analysis. Chapter Four describes the findings of the study. Finally, Chapter Five, connects the findings of the document analysis and interviews analysis, discusses the findings of the study in relation to the larger body of literature, discusses the limitations and strengths of the study, and makes recommendations for future practice as well as research. The thesis ends with the researcher’s concluding thoughts and reflections about the study.

CHAPTER 2: LITERATURE REVIEW

This literature review considers the previous research done on the history of mathematics education in North America and Ontario. This chapter is split into two main sections, one describing changes in North America and the other addressing processes in Ontario. The North American section is divided into the following eras (1) 1700s to late 19th Century, (2) Late 19th to Early 20th Century, (3) 1914-1940, (4) 1940 -1957, (5) 1957-1979 and (6) 1980-2000. The Ontario section is organized by the following eras (1) 1900-1960, (2) 1960-1989, (3) 1990-2003 and (4) 2003-Present

Mathematics education in Ontario has a long and storied history dating back to the time of early European settlers, where mathematics was often taught in a one room school house by the local teacher. Since then, the mathematics community in Ontario has evolved to include both large professional associations of mathematic educators and a mandated Ontario-wide curriculum policy document. Along the way, there have been many external influences on both the mathematics education community and the mathematics that was taught in Ontario. These influences have ranged from World Wars to social reactions to political events, all shaping the goals of mathematics education. Ontario mathematics education did not develop within a vacuum, so it is important to understand the history of North American mathematics education as the context within which Ontario's mathematics curriculum developed.

North American Mathematics Education from Past to Present

1700s – Late 19th Century North American (N.A.) Mathematics Education

Early mathematics education in 1700s North America was based mostly on the arithmetic knowledge of addition, subtraction, multiplication and division for the sole purpose of helping sellers, buyers and investors in the business of commerce (Cohen, 2003). The majority of students did not learn anything past these basic skills and any student requiring any mathematics knowledge beyond the basics could acquire them through private lessons. College curricula of mathematics instruction at this time served only to develop mental discipline and logical thinking, it did not aim at the accumulation of mathematical knowledge (Parshall, 2003). Simply put, the North American economy of the 1700s was able to survive without elaborate and extensive levels of numeracy (Cohen, 2003). Until about 1820, most students did not begin to learn arithmetic until the age of 10. The North American economy during the early 1800s was beginning to shift towards a market economy that now required greater skill in numeracy. In fact, "many mechanics and farmers have lost half their earnings by neglecting to make a regular entry of their daily transactions" (Staniford, 1818, p.iii). The economy could not subsist without a greater diffusion of numeracy skills to the general public so there was increased pressure to teach children at a younger age the rules of arithmetic.

It was in 1821 that a small volume written by Warren Colburn started a complete re-orientation of arithmetic education (Cohen, 2003). Colburn's book was revolutionary for two reasons; first for being focused on students age 4-10 and second, for introducing the pedagogical technique of inductive reasoning based on the works of Johann Pestalozzi (Michalowicz & Howard, 2003), that had the students *discover* the basic arithmetic rules rather than being told. His book was successful in changing the way mathematics was taught at the time, with students learning arithmetic at a younger age than ever before and mental arithmetic being embraced by the mathematics education community. Canadian mathematics texts at this time often followed the trends of the United States (Michalowicz & Howard, 2003). By the 1830s, opposition had already started to form in the mathematics community against this new inductive method of learning and by the 1850s, the scales tipped back towards Socratic instruction (Cohen, 2003). By the end of the 19th century, Coburn's inductive method was but a distant memory; however, the changes his ideas ushered into mathematics were profound and continued to exist well past the 19th century.

Late 19th – Early 20th Century N. A. Mathematics Education

Towards the end of the 19th century, the *Report of the Committee on Secondary School Studies 1893* was released by the Committee of Ten. This report had influence on the rapid expansion of the American Public high school system as well as the creation of post-secondary courses in the teaching of mathematics during the dawn of the 20th century (Donoghue, 2003). Around the same time that universities developed an academic interest in researching mathematics pedagogy, they also started requiring freshman students to take a course in mathematics that covered plane trigonometry, analytic geometry of the conics, and elementary theory of algebraic and trigonometric series (Donoghue, 2003). One of the greatest calls for change to mathematics education at this time came from the President of the American Mathematical Society, E.H. Moore, in 1902. Moore's vision called for the use of concrete materials to teach practical mathematics through the scientific method, the organization of algebra, geometry and physics at the secondary school level into a coherent four-year course centered on a unifying concept such as the function, the extensive use of graphical depictions, a guided discovery approach to instruction and finally a move to a more professional view of the mathematics educator (Donoghue, 2003). Moore's vision caused great debate as to the future of mathematics education over the next decade until the breakout of World War I (WWI).

1914 – 1940 N. A. Mathematics Education

During the time of WWI, the place of mathematics in the school classroom was beginning to be questioned. The goal of the high school was no longer exclusive to college preparation but was seen as having more widespread social goals. This was highlighted in John Dewey's famous 1916 publication, *Democracy and Education* in which he suggested that education should help each individual to develop personal initiative and adaptability. In response to mounting criticism of mathematics education, the National Council of Teachers of Mathematics (NCTM) was founded in 1920 to provide leadership for and by North American mathematics educators (Gates, 2003). The changing perceptions of the purpose of school at this time was evident in enrollment levels of students taking academic mathematics. Student enrollment in high school mathematics had risen until 1920 and peaked in 1922 at 74.9%, before declining to a little more than 50% over the next two decades (Latimer, 1958). As the 1920s turned to the 1930s, education was becoming vocationalized (Kliebard & Franklin, 2003) in response to the changing views of the purpose of education and the changing needs of the student body. Traditional mathematical subjects such as algebra and geometry were no longer being seen as having value to a student's future job and the focus of mathematics courses began a shift toward day-to-day skills such as writing invoices and calculating payrolls. With the Great Depression of the 1930s and the resultant decline of available employment, many students who normally would have left for work were now staying at home or rejoining the high school system (Kliebard et al., 2003). This influx of supposedly "less capable" students saw further change to the secondary curriculum with schools intensifying efforts to implement more functionally-orientated curriculum policies (Mirel, 1993). These "attacks" on traditional mathematics would continue until a brief reprieve caused by the outbreak of World War II.

1940 – 1957 N. A. Mathematics Education

Mathematics was seen as an important part of the war effort, and reports at this time all pointed to the benefit of mathematical ability beyond basic skills as crucial to advancing the war effort. “Unfortunately, this wartime legitimation of school mathematics was transitory” (Garrett & Davis, 2003, p.499) and when the end of hostilities was in sight, different groups resumed the push for vocationalization of mathematics. Towards the end of the 1940s, the notion of subjects like algebra and geometry as part of the general education of high school students was almost completely obliterated in the minds of leading educational policymakers (Kliebard et al., 2003). It was during this immediate post-war period that a perceived lack of rigor in postwar schools began and criticisms were being voiced (Garrett et al., 2003). At the beginning of the 1950s, university-based mathematics educators began to assume a primary role in improving school mathematics after calls from individuals for “a committee of experts with adequate financing, so that they may devote their full time to this most important project” (Schuster, 1948, p.475). This reactionary period to the reforms and vocationalization of the mathematics curriculum ended in earnest on October 4, 1957 with the successful launch of the world’s first artificial Earth satellite.

1957 – 1979 N. A. Mathematics Education (New Math and Back to Basics)

The launch of *Sputnik 1* by the Soviet Union in autumn of 1957 was the beginning of a new crisis in the North American education system. “The military threat of Soviet Space science and technology prompted a variety of political, business and social groups to urge critical examination of American mathematical, scientific and technical education” (Fey & Graeber, 2003, p.521). A major recommendation at this time from a 1961 conference on the Future Responsibilities for School Mathematics was that curriculum change must be based on research (Payne, 2003). Massive reform of the mathematics curriculum took place with a renewed focus on the scientific and technical aspects. Topics such as logic, modern algebra, probability and statistics were added to the secondary school curriculum. Up until the 1960s, the textbook was virtually the exclusive curricular and pedagogical approach to both teaching and learning in

Canada and the United States (Seymour & Davidson, 2003). The primary pedagogical principle that motivated many of the “new math” innovations was that students were to acquire understanding and skills through classroom activities that helped them discover mathematical concepts themselves (Fey et al., 2003). One of the major points of contention at this time was the tension between the value of “pure” versus “applied” mathematics (Payne, 2003). A sense of urgency from the American public during the early 1960s led to enthusiasm in adopting these reforms but this was short-lived. By the end of the 1960s, there was an emerging public consensus that these reforms were a failure and critics were calling for a move “back to basics.” The reactionary “back to basics” era of the 1970s saw curriculum retreating from some of the new topics introduced during the “new math” reforms such as logic, and a return to more traditional Socratic instructional practices instead of discovery learning (Fey et al., 2003). Behavioural objectives and their application to curricular areas were dominant during the back to basics era (Coxford, 2003). The 1970s also saw the emergence of computers and affordable personal calculators that started to find their way into mathematics classrooms. This led to a decrease in the demand for computational skills and increasing the demand for checking reasonableness of answers and dealing with “the constantly increasing bombardment of statistics, facts, and figures” (Fay et al., 2003, p.551). At the end of the 1970s, change was again on the horizon for mathematics education.

1980 – 2000 N. A. Mathematics Education (Agenda for Action and NCTM Standards)

In 1980, the National Council of Teachers of Mathematics released its *Agenda for Action* outlining a vision for mathematics education that would guide mathematics education through the 1980s. The *Agenda for Action* recommended that problem solving be the focus of school mathematics, and that basic skills should be defined more broadly than simple arithmetic. Other recommendations included a decreased emphasis on the use of drills and tables; an increased emphasis on collecting, organizing and analysing data; estimating measures; and, the use of diagrams as aides to understand problems. The *Agenda for Action* also made recommendations for a wide range of student outcome measures and the further professionalization of mathematics teachers. The *Agenda for Action* helped to reverse the “drill-and-skill” mentality of the back to basics era. In 1983, a report on the quality of American education, *A Nation at Risk*, was released and received extensive media coverage. The grave and intense imagery of the report helped to establish a climate that would be supportive to major changes and reform in education (McLeod, 2003). A result of the report was the launch of the NCTM standards project: a ground-breaking initiative that would culminate with the release of the NCTM *Curriculum and Evaluation Standards* document in 1989, and the *Professional Standards for Teaching Mathematics* in 1991.

The *Standards* document of 1989 had a substantial effect on mathematics education to close out the 20th century. The document focused on how the goals of mathematics education needed to change in order to best serve students going forward in the information age. These included an emphasis on problem solving and applications of mathematics; a new emphasis on topics such as statistics and discrete mathematics; reduced emphasis on written computational procedures and increased use of technology; less emphasis on proofs in geometry and more opportunities for deductive arguments; and, finally, more emphasis on real world mathematics (McLeod, 2003). The outcomes-based standards moved the North American mathematics community into a time of accountability and increased professionalism. While the *Standards* document was, overall, well received, it was not without critics, and NCTM released a new standards document for the 21st century in the year 2000. *Principles and Standards for School Mathematics* (2000) complemented and supplemented the 1989 standards with the goal of providing more clarity and balance. These standards have guided mathematics education in Canada and the United States, specifically curricular topics and pedagogical strategies, until the present time.

Mathematics Education in Ontario from Past to Present

1900 – 1960 Ontario Mathematics Education

By the beginning of the 20th century in Canada, mathematics had taken its modern-day place in the high school curriculum in English-speaking schools (Sigurdson, Kiearn, Pothier & Roulet, 2003). For the first half of the 20th century, the majority of debate surrounding mathematics education was how much time to spend during a normal school day on the subject. In Ontario, until 1937, arithmetic had occupied the largest block of time during a day for students in Grades 1 to 8 (McCutcheon, 1941). The mathematics education community at this time was split into multiple different groups due to two major reasons, the first being that education was constitutionally a provincial responsibility and the second being that in Ontario there was a tradition of separating the high school from the elementary school (Sigurdson et al., 2003). This meant that there was no national Canadian mathematics education community, and even the provincial community in Ontario was split between the elementary and high school communities. In Ontario, the Mathematical and Physical Association of Ontario (MPAO) was formed in 1891 with a goal to affect mathematics education by making government officials aware of emerging ideas and pedagogy in mathematics education. As time progressed, the majority of debates at the MPAO revolved less around pedagogy and more about the topics that should be taught in Ontario schools. Some of the pushes for curricular change led by the group included the approval of a new Grade 9 and 10 geometry course in 1902; attempts at including solid geometry in the curriculum in the 1930s and 40s; efforts to create a senior calculus course during the 1930s (which did not happen until the late 60s due to lack of support); the removal of algebra and geometry from Grade 7 and 8 courses and inserting those topics into the 9 and 10 courses during the early 1950s; and, the introduction of final year secondary courses in algebra, trigonometry and analytic geometry during the early 1950s (Sigurdson et al., 2003). As the 1960s began, significant changes were on the way to the mathematics community in Ontario as the “new math” era arrived from the United States.

1960 – 1989 Ontario Mathematics Education (New Math, Back to Basics and Standards)

The new math era had begun in the United States as part of a response to the launch on the Soviet Union’s launch of Sputnik 1 in 1957. It did not take long for the ideas of “new math” to arrive in Canada by the 1960s. While there had been some moderate changes to the mathematics curriculum in the decades leading up until the new math movement in Ontario, the “mathematical content of the programme had remained essentially unchanged for about fifty years” (Coleman, 1991). In 1958, the Ontario Department of Education formed what was to become the Ontario Mathematics Commission (OMC) to examine the teaching of mathematics in schools. The work of the OMC led to the creation and adoption of new mathematics courses for Grades 7 to 13 during the 1960s and in the late 60s, the Grade 13 program was repackaged into three courses: Algebra, Calculus and Functions and Relations (O’Shea, 2003). Reflecting the major ideas of the “new math” reform, the Ontario Ministry of Education’s curriculum guidelines at this time suggested that teachers make use of discovery techniques and problem centre activities, television, multiple textbooks, students self-directed activity and manipulative devices (Russel, Howard & Robinson, 1975). As within the larger North American mathematics education community, there were also vocal critics of the “new math” reforms within Ontario. The Ontario Ministry of Education commissioned a study to receive recommendations for a revised Grade 7-9 mathematics program in 1974 and the recommendations of this report suggested elevating statistics and probability to core topics, using flow charts, introducing functions and relations earlier, introducing estimation, including geometric transformations as an essential topic, developing computation skills and a strong recommendation that the problem solving approach be the predominant instructional approach (O'Shea, 2003). This reform reflected the "back to basics" reaction to "new math" that was happening in the broader mathematics education community at the time. Before the new revised intermediate program was released in 1980, the reformed curriculum was piloted in classrooms and teacher feedback was included in this process which was a new approach to curriculum reform in Ontario (O'Shea, 2003). In 1985, new curriculum guidelines were released that described approaches to teaching mathematics through inquiry and technology (Craven, 2003). All curriculum guides in Ontario up until the late 1980s were very broad in their goals and desired learning outcomes, leaving it up to the local boards and schools to develop specific aims and objectives for each course. This was about to change with the release of NCTM's *Agenda for Action* and *Standards* (1989) documents and the Ontario government's announcement in the late 1980s of its intention to revise the school program to create a common curriculum.

1990 – 2003 Ontario Mathematics Education (Reform and Standards Based Education)

The 1990s were a period of dramatic change in both the Ontario education system and the Ontario mathematics curriculum. The Ministry of Education had been directly involved in the creation and implementation of curriculum documents during the 60s to 80s but as the 90s came around they no longer were directly involved with the implementation due to financial cutbacks (Puk & Haines, 1998). In response to the call to revise the school curriculum, the Ontario Association for Mathematics Education (OAME) and the Ontario Mathematics Coordinators

Association (OMCA) developed a paper in 1993 that reinterpreted the NCTM *Standards* (1989) for the Ontario context (O'Shea, 2003). The reports from OAME, OMCA and NCTM all recommended that the emphasis be on student action rather than course content (Roulet,1997). In 1995, the New Democratic Party (NDP) under Premier Bob Rae released *The Common Curriculum; Policies and Outcomes, Grade 1-9* accompanied by *Provincial Standard Mathematics, Grade 1-9*. *The Common Curriculum* brought the concepts of outcome-based learning and curriculum integration into Ontario curriculum policy and all students were expected to attain a common set of learning outcomes by Grades 3, 6 and 9 linked to provincial standards (Anderson & Jaafar, 2003). The common curriculum also saw the de-streaming of all Grade 9 courses to a common curriculum for all students regardless of achievement level. Specific course descriptions for Grades 10 to 13 were to follow after the implementation of *The Common Curriculum,* but the NDP party was defeated by the Mike Harris Conservatives in 1995.

Just months prior to being defeated in the 1995 election, a report commissioned by the NDP government on a comprehensive review of the Ontario education system was released. The *Royal Commission on Learning* (*RCOL*) made many recommendations to reform the education system such as the prescription by the Ministry of Education of expected learning outcomes in all grades, abolishing Grade 13, the reconstitution of the secondary program into two streams (academic and applied), creation of standardized report cards linked to defined learning objectives and the use of standardized provincial assessments (Anderson & Jaafar, 2003). The new Conservative government would implement many of these recommendations; and, citing low support for *The Common Curriculum,* set about creating a new Ontario curriculum for both elementary and secondary levels. It was at this time that the Field's Institute for Research

Mathematics Sciences successfully applied to manage the secondary writing team (Craven, 2003). Two documents were created at this time; *Mathematics: The Ontario Curriculum, Grades 9 and 10 (1999)* and *Mathematics: The Ontario Curriculum, Grades 11 and 12 (2000)*. The implementation of the new curriculum was staggered with Grade 9 starting in 1999, Grade 10 in 2000, Grade 11 in 2001 and finally Grade 12 in 2002. The new curriculum saw the removal of the fifth year of secondary school but many of the old topics remained compressed into the new 4-year secondary program, with only the notable removal of both trigonometric differentiation and integration (Craven, 2003). The new curriculum was designed around a few main strands in each course, with each strand having its own specific expectations that all students must learn by the end of the course. Each grade level was also streamed into Academic or Applied at the Grade 9 and 10 levels, and University, College or Workplace Preparation at the Grade 11 to 12 levels. Academic courses were meant to develop students' knowledge and skills through the study of theory and abstract problems while Applied students would learn the same skills through practical applications and concrete examples (Macauley, 2015). The Conservative government also created the Education Quality and Accountability Office (EQAO) in the late 1990s with a mandate for evaluating the improvement of education in Ontario. EQAO conducts provincial wide standards-based mathematics assessment of all students in Grades 3, 6 and 9 as part of the mandate (Anderson et al., 2003). The requirements for graduation with an Ontario Secondary School Diploma were also reformed, based on recommendations from the *RCOL* and as a result all students were required to take a minimum of three mathematics courses to graduate. The Conservative government ushered in major change to the Ontario education system around the turn of the century and many of those changes would remain even after being defeated by the Dalton McGuinty Liberals in 2003.

2003 – Present Ontario Mathematics (Revisions and Renewed Mathematics Strategy)

At the time of the election in 2003, there had been increasing calls for revisions to the curriculum released by the Conservatives only a few years previous. The Liberals initiated an extensive revision process and the result was the release of a revised curriculum for Grades 9-10 in 2005, followed by a revised Grade 11-12 curriculum in 2007. The changes made were not a fundamental change to curriculum topics but were seen to be a reworking of the structure of the secondary program as well as mandating a greater emphasis on the language used for the applied level courses. The general consensus has been that the revised curriculum topics were being "covered" in classes but that the instructional methods had remained highly traditional and did not reflect the spirit of the curriculum (Macauley, 2015). Until 2018, the Liberals continued to govern in Ontario and released the document *Achieving Excellence*: *A Renewed Vision for Education in Ontario* (2014), which outlined a plan for the Renewed Mathematics Strategy launched in 2016. In spite of this, there have been no revisions to the Ontario mathematics curriculum since 2007 and the current mathematics curriculum taught in Ontario in 2018 remains based on the reforms of the late 1990s by the Harris Conservatives.

Summary

The literature has shown that there has been a very cyclical nature to mathematics curriculum development—often following a timeline of crisis, response and reform. Every time a new curriculum document was released, the old document just disappeared with no record of the old document and changes to it in the new curriculum. There has also been a lack of transition between documents, with new documents replacing the entirety of the previous curriculum documents no matter the scale of the changes. Decisions made about the content of the new curriculum documents have been based on research and expert opinions, yet the rationale for these changes has not been included or recorded for educators to understand why they are enacted changes. It is important to track these changes and make that available to educators and future curriculum developers alike. The aim this study is to track these changes and using the voices of leaders involved in curriculum change to provide context for them. The next chapter will discuss the research methods used to conduct this study.

CHAPTER 3: METHODS

This study is qualitative in nature as it attempted "to make sense of, or interpret, phenomena in terms of the meanings people bring to them" (Denzin & Lincoln, 2011, p.3) and employed both individual interviews and document analysis in order to elicit meaning, gain understanding, and develop empirical knowledge (Corbin & Strauss, 2008) about the processes for and influences on curriculum change in Ontario over six decades. This chapter describes the research methods used in the study and includes six sections: research design, sampling procedure, recruitment and participants, role of the researcher, method of data collection, and a description of the data analysis process.

Research Design

This study was conducted through two distinct but interrelated phases. Phase One of the research focused on the analysis of Ontario mathematics curriculum policy documents produced by the Ministry of Education between 1960 and 2007. Phase Two was comprised of individual, open-ended, structured interviews with four leaders in the mathematics education community in Ontario.

The purpose of Phase One of the research was to provide a detailed record of the changes to the Ontario secondary mathematics curriculum over time. Bowen (2009) suggests that document analysis can be used to track changes and development over time when multiple drafts of a document are available. Bowen also suggests that information gleaned from document analysis can be used to formulate questions that need to be asked during an interview. The document analysis looked for broad topics that were covered in each curriculum policy document and from this examination, an alignment analysis among documents from different years was completed to determine topics that were added or left out; topics that were diminished or exaggerated; and, topics that ended up being residual as a consequence of changes to content in other grades.

The findings from Phase One were used to guide the development of some of the interview questions for Phase Two of the research. Leaders in the mathematics community in Ontario including mathematics Department Heads, Curriculum Coordinators, Education Officers, Mathematics Education and Mathematics Faculty members were interviewed to describe their role in revising the Ontario mathematics curriculum as well as their reflections on the process. Interviews were used in Phase Two because “at the root … interviewing is an interest in understanding the experience of other people and the meaning they make of that experience” (Seidman, 1991, p.3). While there are two distinct phases to the research, the findings from both Phase One and Two complement each other and come together to build a more in-depth story about the changes to the Ontario mathematics curriculum over time.

Sampling Procedure for Documents

Bowen (2009) suggests that document analysis can be used to track changes and development over time when multiple drafts of a document are available. The researcher used different tools and resources to locate past Ontario mathematics curriculum documents. This process involved using online database searches, visiting secondary schools to determine if they kept any old copies of curriculum documents and visiting local University libraries. Literature suggests the launch of *Sputnik I* in 1957 triggered substantial changes to mathematics education. As a result, one of the selection criteria for the documents was that the document could not be from before this time. Other selection criteria were that the documents were official Ontario government policy documents and used as the provincial curriculum at some point.

Sampling Procedure for Interviews

For the selection of interview participants, the researcher used a combination of purposeful and snowball sampling. A purposeful sampling approach allowed for the selection of "information-rich cases" (Patton, 2002, p.230). Snowball sampling was also used for participant selection, because this method "identifies cases of interest from people who know people who know what cases are information rich" (Creswell, 2013, p. 158). Only a small group of participants were involved in this study as Patton (1990) states that in-depth information from a small number of information-rich people can be very valuable. The selection criteria for participation in the interview phase were that the individual must have held a leadership role on a secondary mathematics curriculum writing team established by the Ministry of Education within the timeframe examined by the researcher.

An initial list of eight possible participants was provided by Dr. Lynda Colgan (my thesis supervisor), a Professor of Mathematics Education at Queen's University. Two of the participants came from this initial list. One of those participants provided the contact information for the third participant and the third participant provided the contact information for the fourth participant.

Recruitment

All participants recruited for this study were past/current leaders in Ontario mathematics education who had participated in at least one stage of an Ontario mathematics curriculum revision process.

Ethical clearance to carry out the interviews was sought from the University's General Research Ethics Board (GREB). Ethical approval for this study was obtained on August 14,

2017. As per protocol, an annual renewal was required each year if the study was to continue after August 14, 2018. Renewal clearance letters were granted on August 3, 2018 and July 24, 2019. All GREB approval letters are included in Appendix C. Upon receiving ethical clearance, the identified individuals were invited to participate in the study through email[4]. This email contained information about the study, the type of questions that were asked and the time commitment to participate. The Letter of Information (LOI) and Consent Form (CF)[5] were also attached to the email so that participants could read these in advance. The CF outlined to participants that they had a choice of whether or not to participate in the study at any time. The LOI explained to the participants the purpose of the study, their role within it, how data collected during the interview would be used, and the process to withdraw from the study. Informed consent from all participants was obtained with a signed copy of the combined LOI and CF at the time of the interview. Any questions that the participants had were also answered at this time. A foreseen risk during the interviews was explained to the participants that the information they provided could make them readily identifiable even though efforts would be made to provide anonymity to the participants through the use of pseudonyms.

Emails inviting candidates to participate in my research were sent out to the initial list of eight candidates. Out of the initial eight I received two "yes I will participate" responses, three "no, I will not participate" responses and no responses at all from three individuals. From this first round of candidates, I was given the contact information for another participant who agreed to participate upon receipt of the recruitment email. This participant provided the contact for a fourth possible candidate who agreed to participate upon receipt of the recruitment email. A final

[4] For the recruitment email sent to potential participants see Appendix A
[5] For a copy of the combined Letter of Information and Consent Form please see Appendix B

candidate was suggested who, when contacted, politely declined to participate. By the end of the recruitment process 11 candidates had been contacted and four candidates agreed to participate in this study.

Participants

Participant A: Participant A, a retired mathematics teacher and Department Head, currently works as a provincial Facilitator on project work for the Ministry of Education. During her teaching career, she was also seconded for two years to work at the Ministry of Education on mathematics projects. Participant A was heavily involved in The Ontario Association for Mathematics Education (OAME) as a chapter representative for approximately seven years and was a member of the provincial Executive Committee for roughly five years, serving in three of those years as President Elect, President (2001-2002) and Past President.

Participant B: Participant B is a retired mathematics teacher, Department Head, and consultant who began teaching in the mid-1970s. Participant B became active in curriculum planning early and participated in various capacities in a range of mathematics curriculum projects.

Participant C: Participant C is a retired Associate Professor of Mathematics Education from a research-intensive Faculty of Education in southeastern Ontario. He started his career teaching mathematics, chemistry and computer science at the secondary level in Northern Ontario. He was also the Head of the Mathematics Department in addition to his classroom teaching role. Due to his involvement and early adoption of computers for teaching mathematics, he moved into a leadership position with his school board to provide in-service professional development to teachers across the district. Subsequent to the brief time spent in this role, Participant C became an Education Officer with the Ministry of Education where his portfolio covered JK to OAC mathematics, computer applications across the curriculum and computer studies. After a few years as an Education Officer, Participant C became a tenure-track professor with teaching responsibilities in the BEd, MEd and PhD programs. He spent 22 years in this role before retiring.

Participant D: Participant D is currently a Professor and Undergraduate Chair at a research-intensive university in southeastern Ontario. He has been a member of the Mathematics Department for the past 50 years and is cross-appointed to both the Faculty of Education and the Department of Biology. His role at Queen's University includes research in mathematical biology as well as teaching pure mathematics courses at the undergraduate and graduate level. A large part of his current research interest is in the area of mathematics education at the high school level, and he is in the process of developing his own mathematics curriculum for Ontario high schools. Participant D has worked with and been a member of various organizations over his career (including OAME and CMESG), often in a role that involved examining curriculum and teaching.

Role of the Researcher

Hoepfl (1997) states that during the data collection process the researcher is "a human instrument, or the vehicle through which data will be collected and interpreted." To evaluate a researcher's ability and readiness to do qualitative research, Glaser and Strauss (1967) and Strauss and Corbin (1990) suggest looking at the "theoretical sensitivity" of the researcher. Strauss and Corbin (1990) explain that "theoretical sensitivity" points to a personal quality of the researcher. This personal quality suggests that the researcher understands the subtleties within the data; has insight and the ability to give meaning to data; and has the ability to separate pertinent from non-pertinent data. Strauss and Corbin (1990) state that "theoretical sensitivity comes from a number of sources, including professional literature, professional experiences, and personal experiences" (p. 50). As a researcher, I have examined the literature extensively, I have professional and research experience, and I have personal experiences tied to the research.

When conducting the interviews, I have abided by the interview protocol described by McMillian and Schumacher (2010) which states that the interviewer: (a) dress accordingly, and be friendly, relaxed, and pleasant, (b) provide honest answers to interviewee questions, (c) explain the purpose of the interview and ask if there are any questions, (d) record all answers either by hand or audio, and (e) probe the interviewee for further clarification of an answer (p. 207).

Data Collection

Phase 1: Documents

During the months of August to October 2017, the researcher used various tools and resources to locate past Ontario mathematics curriculum documents. This involved using online database searches, visiting secondary schools to determine if they kept any old copies of curriculum documents and visiting local University libraries. A large selection of past curriculum documents dating back to the early 1900s were located, spread across different historical archives in 2 different libraries (Faculty of Education Library and Joseph S. Stauffer Library) at Queen's University. One of the documents existed only in microfiche format while the rest were in their original print format. All documents were scanned and reproduced electronically. The electronic copies were then printed out in physical form to allow for analysis. The current curriculum documents (2005 & 2007) were ordered from the provincial printer for use in analysis and a PDF copy of those documents was saved from the Ministry of Education website. Table 1 outlines the documents acquired for this study.

Table 1

List of Ontario Mathematics Intermediate/Senior Division Curriculum Documents

1961	Ontario Department of Education. (1961). *Mathematics: senior division, grades 11,12 and 13.* Toronto: Queen's Printer for Ontario
1964	Ontario Department of Education. (1964). *Mathematics: intermediate division, grades 7,8,9 and 10.* Toronto: Queen's Printer for Ontario
1972	Ontario Ministry of Education. (1972). *Mathematics Intermediate and Senior Division.* Toronto: Queen's Printer for Ontario.
1980	Ontario Ministry of Education. (1980). *Mathematics curriculum guideline for the Intermediate division.* Toronto: Queen's Printer for Ontario.
1985	Ontario Ministry of Education. (1985). *Curriculum guideline: Mathematics: Intermediate and senior divisions.* Toronto: Queen's Printer for Ontario.
1995	Ontario Ministry of Education. (1995). *Provincial Standards, Mathematics, Grades 1 to 9.* Toronto: Queen's Printer for Ontario.
1999	Ontario Ministry of Education. (1999). *Mathematics: The Ontario Curriculum, Grades 9 and 10.* Toronto: Queen's Printer for Ontario.
2000	Ontario Ministry of Education. (2000). *Mathematics: The Ontario Curriculum, Grades 11 and 12.* Toronto: Queen's Printer for Ontario.
2005	Ontario Ministry of Education. (2005). *The Ontario Curriculum, Grades 9 and 10: Mathematics (Revised).* Toronto: Queen's Printer for Ontario.
2007	Ontario Ministry of Education. (2007). *The Ontario Curriculum, Grades 11 and 12: Mathematics (Revised).* Toronto: Queen's Printer for Ontario.

Phase 2: Interviews

Data collection for the interviews took place between April 4, 2018 to July 30, 2019. Four in-depth, semi-structured interviews took place and varied in length (see Table 2). The researcher travelled across southern Ontario to the location of choice of the participant. The interviews occurred in four different locations across three cities. The semi-structured interviews utilized an interview guide[6] to "ensure that the same basic lines of inquiry are pursued with each participant" (Patton, 2002). Legard et al. (2003) suggests that initial responses are often relatively 'surface' level, and that an interviewer usually asks follow-up questions to gain a deeper and fuller understanding of the participant's meaning. The researcher asked follow-up questions not included in the interview guide to have participants further clarify their answers throughout the interview.

The interviews were conducted in a time and place that was convenient for the participants (see Table 2). The interview questions were designed based on the research questions and results from the document analysis. The initial part of the interview focused on the participant's retelling about their background and knowledge of curriculum changes in Ontario in order to build rapport between the interviewer and participant. This section was also later used for the background portion of the participant's profile section. The interview questions were divided into four overall groupings (a) Background, (b) Experiences with Curriculum Change, (c) Reflections of Experiences and (d) Questions that Emerged from Document Analysis.

During the interview process, notes were recorded on the interview guideline sheet. This was done in order to ask any follow-up questions or to record anything that might clarify responses during the analysis process. Creswell (2013) suggests using "adequate recording procedures when conducting one-on-one interviews." Recording of the interviews was done using two devices to ensure a backup copy was made. A laptop using *GarageBand* (version 10.3.1) was used to record one copy and an iPhone using the default voice recording app was

[6] For the interview guideline used see Appendix F

used to record another. All interviews were originally meant to be approximately one hour in length, but all interviews exceeded this.

Table 2

Participant's Interviews – Format, Location, Length and Date

Participant	Interview Format	Location of Interview	Length of Interview	Date of Interview
A	In-person	Participant A's house	1:32:27	April 14, 2018
B	In-person	Participant B's house	1:20:05	April 14, 2018
C	In-person	Queen's University, Duncan McArthur Hall	1:41:21	April 4, 2018
D	In-person	Queen's University, Jeffrey Hall	1:04:51	July 30, 2019

Data Analysis

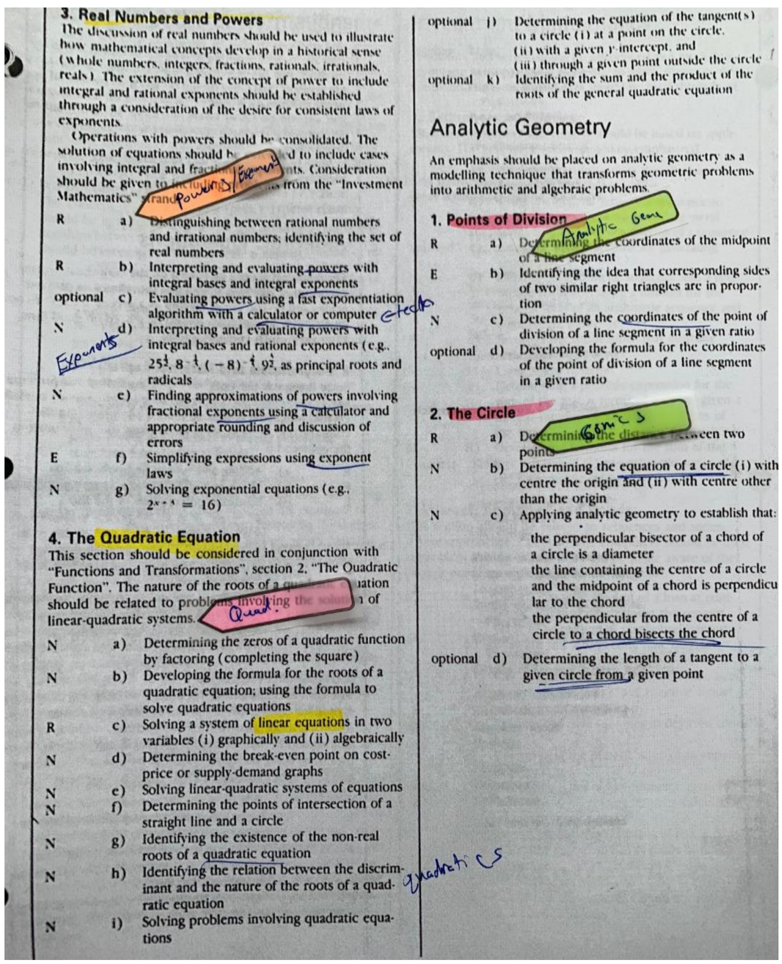
Phase 1: Documents

Document analysis is the systematic procedure for reviewing and evaluating documents which entails finding, selecting, appraising and synthesizing data contained in the documents (Bowen, 2009). There are many benefits to performing a data analysis of these documents including a lack of obtrusiveness and reactivity, stability, exactness and coverage (Bowen, 2009). Curriculum documents published by the government of Ontario for secondary mathematics courses since 1960 were collected and examined for this study. Table 3 lists all the documents that were collected and examined. After each document was collected an initial read through was done to examine larger themes across each curriculum document. These themes represented constructs that each curriculum document was trying to achieve, and the themes could be seen across all levels and all courses. These constructs were pervasive throughout both the front matter and content pages. During the thematic analysis it became apparent that there also existed major structural differences in how the documents were written and presented. There was an interpreted trend from early documents focusing more on what to teach, with later documents including increased focus on how to teach. The changing structural composition of the curriculum documents over time was included in the findings after the appearance of this trend during the thematic analysis.

After the initial thematic analysis, a more in-depth content analysis was completed. The content analysis looked specifically at the mathematical topics covered in each curriculum document. This involved going through every individual course at each grade and level to determine the mathematical content within that course. For later curriculum documents, the courses were split into the level at which they were being taught to better show the difference between streams. For the 2000 and 2007 curriculum documents, the college stream courses were considered to be part of the applied level and the MCF3M course was considered to be part of the academic stream since it can be used as part of a university pathway. Each course was analyzed and coded according to the topic. These topics were then analyzed for larger categories using the inductive data analysis process as described by McMillan and Schumacher (2006). This qualitative framework was implemented because it allowed topics, categories, and patterns to emerge from the data.

In all, 38 categories emerged from the analysis and these can be found in Appendix E. Figure 1 shows a sample a curriculum document page during the coding process. These categories were not further reduced into patterns and big ideas as it would reduce the resolution at which the documents were being examined. The 38 categories show a clear pattern over time of when certain content pieces were added to, removed from or moved around in the curriculum.

With the curriculum undergoing constant change over the years and different grades being released at different times, some of the documents were considered together when representing the curriculum at a certain time. For example, the 1961 document only detailed the Grade 11 through 13 program with the 9 and 10 documents being released later in 1964 but for the purpose of analysis, these were considered to be the same program. At other points in time, new curriculum was to be implemented but only certain grades were released meaning that a full 9-13 curriculum was not available to be analyzed. For example, only Grade 9 of a new curriculum was released in 1995, so while that document was analyzed, it only represents a single grade of what was to be a new curriculum.



3. Real Numbers and Powers

The discussion of real numbers should be used to illustrate how mathematical concepts develop in a historical sense (whole numbers, integers, fractions, rationals, irrationals, reals). The extension of the concept of power to include integral and rational exponents should be established through a consideration of the desire for consistent laws of exponents.

Operations with powers should be consolidated. The solution of equations should b[illegible]d to include cases involving integral and fract[illegible]nts. Consideration should be given to [illegible] from the "Investment Mathematics" strand.

- R a) [illegible]tinguishing between rational numbers and irrational numbers; identifying the set of real numbers
- R b) Interpreting and evaluating powers with integral bases and integral exponents
- optional c) Evaluating powers using a fast exponentiation algorithm with a calculator or computer
- N d) Interpreting and evaluating powers with integral bases and rational exponents (e.g., $25^{\frac{1}{2}}$, $8^{-\frac{1}{3}}$, $(-8)^{-\frac{1}{3}}$, $9^{\frac{3}{2}}$, as principal roots and radicals
- N e) Finding approximations of powers involving fractional exponents using a calculator and appropriate rounding and discussion of errors
- E f) Simplifying expressions using exponent laws
- N g) Solving exponential equations (e.g., $2^{x+3} = 16$)

4. The Quadratic Equation

This section should be considered in conjunction with "Functions and Transformations", section 2, "The Quadratic Function". The nature of the roots of a [illegible]ation should be related to problems involving the [illegible]n of linear-quadratic systems.

- N a) Determining the zeros of a quadratic function by factoring (completing the square)
- N b) Developing the formula for the roots of a quadratic equation; using the formula to solve quadratic equations
- R c) Solving a system of linear equations in two variables (i) graphically and (ii) algebraically
- N d) Determining the break-even point on cost-price or supply-demand graphs
- N e) Solving linear-quadratic systems of equations
- N f) Determining the points of intersection of a straight line and a circle
- N g) Identifying the existence of the non-real roots of a quadratic equation
- N h) Identifying the relation between the discriminant and the nature of the roots of a quadratic equation
- N i) Solving problems involving quadratic equations
- optional j) Determining the equation of the tangent(s) to a circle (i) at a point on the circle, (ii) with a given y-intercept, and (iii) through a given point outside the circle
- optional k) Identifying the sum and the product of the roots of the general quadratic equation

Analytic Geometry

An emphasis should be placed on analytic geometry as a modelling technique that transforms geometric problems into arithmetic and algebraic problems.

1. Points of Division

- R a) De[illegible] coordinates of the midpoint of a [illegible] segment
- E b) Identifying the idea that corresponding sides of two similar right triangles are in proportion
- N c) Determining the coordinates of the point of division of a line segment in a given ratio
- optional d) Developing the formula for the coordinates of the point of division of a line segment in a given ratio

2. The Circle

- R a) Determinin[illegible] the dis[illegible]ween two points
- N b) Determining the equation of a circle (i) with centre the origin and (ii) with centre other than the origin
- N c) Applying analytic geometry to establish that:
  - the perpendicular bisector of a chord of a circle is a diameter
  - the line containing the centre of a circle and the midpoint of a chord is perpendicular to the chord
  - the perpendicular from the centre of a circle to a chord bisects the chord
- optional d) Determining the length of a tangent to a given circle from a given point

Figure 1: Sample curriculum page during the coding process

Table 3

The Groupings of the Curriculum Documents for Data Analysis

Curriculum Group	Documents
1961 Gr 11-13 **1964 Gr 9 &10**	Ontario Department of Education. (1961). *Mathematics: senior division, grades 11,12 and 13.* Toronto: Queen's Printer for Ontario Ontario Department of Education. (1964). *Mathematics: intermediate division, grades 7,8,9 and 10.* Toronto: Queen's Printer for Ontario
1972 Senior Grades	Ontario Ministry of Education. (1972). *Mathematics Intermediate and Senior Division.* Toronto: Queen's Printer for Ontario.
1980 Intermediate Grades	Ontario Ministry of Education. (1980). *Mathematics curriculum guideline for the Intermediate division.* Toronto: Queen's Printer for Ontario.
1985 Gr. 9-12 Basic	Ontario Ministry of Education. (1985). *Curriculum guideline: Mathematics: Intermediate and senior divisions.* Toronto: Queen's Printer for Ontario.
1985 Gr. 9-12 General	Ontario Ministry of Education. (1985). *Curriculum guideline: Mathematics: Intermediate and senior divisions.* Toronto: Queen's Printer for Ontario.
1985 Gr. 9-13 Advanced	Ontario Ministry of Education. (1985). *Curriculum guideline: Mathematics: Intermediate and senior divisions.* Toronto: Queen's Printer for Ontario.
1995 Gr 9 Only	Ontario Ministry of Education. (1995). *Provincial Standards, Mathematics, Grades 1 to 9.* Toronto: Queen's Printer for Ontario.
1999 Gr 9-10 **2000 Gr 11-12** **Academic**	Ontario Ministry of Education. (1999). *Mathematics: The Ontario Curriculum, Grades 9 and 10.* Toronto: Queen's Printer for Ontario. Ontario Ministry of Education. (2000). *Mathematics: The Ontario Curriculum, Grades 11 and 12.* Toronto: Queen's Printer for Ontario.
1999 Gr 9-10 **2000 Gr 11-12** **Applied**	Ontario Ministry of Education. (1999). *Mathematics: The Ontario Curriculum, Grades 9 and 10.* Toronto: Queen's Printer for Ontario. Ontario Ministry of Education. (2000). *Mathematics: The Ontario Curriculum, Grades 11 and 12.* Toronto: Queen's Printer for Ontario.
2005 Gr 9-10 **2007 Gr 11-12** **Academic**	Ontario Ministry of Education. (2005). *The Ontario Curriculum, Grades 9 and 10: Mathematics (Revised).* Toronto: Queen's Printer for Ontario. Ontario Ministry of Education. (2007). *The Ontario Curriculum, Grades 11 and 12: Mathematics (Revised).* Toronto: Queen's Printer for Ontario.
2005 Gr 9-10 **2007 Gr 11-12** **Applied**	Ontario Ministry of Education. (2005). *The Ontario Curriculum, Grades 9 and 10: Mathematics (Revised).* Toronto: Queen's Printer for Ontario. Ontario Ministry of Education. (2007). *The Ontario Curriculum, Grades 11 and 12: Mathematics (Revised).* Toronto: Queen's Printer for Ontario.

Phase 2: Interviews

Patton (2002) suggests that qualitative research begins with an inductive approach—an approach that allows categories, themes, and patterns to surface from the data collected. To find categories, themes and patterns from the interviews, each audio-recording was listened to multiple times and then transcribed. Each interview was initially listened to by the researcher to make note of any similarities among the responses and then these notes were recorded for future use in analysis. The interviews were then transcribed using an online transcribing service at *temi.com*. This website uses technology to automatically transcribe the audio and allow it to be played back at a slower speed, allowing the researcher to confirm the transcription. The transcripts were then exported as a Word document. The researcher then listened to each interview a third time, following along in the Word document to further confirm the transcription. Pseudonyms were used in order to maintain anonymity. The number of pages of each transcript is listed in Table 4. No individual other than the researcher and my supervisor had access to the interviews at any time.

Table 4

Pages Transcribed

Participant	***Pages Transcribed***
A	*34*
B	*26*
C	*28*
D	*23*

Upon completion of the transcripts, participant profiles were created for each participant. These profiles summarized the interviews and were broken down into four sections, (a) background, (b) experiences with curriculum change, (c) reflection on experiences and (d) thoughts on curriculum change. To ensure reliability, a copy of the transcripts and profiles was then emailed to participants to complete member-checking: each participant was asked to verify his/her transcript to ensure the statements characterized his/her beliefs, views and experiences. Participant B responded that they felt that the responses as they were written in the profiles chapter would make them easily identifiable even given the use of pseudonyms. As a result, they rewrote and submitted a profile with which they were comfortable in terms of anonymity. This profile is included in the results section.

McMillan and Schumacher (2006) described four phases in the inductive analysis process, each of which was used to analyze the data in this study. The use of this qualitative framework allowed for topics, categories, and patterns to surface from the data. Patterns of meaning were constructed using segments, topics, and categories (see Figure 2).

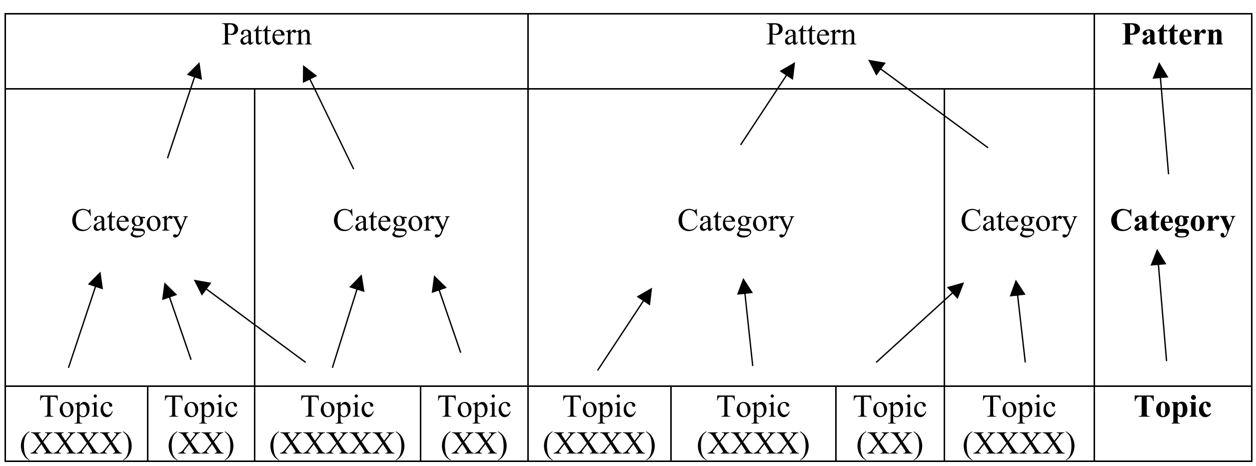


Figure 2: Building patterns and categories of meaning from qualitative data (adapted from McMillan and Schumacher, 2001)

Prior to coding, each transcript was printed off and read through multiple times by the researcher. A highlighter was used to highlight segments of the interviews to be used for coding.

Each segment that was highlighted was then rewritten in a separate word document that included the highlighted text, the participant's name, the time in the interview and a space for a code to be written (see Figure 3). These were then all cut up into individual quotes and were given a suitable code. All four transcripts were coded by the researcher until no new codes emerged from the data. This process was done by hand, rather than using a computer.

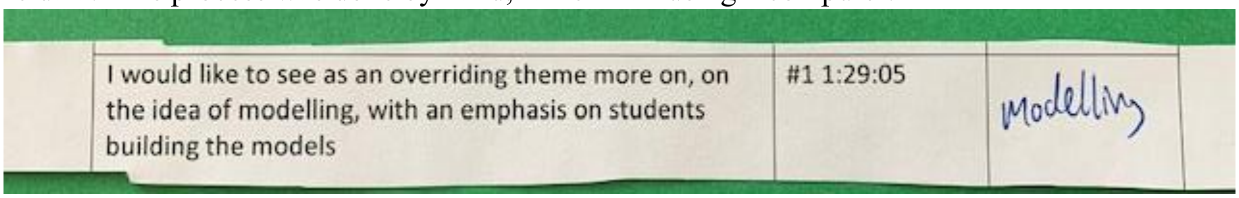


Figure 3: Sample of Coding Process

After analyzing all the interviews 118 initial topics were coded. These initial topics were further analyzed and reduced into 39 topics. Figure 4 shows this process. For example, topics such as RESPECTING OPINIONS, OPINIONS ON CURRICULUM, CONTENTIOUS ISSUES were combined into DIFFERENT OPINIONS. The 39 topics were refined into 12

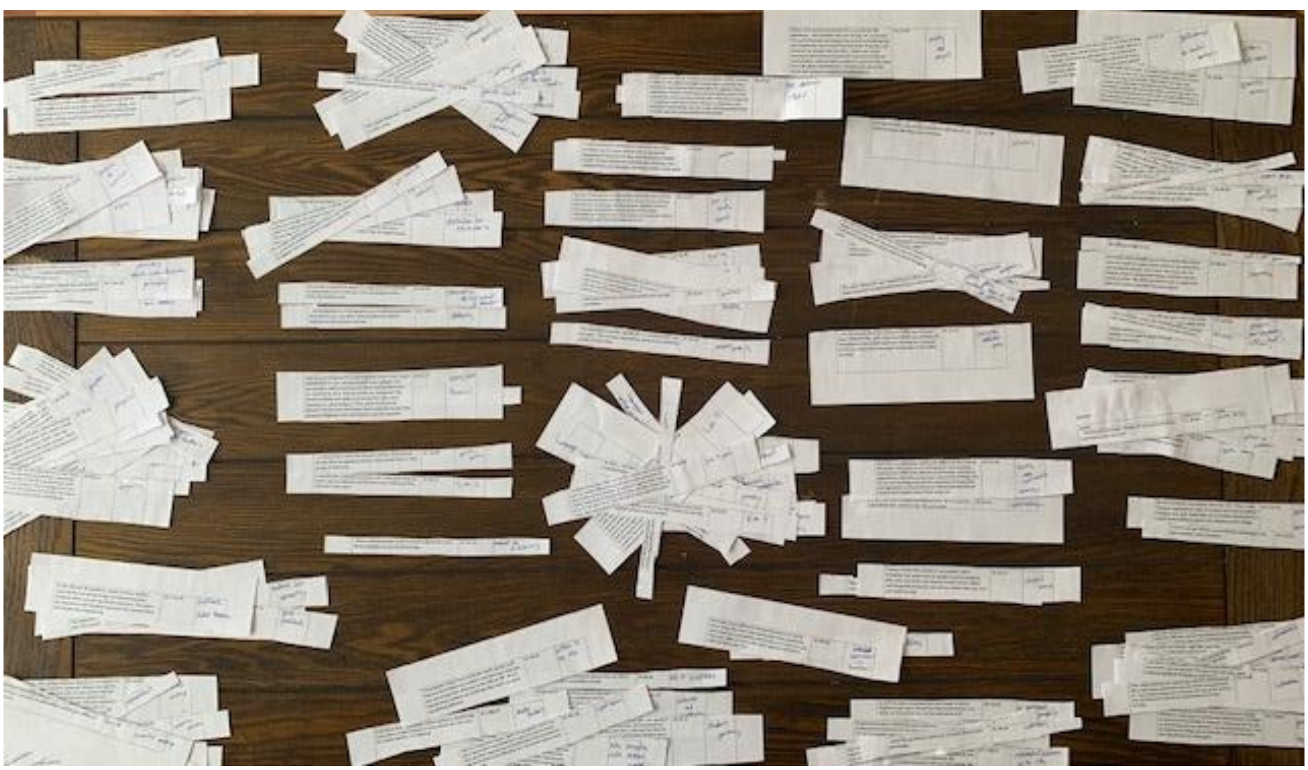


Figure 4: Process of reducing 118 initial topics

categories. Three patterns (themes) emerged from the 12 categories (see Table 5). Using the emergent themes, a cross case analysis was written combing all four interviews.

Table 5

Emerging Topics, Categories and Patterns

Topic (subject identification) →	Category (meaning of linked topics) →	Pattern (themes)
Curriculum reflected OAME	OAME/OMCA/Fields Collaboration	Curriculum Revision Process
OAME/OMCA collaboration		
Teamwork		
Collaboration with Field's Institute		
Proposal Writing	Creating a proposal	
Workshops and Professional Development	Implementation of Curriculum	
Implementation of new curriculum across the province		
Implementation involved little training		
Topics reduced in importance	Removed from curriculum	Curriculum Priorities and Focus
Topics removed from the curriculum		
Ideas not included in curriculum		
Mentorship	Teachers trying new methods	
New ideas being done all over the province		
Teachers experimentation		
Feedback from Universities	Reasons for revisions	
Feedback from teachers		
Focus Groups		
EQAO results		
Mathematical process verbs	Conceptual influences on the writing process	
Streamed courses		
Use of technology in curriculum		

Traditional versus new teaching methods		
Society and mathematics		
Goals of a new curriculum	Philosophy and vision for a new curriculum	
Philosophy of how to teach mathematics		
Vision of where students need to be at end of high school		
Old curriculum not good for all students		
Timelines to complete curriculum	Timelines	External Factors
Self-Interest and lobbying	Opinions	
Different opinions		
Committee representation is equity based	Writing committee composition	
Included all stakeholders of mathematics education		
Stakeholders had to be involved in writing		
Lack of funding	Constraints on the writing process	
Outside influences		
Ministry sets the guidelines and expectations for how to write		
Accountability and NCTM standards		
Five into four years		
Removal of Grade 13		

CHAPTER 4: THE PRESENTATION OF DATA

In this chapter, the main findings will be presented. The chapter is organized into two sections. The first section presents the data from the document analysis. Each curriculum document is presented within its own subsection. The second section presents the interview analysis. Participant profiles are presented followed by a cross-case analysis that describes similarities and differences among the participants. As a result of the member checking process, the profile for Participant B in this chapter was written by Participant B.

Document Analysis

1961 and 1965 Curriculum

From a structural perspective, these documents are the most concise. The documents open with a one to two-page introduction to the curriculum followed by the courses of study and the topics/content for each. The introduction includes a brief rationale for some of the modifications made from previous curricula, the mathematics education research that resulted in the changes and explanations for the "optional" portion of the curriculum. This curriculum was organized into a four- and five-year program.

The Grade 9 and 10 courses were general courses with specialization occurring in the senior Grades. Grade 11 focused on Geometry, Grade 12 focused on Algebra and then the 5-year program students could take Grade 13 courses in Algebra, Geometry or Trigonometry and Statics. Individual courses were further broken down into units and each unit had a list of topics that students were to know. These topics were stated as mathematics concepts, often with no example or achievement language. Examples of this is from the Grade 12 Algebra course where the section was Power, Roots and Surds and one of the topics simply states "Solutions of equations with surd coefficients" (ODE, 1961, p. 16) and from the Grade 10 course from Unit 2:

Irrational Numbers and Squares Roots a topic reads “Rational numbers as periodic decimals” (ODE, 64, p. 3). These curriculum documents concisely presented the mathematical concepts that students would learn as part of the course and left it at that. Within each course there were also optional topics that could be included as a way to enrich the course. The documents stated that it “is important that these be included in the work taken with above-average classes or in the assignments given to the better students within a class-group of varying ability” (ODE, 1961, p.3).

While the document does go on to state that all students are required to reach a “suitable minimum standard” (ODE, 1961) it is interesting how the curriculum writers recognized the importance of challenging “the better students” and built this directly into the curriculum. Often the optional topics were broad which allowed the teacher flexibility when delivering the chosen topic. Examples of some possible enrichment topics from the Grade 9 course included three-dimensional models, modular arithmetic, vectors and history of mathematics. Finally, the documents from this time included suggestions both on the delivery of the courses and the timing of each unit. Within the Grade 9 and 10 documents, the suggestions include the number of weeks each unit of study should take, while the Grade 11-13 document makes a few general comments about the timing of certain topics. Suggestions often listed things to stress within the course of study such as “stress [the word] analyze, the use of clear, precise English, the nature of the proof and applications of geometric reasoning to real life situations” (ODE, 1961, p.9) or how to deduct marks for “rounding off as applied in recent annual Departmental examinations” (ODE, 1961, p.32). The courses of study were the main structural component of these early documents while being supplemented by a brief introduction and suggestion section.

There did not appear to be an overall theme or purpose within these documents. While later documents saw the introduction of technology in the curriculum, or the use of discovery learning as a theme this document appeared to simply focus on the mathematics concepts to be learned and aside from a few suggestions on how best to do that, did not extend much beyond that. Technology was limited during this time but there are many references to using mechanical calculators and the use of slide rulers to aid in calculations, but neither were the focus of lessons. There was also a focus on simple computation and working with approximations in the intermediate Grades, presumably to build a strong base for senior mathematics. Equal emphasis was placed on both geometry and algebra throughout the curriculum with much of the concepts at the senior level being abstract concepts. Overall, these documents were simply lists of topics to learn and the how it was taught was mostly left to the teachers.

Grade 9 and 10 Content

Examining the content of this document reveals a much different curriculum than that which exists today. The obvious difference that first appears is that the high school mathematics curriculum was a five-year program. Some of the language used to describe certain topics is also much different than what is used today. Words such as ‘mensuration’ and ‘surds’ are used in place of the words ‘measurement’ and ‘irrational numbers,’ respectively, that would be found in today’s curriculum. Starting in Grade 9, there is a strong focus on computation, specifically working with integers, rational and irrational numbers, exponents and polynomials. There is also a focus on geometry, specifically on analytic geometry and a small number of measurement topics such as volume and perimeter. The Grade 10 curriculum continued to build on these same topics but introduced the concepts of vectors, trigonometry and some personal finance to the course of study.

Grade 11, 12 and 13 Content

The Grade 11 course was a geometry course. The topics taught in this course included analytic geometry, ratios and proportions, sum of angles in a polygon and proofs. Students learned how to prove many geometric properties as well as do geometric constructions. An overall focus of the senior course was the use of proofs, and students started to develop that skill heavily in this Grade 11 course. The Grade 12 course was based solely on algebra. Students in this course were introduced to the concept of a function, learned about linear functions, quadratics (graphing and factoring), indices, logarithms, surds, arithmetic and geometric series. The Grade 13 algebra course continued to build on all the same topics while introducing permutations and combinations as well as the mathematics of investment. The Grade 13 geometry course used the basis of analytic geometry developed in the Grade 11 course and applied it to straight lines in a coordinate system (calculated slope, points, y-intercept) and conics (circle, ellipse, parabola and hyperbolas). The Grade 13 course in trigonometry had students learn about trigonometric functions, trigonometric proofs, trigonometric equations, logarithms and statics (forces). The senior level courses would see the most change over all the curriculum changes. Many of these topics would either be moved into a different Grade or dropped all together with some Grade 13 topics eventually being moved into Grade 9 courses.

1972 Senior Courses

The presentation of structure of this curriculum document marked a radical departure from the previous curriculum documents and would set a precedent for which that all documents that followed would adhere. This is the first mathematics curriculum document that saw a substantial use of what is now called the 'front-matter;' a section in which the curriculum developers were able to convey the thought process and rationale for the curriculum. Whereas this section was a brief one-page introduction in the previous curriculum, it now consisted of multiple pages outlining the assumptions made in designing the document, the place and importance of mathematics in society and recent developments and research in school mathematics. The front-matter does not include any mention of how to teach or assess the students but was included to inform the reader of the important issues in mathematics education at the time and how the curriculum responded to these issues. The high school mathematics program was divided into two distinct streams of mathematics. The Grade 11 and 12 courses consisted of Foundations of Mathematics 1 and 2 or Applications of Mathematics 1 and 2. The Foundations stream led directly to the Grade 13 honours mathematics courses while the Applications streams required a supplementary course to be completed before taking any honours level mathematics. The four honours level courses were Relations and Functions, Calculus, Algebra and the Mathematics of Investment.

Within the document, each course has a brief one page introduction along with a table outlining the units and overall sections within the units. Within each course of study, the unit is broken down into sections and then further broken down into specific topics. This document maintains the same structure for listing topics as in the previous document by simply stating the mathematics concept to be taught. For example, from Applications of Mathematics 1, unit 3, section 3.3 it simply states, “simple interest in the fractional part of a time period” (MOE, 1972) or from Relations and Functions, Unit 3 section 3.2 “some practice with trigonometric identities” (MOE, 1972). The suggestions area was not continued from the previous documents, with this version instead having some brief suggestion for pacing with the course introduction and outline. This curriculum also included optional topics within each course that teachers could present to the students. These topics were colour coded blue and placed within a specific unit within each course so that teachers knew where to best deliver those topics. The curriculum also included options for teacher- or student-directed topics that they could choose based on interest to supplement the curriculum. The document also allowed for experimental courses to be developed locally within a school to respond to the needs of the students and changing societal needs.

New Streams

The analysis of the 1972 senior document led to the emergence of a few themes that would set the stage for documents to follow, as well as some themes that faded over time. This document saw the first clear distinction and creation of two streams of program. One stream focused primarily on applications and another centred on more abstract mathematics. The applications stream was intended for students who "understand mathematics better when it grows out of and is applied to practical situations" (MOE, 1972). This stream sought to develop mathematical principles by relating them to practical applications at all possible times. It also "de-emphasized pencil and paper computational skills in involved problems in favour of the use of business machines, computational devices and tables of value" (MOE, 1972). Although the term technology was not used in describing these devices, this was the start of a decreased emphasis on computational skills by offloading large calculations to machines.

The Foundations stream was meant "for students who may study mathematics at the honour graduation level and possibly beyond, or who have intrinsic interest in mathematics and some facility with abstractions" (MOE, 1972). The focus within this stream of programming was on logic, proof, structure, transformations and vectors. This document also saw an emphasis placed on problem-solving as a "central activity in any mathematics program…and is desirable throughout the program" (MOE, 1972). All these small themes within the course contributed to the larger theme of a modernization of the mathematics curriculum with the ability to change and adapt to the needs of students and society. This document recognized the effect that computers, technology and media were having on society and attempted to create a curriculum that would meet the new needs of a changing society while also having enough flexibility to continue to meet those needs in the future. The writers of this document realized that "it is impossible to anticipate all the applications of the mathematics of tomorrow. Nevertheless, it is certain that mathematics will play an even greater role." (MOE, 1972).

The inclusion of optional topics, topics chosen by teachers and students and the ability to create experimental courses based on student needs all reflected the modern notion of responsiveness in the teaching mathematics. The document writers also placed value in the educators at the school level to advance and adapt the mathematics curriculum as evidenced by the following statement from the front-matter of the document:

> "In summary, this document supports the premise that curriculum is constantly changing and that yesterday's mathematics is not sufficient for the society of today. A truly current program should anticipate the needs of tomorrow. It should build on the students background and be continually updated. Thus the optimal planning of the mathematics program should be done in the school itself. Only here can courses be adapted from year to year in designing programs that will appeal to students and meet local needs, only here can innovations in methodology and in mathematical approaches be tried with the opportunity for instant assessment and change, when change is desirable; only here can the program in mathematics be adapted to the facilities and resources available and to the programs in other subject areas" (MOE, 1972)

While some themes developed within this document would continue to be used and adapted in later curricula, the theme of local program development and adaptation at such a large scale would not continue to be seen in later documents.

Content Changes

The 1972 curriculum saw a massive change in the direction of the mathematics curriculum and with it came many new topics that were either not taught or focused on before. In an effort to modernize the curriculum, topics such as probability and statistics were introduced as a major focus into the curriculum. Other new topics that were introduced as major content for students to learn included polar coordinates and complex numbers in Grades 12 and 13 as well as transformations, exponential functions, matrices, logic, derivatives, planes and set notation in Grade 13. Some topics such as statics and computations with a slide rule continued to see limited use but were well on their way to being dropped from the curriculum as had been the case with other less-contemporary topics such as indices. Many topics that were previously only taught at the Grade 13 level saw an expansion of the courses in which they were included. Topics such as logarithms, sequences and series, slope of a line, conics and trigonometry all saw an expanded role in this curriculum. With the introduction of calculus as an honour level course, introductions to polynomials, functions and relations were all pushed back to earlier Grades in order to prepare students for the calculus course. Work with logic and proofs was also expanded to almost all senior level courses to give students a strong foundation. Overall this curriculum saw the addition of many new topics and content areas for students to learn and the deletion of very few. The topics that were either removed or given reduced focus were diminished in an effort to modernize the curriculum and to better meet the students of the 1970s. The work done in this document in an effort to modernize the mathematics curriculum would have lasting effects on the curriculum documents to follow.

1980 Intermediate Grades

Eight years after the release of the 1972 document covering the senior Grades, the new curriculum for the intermediate Grades was released. This document replaced the Grades 7-10 mathematics curriculum from the 1960s. Structurally this document resembled the 1972 document with a front-matter section that included the rationale, introduction and information about the courses of study followed by outlines of the courses and the topics within them. The front-matter section had continued its trend of growing in size with the front matter of this document growing to 15 pages compared to four in the previous document. New to this document was the introduction of a small one-page section on student evaluation of mathematics. This small section outlined the purpose and strategies for grading mathematics within the courses of study. This curriculum built upon the two different streams introduced in the 1972 curriculum with the introduction of a third stream and the renaming of the two streams. The Grade 9-10 curriculum now included a Basic, General and Advanced stream for students to take. This new way of streaming was the biggest structural change from the previous document but for the most part only saw minor changes from the previous curriculum. This document, like preceding documents, maintained a small page count, registering at only 43 pages total. This was the last time a document would include a relatively small page count with future curriculum documents ballooning in size.

The themes of this document continued to build on some themes introduced in the 1972 document while introducing a few new ones. Problem solving remained a primary focus of this curriculum with an expanded written portion espousing the values and importance of problem solving not just in mathematics but education as a whole. “Developing the ability to solve problems is the ultimate, but often elusive, goal of education” (MOE, 1980). Along with problem solving, the curriculum document also continued to build on the theme of applications that was introduced in the 1972 document as the “guidelines place a clear-cut emphasis on applications and problem solving” (MOE, 1980). New to this guideline was a focus on experiential approaches to mathematics and the creation of mathematical models to represent reality. The use of experiential learning saw the implementation of “concrete materials and investigations and should emphasize real-life situations” (MOE, 1972). The language associated with these themes also started to be integrated into the list of topics to be covered in each course outline. While it remained mostly a list of topics, some topics started to begin with words such as “experiment,” “activities that,” “practical examples of” and “investigating.” This trend would continue to be developed in future documents as the list of topics to be learned evolved into the expectations that we have today.

Basic Stream Content Changes

The three new streams introduced three distinct content pathways for students to take. The Basic pathway focused heavily on computational skills, basic geometry, measurement and very introductory probability. None of these concepts were new to the curriculum or Grade level but this course was focused on students who “will have experienced frustration in their attempts to learn mathematics in the past” (MOE, 1980) and the approaches used in the course “should stress attention to individual differences, provide opportunity to individual differences, provide opportunities for success, and alleviate student anxiety” (MOE, 1980). The Grade 10 course of the Basic stream built on these topics while introducing many personal finance topics for the students to learn.

General and Advanced Stream Content Changes

The General and Advanced stream saw many new topics introduced at the Grade 9 and 10 level. Topics such as linear equations, matrices, transformations, probability, statistics, vectors, rational numbers, conics, slope, functions, and proofs were all added to the Grade 9 and 10 content. Many of these topics were previously only seen in Grade 12 or 13 courses and were now being introduced in the 9 and 10 courses. Other topics such as analytic geometry and trigonometry saw an increased emphasis from previous documents. Computation remained part of the course but was given much less emphasis. Tools such as the slide rule disappeared from the curriculum at this time, replaced with the use of computers. This document even went so far as the include "studying a computer language" (MOE, 1972) as a topic in the Grade 10 Advanced course of study. Overall, this was an ambitious program for Grade 9 and 10 students, and was short-lived, this document was replaced only 5 years later with another reshuffling of topics within these Grade levels.

1985 Curriculum

The 1985 curriculum brought with it massive structural changes to the documents. This document came in three separate parts with the total overall page count ballooning to over 180 pages for the Grade 8-13 curriculum. One of the major structural differences was that the curriculum policy documents were now organized as 3 separate booklets, with each booklet covering one the streams with-in the curriculum. The streams in the 1985 curriculum followed the same streams that were introduced in the 1980 document: Basic, General and Advanced. Each booklet followed the same structure, i.e., a lengthy front matter portion, and then sections for each course of study.

The front matter section had been renamed to Policy and Direction and was now approaching 30 pages in length. This section now covered topics ranging from the introduction and goals of education to cross-curricular and process components and evaluation. This document does not specifically include a rationale section; the type of information that had been included in previous documents was now woven throughout the introduction section instead. Within the evaluation section, the terms ‘formative evaluation’ and ‘summative evaluation’ were introduced for the first time. This document defines a formative evaluation as “evaluation of student achievement taking place while students are studying or learning new material,” (MOE, 1985). Summative evaluations were defined as “evaluation of student achievement takes place after the completion of a topic or unit,” (MOE, 1985).

Each individual course includes a one to two page introduction outlining the aims, component and evaluation of the students within the course before listing the sections and topics to be taught. Each section includes a brief one paragraph summary before listing the topics contained within. A significant new feature was that each topic has the letter E, N or R beside it to represent whether the topic is an extension (E) of previous learning, a review (R) of a previous topic or a new (N) topic to learn. Optional topics do make an appearance within this document, but they come up much less frequently than in previous documents. The flexibility of the teacher to deliver a more personalized program is reduced through this action. This document also saw the introduction of a course coding system that would continue into the future. In previous documents, courses were assigned abbreviated version of their names but in this document, a course such as Mathematics for Work and Home Grade 10, Basic Level were given the code MTW2B while Algebra and Geometry OAC was given the code MAGOA. Finally, these documents included a section towards the end detailing acknowledgements of individuals involved in the creation of the documents and the roles they played. The overall structure of the Grade 9 to 13 program introduced within this document would lay the foundation for the mathematics program in Ontario for the decades that would follow. The structure of the program can be seen in Figure 5 below.

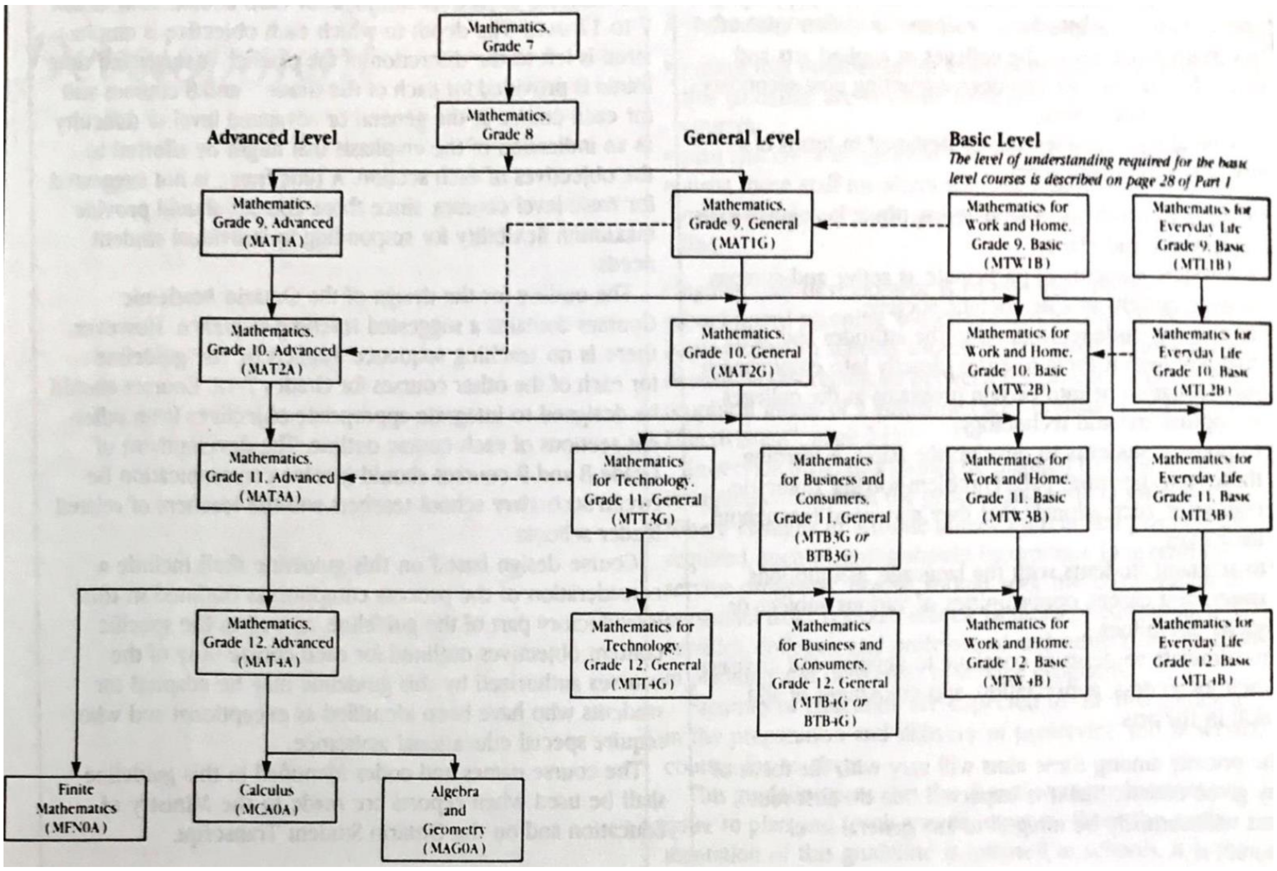


Figure 5: The 1985 Mathematics Program

While the names, streams and courses would be changed and content would be moved around, the basic structure of the secondary school mathematics program remains the same today. Students selecting the Advanced stream study one mathematics course a year until the final year of high school when 3 mathematics courses were available: Finite mathematics, Calculus and Algebra and Geometry. The General stream had one mathematics course each year in Grades 9 to 10 followed by the option to take a general ‘Math for Technology’ stream or ‘Math for Business’ stream. The Basic level allowed students to take ‘Math for Work and Home’ or ‘Math for Everyday Life.’ It was this general structure that would be the baseline for mathematics in Ontario going forwards.

The 1985 document saw many of the same themes introduced in the 1980 document either maintained or expanded upon. The emphasis on experiential approaches and problem solving continued to be developed. Experiential approaches now specifically recognized that “manipulatives and material representations play a crucial role in students’ mastering of mathematical concepts” (MOE, 1985). The use of manipulatives as a learning tool crucial to mathematics would become a major part of the mathematics curriculum going forward and was a major leap forward in the Ontario mathematics curriculum to specifically place emphasis and importance on it within the document. The use of technology is discussed in the front matter as a way to enhance and restructure the mathematics program, but very little attention is given to the use of technology elsewhere in the document. The document recognizes the benefits of technology in teaching and learning mathematics but does not build the use of technology into the actual course expectations.

Problem solving continues to be a main theme with a large section of the front matter dedicated to what makes good problems and the steps to problem solve. Problem solving is woven into the curriculum expectation as well with some expectation specifically using the term “solve problems” such as in the Grade 11 Advanced course under quadratics it states “solve problems involving quadratic equations” (MOE, 1985). Expectations like this arise throughout the Basic, General and Advanced curriculum. Applications of mathematics for everyday use was a continued theme from the previous documents. This document specifically states that the mathematics program “should give students many opportunities to see a direct relationship between their studies and the real problems that they face now or will encounter in the future”

(MOE, 1985). This theme is evident in how the courses were structured with many of topics within the Basic and General courses being built around real-world applications. Within each unit of these courses there is a section devoted to applications of the teachers' or students' choice to help make the applications relevant to problems the students are encountering.

Some newer themes began to appear in this document such as a focus on the 'language of mathematics.' While individual topics within courses did not focus on communication, there was a distinct focus on using language to understand mathematics and mathematics itself as a language. This could be seen within the front matter where it explicitly states that "language plays a fundamental part in the teaching and learning of mathematics" (MOE, 1985). While not a major theme of this document, this is a theme that continued to be developed in future curriculum documents. Mathematical modelling is one of the major new themes of this document and was a direct result of the development of problem solving and applications as a theme within the mathematics curriculum. "The process of problem solving using mathematics inevitably involves the choice or creation of a mathematical model. As a problem becomes more complex the selection of an appropriate mathematical model becomes more crucial in the attainment of the solution" (MOE, 1985). Mathematical modelling was an underlying theme of this entire document as is used both problem solving and applications to help students learn and understand mathematics. This theme would continue to be developed and used as a major theme in future curriculum documents.

Basic Stream Content Changes

As with previous documents, the content and focus of the different streams continued to differ greatly. The Basic stream continued to focus on real life mathematics content and problems within the Advanced stream focused on the development of functions and higher-level abstract mathematics. The General stream courses mix together both real life mathematics and some more abstract concepts. Both the Basic and General streams' terminal courses were in Grade 12 and the Advanced streams terminal courses were the OAC courses. The content in the Basic stream continued to focus around personal finance, computation and measurement with an increased emphasis on probability and statistics. While there were no major changes in the content being taught at the Basic level it did get into some more specific cases within the course such as course topics that included "calculating the cost of roofing," "calculating the cost of concrete" and "reconciling a bank statement" (MOE, 1985). This was the bulk of the changes to the content in the Basic stream, where the focus was on more specific problems and real life applications of a mathematical concept.

General Stream Content Changes

The General stream saw its focus in Grades 9 and 10 on numerical methods, algebra and geometry. As in previous documents, students learned to work with numbers, powers, roots, ratios, rates and polynomials. A greater focus was placed on linear equations and graphing along with geometric constructions. New to this document was the emphasis on personal finance and statistics in Grade 10 and beyond. Students were required to "identify the type of credit available in the community" and "apply record keeping to personal income and expense data" as part of the personal finance section of the General course. In Grade 11 and 12 students in the General stream had the option of taking 'Mathematics for Business and Consumers' or 'Mathematics for Technology.' The business and consumer course focused solely on statistics and personal finance as content while the technology course looked at some personal finance but with the study of much more abstract concepts. These more Advanced concepts included properties of geometric figures such as circles, trigonometry and trigonometric functions, radian measures and forces and vectors. These were concepts that were new to a General level stream and presently some of these topics are only found in the most advanced high school mathematics courses. While General level students normally would learn more concrete and real-life based mathematics, this course was meant for General level students who were planning on moving onto technological programs at the college level.

Advanced Program Content Changes

The Advanced level stream had Advanced level course from Grades 9 to 12 followed by the Ontario Academic Courses in Grade 13. The OAC courses consisted of Algebra and Geometry, Calculus, and Finite Mathematics. The Advanced program placed much of its emphasis on the use of functions, analytical geometry and used proofs throughout the program. Unlike the Basic and General streams, there were very few personal finance topics within the Advanced program as it mostly focused on abstract mathematical concepts. Within the Grade 9 course, a major difference from previous documents was the emphasis of topics on geometric constructions, congruence, transformations and dilations. This course required students to construct geometric shapes "using a variety of techniques and instruments" (MOE, 1985). In Grade 10 Advanced these topics would be extended to coordinate geometry, 3-D geometry and the straight line. Applying these concepts and using deductive reasoning, students were required to, for example, "prove the Pythagorean theorem" (MOE, 1985).

There were optional topics within the Grade 10 Advanced course that explored topics such as matrices, vectors and isometries. Grade 11 Advanced saw the introduction of the function and quadratics, a continued development of analytic geometry by looking at the circle and also included a section of investment mathematics. Grade 12 Advanced examined congruence and parallelism as part of its geometry unit, while introducing trigonometric, exponential and logarithmic functions. Each OAC course continued to build on topics covered within the Grades 9 to12 courses. Algebra and Geometry covered matrices, vectors, complex numbers and mathematical induction. It is interesting to note that the majority of these topics were removed in the 2007 senior mathematics curriculum. The Calculus course covered limits, derivatives and curve sketching with a look at antidifferentiation. The Finite mathematics course included matrix algebra, combinatorics and probability. It is interesting to note that applied trigonometry did not appear as a major topic within the Advanced stream as the main focus was on analytic geometry and functions. This was to be the last curriculum document released in Ontario that included a 5-year secondary program. With the fifth year being eliminated, this would be the last time a mathematics program in Ontario included as many different content topics as the 1985 curriculum. From this point on, mostly in an effort to reduce a 5-year program into 4, more content would be eliminated from the curriculum than added.

1995 Common Curriculum

The early 1990s was a time of political change in Ontario and this led to many modifications to the overall Ontario secondary school program, including the mathematics curriculum. The 1995 curriculum was a short-lived curriculum with some of its more radical changes later discarded; nonetheless, some of the ideas reappeared in later documents. The only part of this curriculum released was the Grade 1-9 portion and never any senior level mathematics. This discussion will only consider the Grade 9 component of this curriculum. Both the mathematics course of study and curriculum document were radically different from anything that came before. The curriculum no longer had streamed programs; instead all students learned the same mathematics topics. Instead of grade by grade programming, topics were organized into 3 year groupings for which each student would be required to show proficiency in listed outcomes by the end of Grade 3, Grade 6 and finally Grade 9. The same strands: problem solving and inquiry, number sense and numeration, geometry and spatial sense, measurement, patterning and algebra and data management were present in each grade from one to nine. The document itself was relatively short at just over 50 pages compared to previous documents. The front matter covered about 20 pages with the topics covering the rest. The front matter continued to evolve from previous iterations but mostly addressed the same major issues as previous documents. This front matter included a background, a framework for assessment, definition of what standards are, key components of mathematics learning and finally the strands of mathematics.

The NCTM *Curriculum and Evaluation Standards for School Mathematics* of the late 1980s had a clear impact on this document because the same language is prevalent in both, e.g., "standards" and "outcomes". A move to the word "assessment" rather than "evaluation" was significant in this document and marked a move away from a focus on final grades. The document defined assessment as "the process of gathering evidence about a student's knowledge, skills, and values and of making inferences based on that evidence for a variety of purposes" (MOE, 1995).

There are no listed courses in the content area of the document nor is there a required list of topics or expectations. The content area is divided into three milestone periods, the ends of Grade 3, 6 and 9. Each of these grade spans is further divided into the content strands. Within the content strand it lists general outcomes followed by specific outcomes, a sample assessment activity and a performance chart from level 1 to 4 that describes characteristics of student performance in that level. In this first iteration, student achievement is described in the following way: Level 1 "the student is not yet performing within the expected range;" Level 2 or 3 was the standard of performance where "students were performing within the expected range" and Level 4 had "students performing beyond the expected range." There were no grades associated with the achievement level, and it is interesting to note how Level 2 was considered to be within the acceptable range of performance. While the structure of the mathematics program and courses in Ontario witnessed a variety of changes, the themes that had been arising in mathematics education over the past few documents mostly remained the same for this document.

The major themes that arose in this document were problem solving, communication, technology and assessment. Problem solving continued to be an integral theme of the mathematics program with the 1995 document itself stating "problem solving should be the central focus of the mathematics curriculum" (MOE, 1995). While problem solving is woven throughout the curriculum, the 1995 curriculum is the first to include it as a specific content strand within the course of study. Within this document, some newer contexts for problem solving such as 'through inquiry' or 'cooperative problem solving' are introduced. While inquiry and cooperative problem solving were not an emphasis within this document, these themes would take on greater significance in future documents.

Communication continued to evolve as a theme, moving beyond simply using the language of mathematics as theme from the 1985 document, to having students "write about their mathematics experiences" using a journal entry (MOE, 1995). Technology continued to be a theme that arises with statements such as "every classroom should have at least one computer that is available for student use" and "software should enable students to develop and deepen their understanding of new concepts" (MOE, 1995). While the documents make reference to the importance of the use of technology in teaching and learning mathematics, they continue to be vague about exactly how it is to be used in the classroom to meet the standards and outcomes within this curriculum.

Finally, the major new theme introduced in this document was that of assessment. A direct evolution from the minor themes of evaluation in previous documents and the introduction of the NCTM standards of 1989, assessment appears throughout the entirety of the document. Much of the front matter is dedicated to defining what standards are, how they can be used and providing a framework for assessment. An entire portion of the curriculum document is dedicated to provided different assessment strategies that can be utilized and how best to utilize them. These strategies include performance assessments, open-ended questions, investigations, journals, observations, conferences, interviews, portfolios and self-assessments. Even the content that students are to learn is presented in the document in a way that includes performance indicators to help educators with assessing where students are falling on the achievement chart. While this theme of assessment would not show up in future documents as heavily as it did in 1995, features such as the achievement chart would continue to feature prominently in the coming documents.

Content Changes

Since there is only one year and one course to examine for the 1995 secondary curriculum, there is not much information in terms of major change to content. As stated earlier, the Grade 9 mathematics program was organized by strands: problem solving and inquiry, number sense and numeration, geometry and spatial sense, measurement, patterning and algebra and data management. Each of these strands contained the same topics/concepts as the Grade 9 Advanced course from the 1985 policy document. Missing was the content included in the Basic and General courses, most notably the section on personal finance. Linear equations and graphing were moved into the Grade 9 topics from the Grade 10 Advanced course: students were now required to “solver linear equations in one variable using a variety of methods and tools” (MOE, 1995) by the end of Grade 9. This is a revision that would remain unchanged in future documents. While this document was limited to Grade 9 and was only in place for 4 years, it was an important steppingstone along the development path of the Ontario mathematics curriculum as we know it today.

1999-2000 Curriculum

The 1999-2000 curriculum replaced the 1995 Grade 9 curriculum documents and the 1985 documents for Grades 10 to 12. This was the first full curriculum document to include the removal of Grade 13 (Ontario Academic Courses) from the Ontario curriculum which would result in massive changes to the curriculum in Ontario. The documents themselves went back to resembling the older 1985 document rather than the more recent 1995 document. One document for Grades 9 and 10 was released in 1999 and the Grade 11 and 12 document was released in the year 2000.

The curriculum returned to streaming of courses with Grade 9 and 10 courses being streamed into applied and academic courses. At the Grades 11 and 12 level courses were now streamed into university preparation, university/college preparation, college preparation and workplace preparation. The course coding system was continued from the 1985 document with applied being labelled using “P,” academic used “D,” university preparation used “U,” university/college preparation used “M,” college preparation used “C” and workplace preparation used “E.” Both documents included a much smaller front matter section than previous documents because program planning and assessment now existed within their own separate policy documents[7] that covered all disciplines within the Ontario secondary program.

The front matter included a brief overview, teaching approaches and a breakdown of the different strands in the curriculum. In both documents, the front matter took up less than 10 pages. After the front matter, both documents deconstructed each course into strands which included both overall and specific[8] expectations. This was the first time that the term "expectations" was used and instead of a list of topics that teachers were to address, each expectation now came with a descriptive action such as "manipulate," "determine," "represent," "substitute" and many more. A major difference from all previous documents was the complete removal of optional topics to be covered within the individual courses.

Towards the end of each document is the inclusion of an achievement chart for mathematics that has clearly been adapted from the charts introduced within the 1995 curriculum. This refreshed achievement chart is broken down into subsections that provide descriptors for four criteria: Thinking, Communication, Application and Knowledge. The achievement chart makes a return with some differences from the 1995 document: Level 2 represent no longer represents where a student should be achieving as only a level 3 now represents provincial standard. Level 1 still represented not achieving provincial standard only showing limited evidence of achievement. Level 4 represented achievement above the provincial standard. In 1995, the levels did not coincide with percent grades but in this document a Level 1

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[7] This document was *The Ontario Curriculum, Grades 9 and 10, Program Planning and Assessment, 1999* and *The Ontario Curriculum, Grades 9 to 12, Program Planning and Assessment, 2000*

[8] The *overall expectations* describe in general terms the knowledge and skills that students are expected to demonstrate by the end of each grade or course. The *specific expectations* describe the expected knowledge and skills in greater detail. Descriptions as seen in *Growing Success: Assessment, Evaluation and Reporting in Ontario's Schools : Covering Grades 1 to 12*. (2010)

represents a grade between 50-59%; Level 2 between 60-69%; Level 3 between 70-79% and Level 4 between 80-100%. At the very end of the document, an explanatory notes section is included which explains and gives definitions for mathematical terms used in the document. This is the first time any substantial explanation of mathematical concepts or terms were included in a document and indicate that the audience of this document may no longer have been solely mathematics educators.

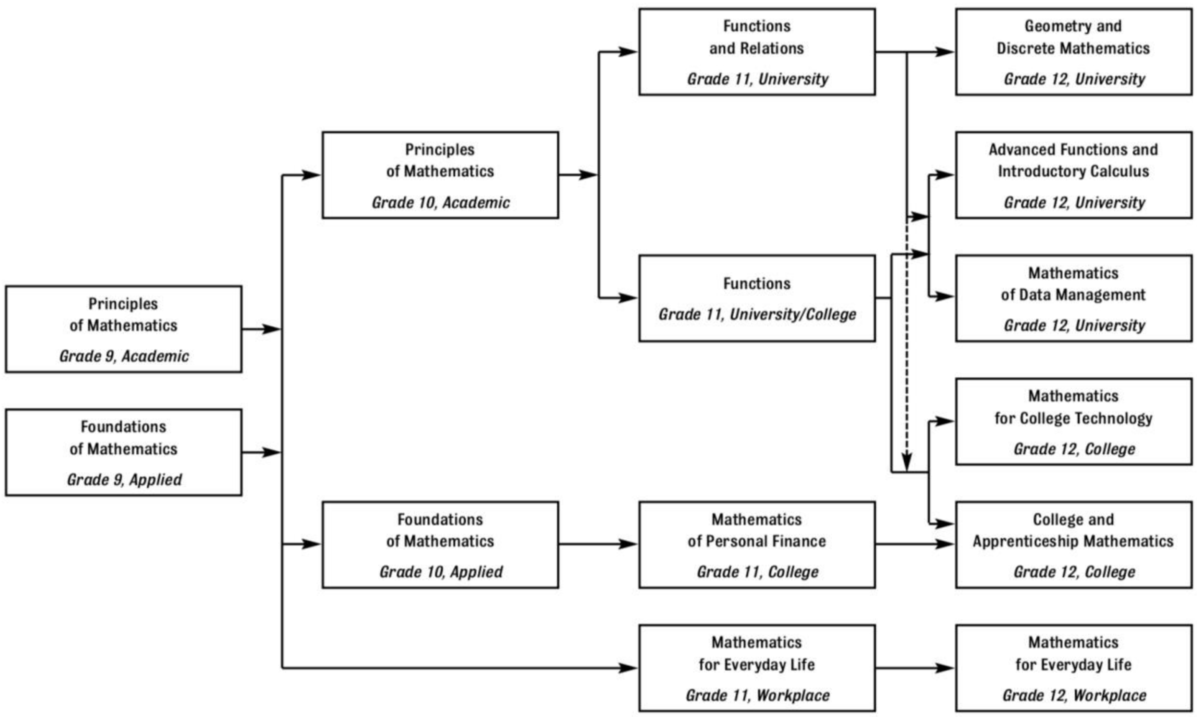


Figure 6: The 1999/2000 Mathematics Program

The removal of the fifth year of the secondary program in Ontario resulted in numerous changes to the structure of the actual curriculum as can be seen in Figure 6. Up until this curriculum implementation, students were able to take one single mathematics course in Grades 9 through 12 and then in Grade 13 choose among three different OAC mathematics courses. These terminal OAC courses were downloaded into Grade 12 becoming courses in Data

Management, Advanced Functions and Introductory Calculus, and Geometry and Discrete Mathematics. The previous Grades 9 through 12 Advanced curricula was squeezed into the new Grade 9 to 11 University preparation program. Both the Basic and General level programs terminated at Grade 12 in the 1985 curriculum; therefore, the move to a 4-year program did not have as great of an effect on the college and workplace streams in 1999/2000 as it remained a 4 year program. This document would see some minor revisions a few years after being released but this release set the stage for the mathematics program in Ontario for the next 20 years.

The 1999/2000 curriculum focused on two main themes that can be seen throughout the curriculum documents. "An important part of every course in the mathematics program is the process of inquiry. Knowing how to learn mathematics is the underlying expectation that every student in every course needs to achieve" (MOE, 2000). The theme of inquiry is pervasive throughout the documents, from the front matter to the expectations within the individual courses. Under many of the strands in different courses, students are to be tasked with investigating relationships and properties rather than simple rote learning. The word investigation is often built directly into the specific expectations, for example from analytic geometry strand of the Grade 9 Applied students will "identify the geometric significance of m and b in the equation $y=mx + b$ through investigation" (MOE, 1999). This document also builds on the 1985 document's theme of modelling and integrates it into the inquiry theme that is pervasive throughout.

Within the front matter itself, the document states that "an important stage in the inquiry process is that of *modelling*" (MOE, 2000). In the same way that inquiry was built into the curriculum as a theme so was the theme of technology. The front matter espouses the benefits of technology and how it can be used to solve problems. It also makes note that technology was not included to replace skill acquisition but “rather, technology is required when its use represents either the only way or the most effective way to achieve an explanation” (MOE, 2000). The use of technology also appears directly within the specific expectations multiple times throughout all the courses. For example, within the Grade 11 University Preparation course, ‘Loci and Conics’ strand, students are required to “illustrate the conics as intersections of planes with cones, using concrete materials or technology” (MOE, 2000) and within the Grade 10 Applied ‘Quadratics Functions’ strand, students will “determine the zeros and the maximum or minimum value of a quadratic function from its graph, using graphing calculators or graphing software” (MOE, 1999). These are but two examples of an extremely pervasive theme of using technology to help students learn and build upon their mathematical knowledge and skills.

Grades 9 Content Changes

With the reduction of the secondary program from five to four years, there was a dramatic amount of change when looking at the content of the curriculum documents. The Grade 9 applied and academic course were both very similar in the content addressed, differing mostly in levels of abstraction and complexity. As in previous Grade 9 courses students continued to work on number sense, ratios, algebra skills, statistics, measurement (area, perimeter, volume) and geometry (angles, sides of polygons). One of the newer topics was the large emphasis placed on linear equations, relationships, graphing and determining slope and y-intercept. Up until the 1995 curriculum, these topics had not been covered in depth in the Grade 9 curriculum. The 1995 curriculum started the process of moving this topic into Grade 9 and the 1999 document fully embraced this topic as a major component of the Grade 9 content.

Grades 10 Content Changes

In Grade 10, the academic and applied stream starts to separate slightly in the topics covered but still remain similar. Both Grades introduce quadratic functions into the Grade 10 courses for the first time along with making it a major strand of study. Up until this curriculum the earliest a student covered quadratics in depth had been in Grade 11 Advanced courses. This move is another example of more abstract concepts appearing in applied level courses. Both courses also continued the study of linear equations and systems and determining slopes and intercepts using analytical geometry. Trigonometry was covered in both Grade 10 courses and this was the same grade it had been introduced in the past. The difference here was that students at the Applied level were being introduced to a topic that was rarely taught at that level. To make room for these new topics at the Applied level no topics in Personal Finance appear at all. Previous documents were heavy in the personal finance aspect in the non-university level courses and in this document, it does not appear in the Grade 9 or 10 applied level course, which have a new direction focused on abstract concepts.

Grades 11 Content Changes

The Grade 11 University preparation course was vastly different from the previous Grade 11 Advanced course from 1985. No longer heavily focusing on analytic geometry and proofs the new course instead emphasized functions–examining linear, quadratic, trigonometric and exponential types. The course also looked at sequences and series and its applications to financial mathematics. This is one of the only topics that cover any sort of financial mathematics in the university preparation stream. Students were also expected to learn and work with complex numbers in this course. Finally, a major focus was on loci and conics.

The Grade 11 University/College preparation course was very similar to Grade 11 University preparation with the removal of the study of loci and conics being the major difference. At the College level, the Grade 11 course focused on exponential functions and applying the principles to the mathematics of investments by looking at compound interest and annuities. Students complemented this with expectations that covered personal finance related to budgeting for everyday life. At the Workplace level in Grade 11, students solely had expectations that covered various personal finance topics from renting to travelling to getting and building credit. In the 1985 curriculum, students did have the opportunity of taking two different courses at each level with different foci. In the 2000 document, students no longer had this option in Grade 11 because there was only one course in each stream.

Grades 12 Content Changes

The Grade 12 programming saw the most drastic changes in terms of content. Previous to this document there existed a single Grade 12 course at the Advanced level for students to take that introduced topics such as trigonometric functions, logarithms and conics. With many of these topics now included in the Grade 11 course, students now had three available university preparation courses. The Advanced Functions and Introductory Calculus course focused on working with different polynomial functions (exponential, logarithmic functions and curve sketching) followed by rates of change, introductory derivatives and applications of derivatives. Integrals and anti-differentiation were removed from the secondary mathematics program.

The Geometry and Discrete Mathematics course introduced students to the concept of vectors, matrices, geometric and algebraic proofs, permutations and combinations. The concepts of vectors, matrices and proofs were concepts that used to be introduced to students in Grade 10 in the 1985 document, while the permutations and combinations were moved from a Grade 13 course.

The Data Management course included topics such as introductory graph theory, counting methods, matrices, probability, permutations, combinations, probability distributions, and one and two variable statistics. This course had substantial content overlap with the discrete mathematics course with topics such as matrices, permutations and combinations appearing in both. Many of the topics within statistics were pulled from one of the Grade 13 OAC courses from 1985 to be included in this Grade 12 course. Overall, at the university preparation level, many of the topics from the old OAC courses were condensed into Grades 11 and 12 but not addressed to the same depth. The only content area that saw major reductions in topics was Calculus with the removal of integrals from the course of study.

At the college preparation level, students had the option of a college and apprenticeship course of a college technology course. The college and apprenticeship course had a focus on statistics, measurement, basic trigonometry, linear systems, and basic quadratic work. The college technology course focused on polynomial, linear, quadratic, exponential and logarithmic functions and its applications. Neither course included any content about personal finance which had been a major content area in the 1985 curriculum at this level. The workplace level course focused on very introductory statistics and probability, measurement and personal finance. This is the only course that included a substantial personal finance component. Between 1985 to 2000, the Grade 12 courses at the college and workplace level saw the inclusion of many more abstract concepts than in earlier iterations and, very significantly, the removal of personal finance and real-life mathematics.

2005-2007 Revised Curriculum

The 2005/2007 curriculum documents represented a revision of the curriculum released in 1999/2000. The 2005 document was a revised version of the Grades 9 and 10 courses with the 2007 document a revised version of the Grade 11 and 12 courses. The structure of these new documents and curriculum were both very similar to 1999/2000 documents except for a few major changes. The only major change that happened at the programming level was at the Grade 12 university preparation level. The Geometry and Discrete Mathematics course from the 2000 document was removed completely and replaced with an Advanced Functions course for the revised document. This course was intended to be run as a prerequisite for the Grade 12 calculus course but had the option of being run as a co-requisite as well. The third Grade 12 university class remained the Data Management course.

While other courses saw some minor changes to their names, the streams and courses pathways introduced in 1999/2000 remained the same. The general structure of the documents was similar to the previous documents as well. The documents still had a front matter, the courses were presented in the same way using strands and expectations and a glossary of terms was included at the end. Many of the specific individual expectations now included sample problems.

The major change that occurred in the revision was the extension of what appeared in the front matter. The front matter of both revised 2005/2007 curriculum documents increased from the 1999/2000 documents. The Grade 9 and 10 document increased to 30 pages and the 11 and 12 document increased to 40 pages. The typical introduction and overview was present but the rest of the front matter now included a section on the mathematical processes, a larger assessment and evaluation section including a revised achievement chart and finally some program considerations that covered topics from ESL to health and safety in the mathematics program.

The themes within the revised curriculum remain similar to the themes from the 1999/2000 documents. One major revision to the themes was the extra emphasis placed on the mathematical processes in this new document. In the 1999/2000 document, the mathematical processes were incorporated into the expectations within each course and strand. This new document felt that there was a “need to highlight these process expectations” and this arose from “the recognition that students should be actively engaged in applying these processes throughout the course” (MOE, 2005). The mathematical processes as defined by the 2005/2007 documents were ‘problem solving,’ ‘reasoning and proving’, ‘reflecting’,’ selecting tools and computational strategies’, ‘connecting’,’ representing’ and ‘communicating’. Many of these processes were instructional foci that had been developed over the course of many previous curriculum documents but in this document, they had been synthesized into one larger instructional requirement. Inquiry and the use of technology continued to be pervasive themes within the curriculum expectations. Many specific expectations explicitly stated that content would be learned “through investigation.” Technology and the use of manipulatives appears often in expectations as it did in the previous document.

Grades 9 and 10 Content Changes

The major changes that occurred within these new documents occurred in the content that was being delivered. The changes were very minor at the Grade 9 and 10 levels, consisting of slight word changed to some of the expectations, with the most drastic changes occurring at the senior level courses.

Grades 11 and 12 University Preparation Content Changes

In the university preparation stream, the first major content changes occurred in the Grade 11 university level course. In this course the strand that addressed loci and conics was completely removed, complex numbers were removed, radian measures were removed and graphing (the trig function) *tan* was removed. While radian measures and graphing *tan* were introduced into the new Advanced Functions course in Grade 12, the content covered in loci, conics and complex numbers disappeared from the curriculum. No new major topics were introduced to the Grade 11 course to balance the removal of these topics, instead previous content it was given more instructional time. The university/college Grade 11 course remained largely unchanged with minor wording revisions. At the Grade 12 level, the new Advanced Function course served as an extension of the Grade 11 course, addressing most of the same topics to a deeper level. Advanced Functions was originally a single strand in the calculus course in the 2000 document but was extended into a full course in the 2007 document. The major topics covered include logarithmic functions, trigonometric functions (same as current Grade 11 but now includes radians and tan), polynomial functions (curve sketching), limits and characteristics of functions.

The new Calculus course addressed the expectations from the rest of the previous Calculus course that had not been reassigned to the Advanced Functions course. These topics remained as rate of change, derivatives of functions and applications of derivatives. Introductory vectors and planes were added to the new calculus course. These topics came from the discontinued geometry and discrete mathematics course. The Data Management course remained mostly unchanged, addressing the same broad topics as before with some minor revisions. One of the minor changes involved the removal of introductory network theory and matrices. With these reworks at the Grade 11 and 12 University preparation stream, the following topics were either removed completely or significantly reduced: matrices, conics, complex numbers and proofs. It is clear that the calculus course became the premier mathematics course for the entire academic mathematics curriculum with every course from Grades 9 to 12 building the foundations for its content and processes.

Grades 11 and 12 College Preparation Content Changes

At the college level, the Grade 11 course removed some of the focus on financial mathematics, e.g., annuities. The financial mathematics focus was replaced with strands that covered trigonometry (solving right angle and non-right angle triangles), introductory statistics, introductory probability and modelling with quadratics. This change placed many more abstract concepts into the college level course at Grade 11 than there had been previously. The Grade 12 college program continued to offer two courses: The College Technology course and Foundations for College Mathematics (formerly known as the College and Apprenticeship course). The College Technology course had the topics of introductory vectors and solving geometry and circle problems added to the course. The foundations course continued to build on the Grade 11 college courses topics with a personal finance strand added to the course. These covered annuities which was removed from the old Grade 11 course in 2000 and put here along with budgeting. At the workplace level students continued to exam basic geometry and measurement problems along with personal finance topics.

Tables 6 and 7 summarize some of the key changes described in this section. Table 6 summarizes the length between revisions, total length of the document, length of content pages, length of front matter and whether the authors were listed in the document. There is no discernable pattern in the time between revisions. The front matter and content pages continuously grow in length with each revision. In 1999, there is a break in this pattern as they decrease in length, but this was due to policies being removed from the front matter and placed into other policy documents. Authors were listed for documents during the 1980s but were not included for all other years. Table 7 summarizes some of the key content changes to occur. Linear systems (red) appears in senior level courses in the 1960s documents and this topic slowly drifts down the grade until the most recent documents where it appears in Grades 9 and 10. Vectors and matrices (purple) is taught in Grade 10 courses in the 1960s and bounce around to different grade levels before only appearing Grade 12 courses in the most recent documents. Conics (orange) is a topic that does not currently exist within the documents but has been taught in all different grades in the past. Personal finance (pink) was heavily integrated into all courses in the General and Basic streams in the 1985 documents but only now exists in the senior level applied courses. Students currently in high school who take the academic stream receive no exposure to personal finance mathematics. The move to four years from a five-year curriculum is apparent in the table as topics can be seen either disappearing or being downloaded to lower grades. A more in-depth examination of the content changes between documents can be seen in Appendix E.

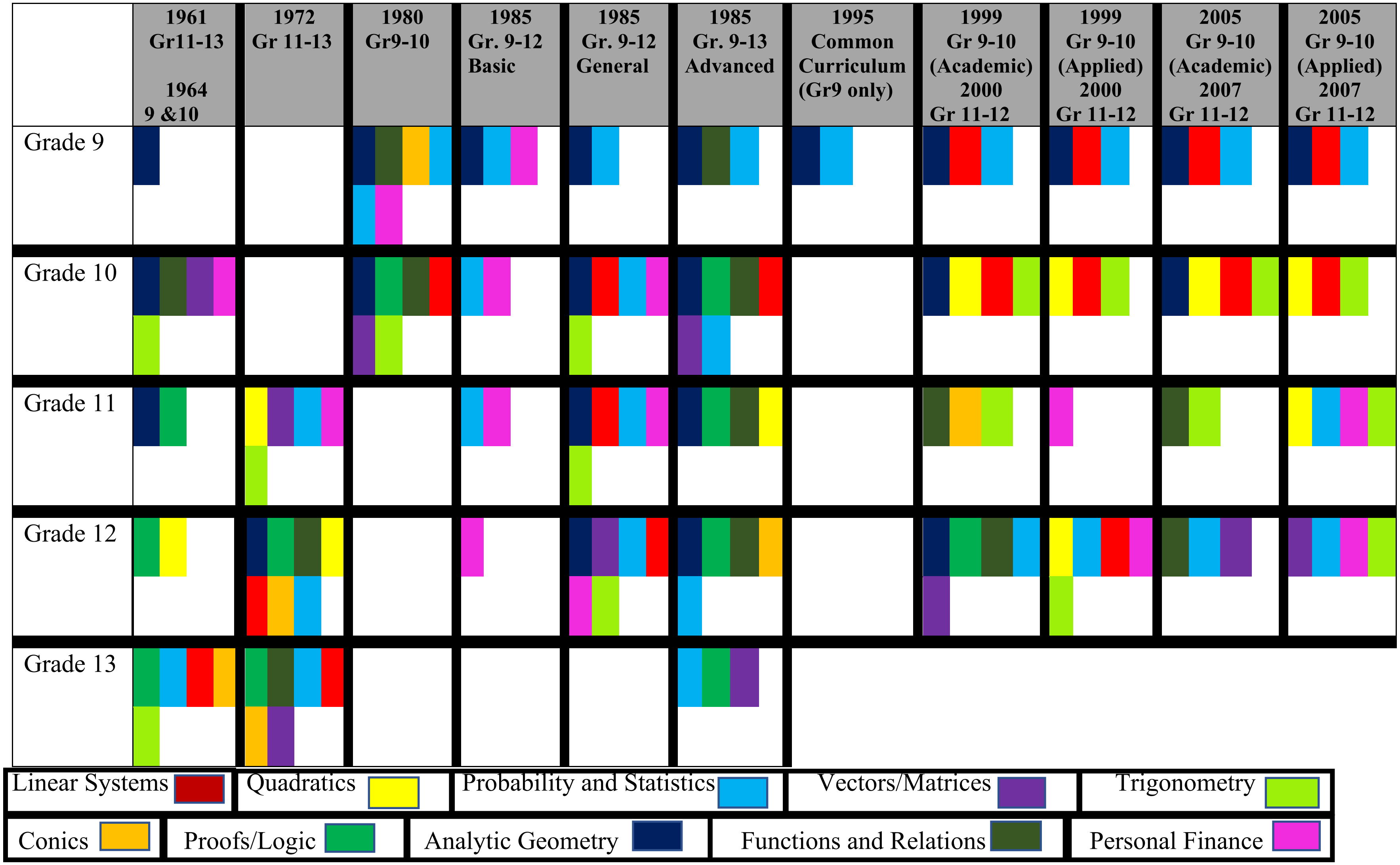
Table 6

Summary of Specific Document Changes

	1961 Gr11-13	1964 Gr9-10	1972 Gr 11-13	1980 Gr9-10	1985 Gr. 9-12 Basic	1985 Gr. 9-12 General	1985 Gr. 9-13 Advanced	1995 Common Curriculum (Gr9 only)	1999 Gr 9-10	2000 Gr 11-12	2005 Gr 9-10	2007 Gr 11-12
Time Since Previous Revision (years)	-----	-------	11	16	5	5	5	10	4	15	6	7
Total Pages	35	49	47	43	58	72	78	56	40	75	65	147
Front Matter Pages	2	7	10	20	26	26	26	21	10	12	33	40
Content Pages	33	42	37	23	32	46	52	35	30	63	32	107
Authors Listed (Yes or No)	No	No	No	Yes	Yes	Yes	Yes	No	No	No	No	No

Table 7:

Summary of Content Changes to Curriculum



Interview Analysis

Participant A

Background

Participant A, a retired mathematics teacher and Department Head, currently works as a provincial Facilitator on project work for the Ministry of Education. During her teaching career, she was also seconded for two years to work at the Ministry of Education on mathematics projects.

Participant A was heavily involved in The Ontario Association for Mathematics Education (OAME) as a chapter representative for approximately seven years and was a member of the provincial Executive Committee for roughly five years, serving in three of those years as President Elect, President (2001-2002) and Past President.

Participant A has also been heavily involved in delivering workshops on mathematics education for her school board and as a representative of OAME, the Ministry of Education and the Ontario Secondary School Teachers' Federation (OSSTF).

She was a member of the Steering Committee for the Education Forum at the Fields Institute for Research in the Mathematical Sciences when that group led the Data Management Project: an important precursor to the creation of the new Data Management course.

Participant A was also a member of the Secondary Schools Committee Executive at the OAME when that organization responded to a Request for Proposals (RFP) from the Ministry of Education to develop a new secondary curriculum for Ontario mathematics in the late 1990s.

Experiences with Curriculum Change

Participant A was involved in writing the 1999/2000 Ontario Secondary School Mathematics Curriculum, serving as a member of the team that reviewed and rewrote the Grade

11 and 12 courses. Participant A's role was focused on the Grade 12 courses and the topics that were key to them. She was also involved in generating profiles for the new courses and the creation of the Targeted Implementation and Planning Supports (TIPS) for the new courses through OAME.

Reflections on Experiences

Creating a new curriculum comes with both positive and challenging experiences. Participant A noted that it was a particularly positive experience in terms of "…getting a chance to work with people all across the province and all across the branches of education…" (A, p. 12) and she especially enjoyed working with the leaders of the new curriculum team "…who had tremendous ambition about what we should do and where the future was." (A, p. 12). Participant A noted that she "may have not had the vision myself, but once I saw it through their eyes, I could take it and make it happen in the classroom" (A, p. 12). The experience of working with a wide variety of stakeholders and mathematics education leaders was quite positive and led to many lasting connections with other mathematics educators. Participant A noted that she "...learned tremendously from everybody and then I formed a strong network with Fields because those are many of those people who went to Fields…" (A, p. 12).

Creating a new curriculum was not without challenges. Some of these challenges came from pressure and instructions given by those in positions of authority within the Ministry of Education. One of the pressures came from the ruling government party that was trying to get the curriculum produced quickly by releasing the Grade 1 to 12 documents in chunks. "…They released, back then it was [grades] one to eight and I think they'd done that before we started writing the secondary and we couldn't touch those courses. So if we wanted kids to have a better understanding of percent before grade 9, we couldn't touch it" (A, p.8).

One of the other challenges was caused by the removal of the OAC courses and how everyone wanted to keep the OAC material in new a four year program. Participant A felt that if they had been able to work on a Grade 1 to 12 curriculum then the team "might have been able to download some of those things in a different way" (A, p.8).

Participant A felt that there was a rush in creating the 1999/2000 documents that had not been there in previous curriculum review and development cycles and expressed concern that the entire curriculum review, development and implementation process lacked field testing and program evaluation. "It's problematic when you're in a rush and I mean when they had the 1985 curriculum, they field tested all the textbooks for three years before they published them." (A, p.8)

According to Participant A, most people on the 1999/2000 curriculum writing team were teaching mathematics using non-traditional methods and using technology in their classroom. Even though there was a shared vision of what the new curriculum should include among members of the development team, there were still many blocks of people who opposed the changes. One of the more influential groups within the team were the French writers.[9]

> "…they didn't want to lose any of their topics and…although they agreed with us about how the instruction should happen, they were really hard. It was really hard to give up topics and we had many fights over calculus…but they held a lot of sway. They were way, way smaller. Their team was way, way smaller, but they had a big influence because the Ministry wanted to present this as a joint effort." (A, p.7)

After the 1999/2000 document was released, the Ministry of Education held focus groups and "they talked to real teachers who were reluctant to make changes" (A, p. 10) and "…when the

[9] For the 1999/2000 curriculum the English and French mathematics curriculum documents were written and reviewed by separate teams

EQAO results were so dismal, they said we've got to revise this [curriculum] especially [Grade] nine Applied.] And so when they revised, I think they only intended to revise [Grades] 9 and 10, but once you start revising that, then they revised all of it…" (A, p.9). In 2005/2007 the revised curriculum documents came into effect and at the Grade 12 level, Participant A recalled losing geometry as a major topic. When Participant A reflected on the revision process and its implementation, she felt that "…we weren't very successful, I don't think implementing [grades] 11 and 12, but more successful with [grades] 9 and 10." (A, p.9)

Thoughts on Changes to Curriculum

Participant A believed that before the 1999/2000 curriculum document was created, the existing 1985 curriculum created problems for students who struggled with mathematics as it "…just wasn't working for them [students who struggled]… it was really good for good math students and not so good for kids who struggled a little bit" (A, p.5). One of the major changes that the writing team did for the 1999/2000 document was the inclusion of the mathematical processes throughout the document. The team "worked really hard on the processes because that's what it [the mathematical process] should look like" (A, p.18) and they wanted to make sure the specific expectations "had the verbs in it, that it, it showed what kids would be doing" (A, p. 18).

Participant A found that teachers did not understand the vision, aims and goals of the 1999/2000 curriculum and thought that "professional development is key to the implementation of curriculum" (A, p.26). Reflecting on her experience, Participant A stated "we implemented the new curriculum with very little training. We didn't help teachers to understand…" (A, p.25). One of the ways they tried to improve the implementation was through the creation of the TIPS documents to go along with each course. Participant A was involved with the creation of these documents. While Participant A was happy with how the Targeted Implementation and Planning Supports (TIPS documents) were being utilized by teachers, she regretted that some teachers were using them "…as their course of study…" (A, p.14) when the TIPS documents were "…always meant to be a resource…" (A, p.14).

Looking ahead to future curriculum review, development and implementation processes, Participant A advised new writing teams to "look at the whole curriculum K to 12…and look at what's really important. And then I'm top down" (A, p.21). She believed that since Ontario has a destination-based curriculum, it is most important to consider the Grade 12 courses and what students will need to be successful and work backwards from there. While our current curriculum is structured in a way that Calculus is considered by many educators, students and parents to be *the* premier secondary school mathematics course, participant A believes that "the biggest group of kids need data" (A, p.22). Even though over time there has been a notable decrease in the number of content topics listed in the curriculum, Participant A does not believe that "…there's a decrease in the rigor" (A, p.23) and that it is up to the teacher to make the course rigorous "by teaching differently…you have to use problem solving" (A, p.24). Participant A strongly feels that if the curriculum were to be revised again, the Ministry of Education "can't just send it out there. They have to train teachers how to implement…we need to have a mechanism where you have professional development on the new curriculum" (A, p.25). Participant A emphasized the importance of implementation as a key phase in the curriculum development process and that it must be a priority.

Summary

Participant A described a rushed process with pressure to get the final document completed quickly. The process for the 1999/2000 document did not look at the full scope and sequencing of the JK-12 curriculum, but rather focused only on Grades 9-12. Participant A explained how once the curriculum was complete it was released to be used in the classroom without an implementation plan. Finally, Participant A had an opportunity to influence and direct curriculum based on her own experiences and curriculum materials.

Participant B

Background and Experiences with Curriculum Change

Participant B is a retired mathematics teacher, department head, and consultant who began teaching in the mid-1970s. Participant B became active in curriculum planning early and participated in various capacities in a range of mathematics curriculum projects.

Reflections on Experiences

Participant B's first involvement was in the revised Grade 9-10 Curriculum in the late 1970s. This was a time when four-function calculators were becoming more common and scientific calculators were just becoming available. Socratic teaching[10] was still the technique primarily in use, but early resources involving discovery-based learning were appearing. The revised curriculum called for the use of calculators where appropriate. This was not a universally supported idea, perhaps understandably, since many teachers still valued hand calculation and the existing curriculum contained topics like the formal method of square root. The new curriculum also introduced transformation geometry as a contrast to the deductive Euclidean approach. This topic was particularly controversial, being that it called for a major shift in the

[10] Socratic teaching refers to traditional teaching methods that involved the teacher lecturing to the class. There is little student engagement during the lesson.

thinking about high school geometry. As well, illuminative examples were not provided within the curriculum.

The next major curriculum development came with the 1985 Guidelines: a revision to course types and content. There was a lot of work to be done by boards and teachers in this curriculum release and Participant B led board-level writing teams to develop courses of study. Each of Grades 9–12 had three streams–Basic, General, and Advanced. That meant the writing of 12 courses of study covering those grades. n addition, the three Grade 13 Courses of Relations and Functions, Calculus, and Algebra became the three OAC courses of Finite Mathematics, Calculus, and Algebra. The Finite Mathematics course was accessible from Grade 11 Advanced, while the other two courses required Grade 12 Advanced. The thinking was that students not headed to a Math/Science/Engineering future would benefit from a course involving some probability and statistics, for which the extra preparation in functions and relations would not be necessary. So, those students could go from Grade 11 to the OAC Finite Mathematics. This thinking was related to a possible future of Grade 12 being the final year of high school in Ontario.

The 1985 curriculum document itself was a departure, in that it included a lengthy section at the beginning that focused on various aspects of experiential learning. It gave an exciting vision of what mathematics teaching might become but was not recognizable to the majority of teachers who were still teaching in a Socratic mode. No examples were provided. Interestingly, ten years later, when graphing calculators became available, it all began to make some sense. Early adopters of graphing calculators recognized the connection to the 1985 curriculum and began to soar.

The 1990s were an incubator for new ideas in the teaching of mathematics. New technologies began to appear in mathematics classrooms. Graphing calculators, computer graphing programs, and spreadsheets became more and more accessible and leading edge thinkers began to develop resources. It was by no means common, but the direction had been established and computer applications were showing up frequently in mathematics education workshops and conferences. The Fields Institute began a mathematics education group, composed of mathematics teachers from all levels (elementary, secondary and post-secondary). Their regular meetings explored new directions for mathematics education, with participants sharing some of the ideas that they were trying in their own classrooms. OAME and OMCA were prominent in the membership of this group.

Towards the end of the decade, a major revision of all secondary school curriculum was announced by the Ministry of Education, in which the secondary school experience would become four years in length, instead of five. The writing of the new curriculum was to be done through a Request for Proposal process, in which qualified groups would make proposals. OAME, OMCA, and the Fields Institute combined to create such a proposal, and were successful in their bid. The writing began in 1998 and continued through 2000. Participant B was part of the writing team.

The writing team was faced with significant challenges, but also some great opportunities. One challenge involved Calculus…it was expected that a student would be able to complete a Calculus course within four years, instead of five. But there was an equally serious opportunity…to write a curriculum whose vision was of students constructing their own learning through modelling and experimentation, aided by the use of technologies. But with this opportunity came another significant challenge. As the writing began, growing numbers of teachers were embracing experiential learning, but there was still a broad spectrum of attitude. The challenge, according to Participant B, was to open the door for those who were ready to go through it, while making it possible for all teachers to function within the curriculum. The writing team had to find a middle point that would allow those who were ready to really create, while at the same time, not lose the people who were not yet ready.

Despite all the hard work and challenges, Participant B had many positive experiences and two things stood out…the willingness and determination of OAME, OMCA, and the Field's Institute to come together to make this happen, and the teachers who participated over time and kept sharing their commitment and expertise.

What advice would Participant B give to someone creating a new curriculum in the future?

- Start with a vision of where the students are going and what they will need in the future. You need an image of what a student must have at the end of high school in order to be successful after high school.
- Get as broadly balanced a team as you can, people at varying stages of where you want everyone to be eventually. Recognize that people do move at different speeds and have different points of view…and that firmly held opinions are frequently sincerely held opinions. Respect must be at the base of it all.
- And, from my wish list…Let there be a future in which a curriculum is written, resources developed, and field testing done…all of this *before* the curriculum is released to the entire province.

Summary

Participant B described the changes to the Ontario curriculum over their teaching career. They explained how the curricula were designed to move teachers over time from a Socratic method of teaching to a more experiential method. Participant B described how technology played a role in facilitating the ability to make these changes. Finally, they explained the importance of having a strong vision, having a balanced writing team and having proper implementation.

Participant C

Background

Participant C is a retired Associate Professor of Mathematics Education from a research-intensive Faculty of Education in southeastern Ontario. He started his career teaching mathematics, chemistry and computer science at the secondary level in Northern Ontario. He was also the Head of the Mathematics Department in addition to his classroom teaching role. Due to his involvement and heavy use with computers for teaching mathematics he moved into a leadership position with his school board to provide in-service professional development to teachers across the district. Subsequent to the brief time spent in this role, Participant C became an Education Officer with the Ministry of Education where his portfolio covered JK to OAC mathematics, computer applications across the curriculum and computer studies. After a few years as an Education Officer, Participant C became a tenure-track professor with teaching responsibilities in the BEd, MEd and PhD programs. He spent 22 years in this role before retiring.

Participant C was involved both locally and provincially with the OAME, OMCA and The Field's Institute Mathematics Education Form during his career. He remains actively involved with the OAME and assisted with the organization of a recent annual OAME provincial conference.

Experiences with Curriculum Change

Participant C was able to be involved with curriculum changes in different roles and subjects due to his background. Participant C was involved in the implementation of the HS1 program (1979-1981) which was the provincial program that was looking at changing the whole high school program and removing the 13th year and introducing the OAC courses. Participant C was directly involved in the implementation of the 1985 mathematics curriculum in his role as Head of the Mathematics Department, board-wide mathematics consultant and later as an Education Officer. Participant C was the Chair of the provincial committee that rewrote the secondary Computer Science program in the late 1980s. When the provincial government was starting to look at revising the curriculum during the 1990s, Participant C was awarded a contract to write the research-based background paper about the [then] current state of mathematics education in Ontario and propose empirically-grounded recommendations for content- and pedagogical considerations as a first step in directing and framing the curriculum development process. Due to provincial policy at the time, Participant C was not allowed to further directly participate in the development because the government did not want the same individuals or stakeholder groups dominating or directing the entire process. After the release of the new 1999/2000 mathematics curriculum, Participant C organized and led workshops to help implement it across the province through the OAME.

Reflections on Experiences

Throughout Participant C's career, he witnessed many different curriculum change processes and was able to see how the revision process itself changed over time. Prior to 1999, the Ministry of Education had written curriculum documents in-house. When creating the curriculum writing committees, he said that "…the idea is to have it as broad as possible" (C, p.4). To be as broad as possible he said that it is important to consider race, gender, people from rural areas, people from urban areas and French speaking individuals in order to have a more diverse and provincially representative committee. Reflecting on this process he stated that "… there's a lot of politics involved in this. Largely not to offend anybody or give anybody grounds for a legitimate complaint" (C, p.5).

Participant C found that the 1985 curriculum document was the start of some real change, particularly due to the front matter of that document.

> "Those first 20 pages it said, you know, it'd be good to use calculators. Computers are coming along, maybe you should look at those. Mathematical modelling should be a theme, experiential education … it's [front matter] 25 pages and then the rest of the curriculum looks like the old one, lists of topics like the old one, just some of the topics shuffled from place to place. So if you were not interested in change, you could just plow along. But if you were interested in change, you sort of had an invitation to try some things from those first few pages and a significant number of teachers did" (C, p.13)

Participant C found that the 1985 curriculum allowed a significant mass of teachers to try new things and that there was "…a lot of experimentation from '85 to mid '90s, which then continued to grow for the 1999 curriculum" (C, p.15). A critical majority of the teachers that were experimenting with technology, inquiry-learning and alternate strategies (e.g., collaborative group work) were members of OAME, OMCA and The Fields Education Forum—groups that would eventually take the lead on rewriting the 1999 curriculum. At the start of the curriculum writing process, the Ministry of Education accepted proposals for the contract to write the curriculum from any group that was willing to create one. Participant C reflected that "…some on the more progressive left side of politics imagined corporations, you know IBM, deciding

‘Okay, we’re going to make a proposal that’s all highly computerized or something’. I mean the fact that they think that there’s going to be a lot of effort and there's no money you know. And so they didn't [make a proposal]” (C, p.7). Participant C thought that the Ministry of Education was expecting several different proposals from different groups, but ultimately these groups decided not to go ahead with their application due to the perceived lack of funding.

As Participant C wrote the Background Paper on mathematics education in Ontario prior to the new 1999/2000 curriculum being written, he was excluded from being on the committee that wrote it as the Conservative government of the day said the new curriculum would be created “… by teachers for teachers. We [government] weren’t going to let these elite people [be involved]” (C, p.7). So while the government was looking for a more broad-based committee to write the curriculum after the background paper and proposal process “… the only people left, the only people that could organize the committee were the people running the show for years” (C, p.8). This resulted in a 1999/2000 curriculum document that “… in many ways reflected what the OAME was writing and individuals in the OAME had been writing for a while through the decade of the 1990s …” (C, p.10).

Even though Participant C was excluded from the writing committee for 1999/2000, he was still able to provide feedback on the draft copies. Participant C felt that the majority of feedback the writing team received was largely reinforcing. He further noted that many of the people who gave feedback “…were of the same orientation as the people writing it, so I don’t know that they got a lot of feedback that was well argued in opposition.” (C, p.8). Participant C reflected that there appeared to be a rush at the time for the government to get through the feedback process.

The revision process that led to the revised curriculum in 2005/2007 was partly due to feedback from individuals who had not paid attention to what was going on. While some people had provided feedback to the 1999/2000 document when it was being created, Participant C noted that certain groups had not fully paid attention to what was being done in that [then] new document and the revision process was in response to complaints from these special interest groups. One of the major groups calling for the revisions were Faculties of Engineering and Applied Science in Ontario universities.

> "I was on the team… looking at it in 2005 and they let other people come back who had been involved. And so I was in on a number of large, you know, three, four day meetings looking at ways we could massage the curriculum and try to balance these various things and it was, I mean the pressure was seen to be more mainly from science and engineering rather than math, you know pure math people, and because mainly they wanted calculus. They want to be able to use calculus as a tool in their first year physics courses for sure, engineering courses without doing a lot of preparation and you know, they didn't have a great love for calculus. It's just that the kids need to know how to differentiate…it is a tool." (C, p.18)

Thoughts on Changes to Curriculum

One of the things that has really stood out to Participant C as he has witnessed and/or lived through several curriculum change processes was that there is a lot of self-interest and personal history involved in the writing process. He further added that many of the people who were part of the committee had motives for keeping certain topics based on self-interest. When describing many teacher's mindsets on particular topics, he said "it's you know 'I'm really comfortable … I've done a really good job and I got a really good unit on this and I like it. So yeah, it's got to stay in the curriculum" (C, p.6). Participant C noted that over time "…we've gone through waves of moving forward and when we, when the curriculum has had the biggest moves forward, it's been when teachers say, I'm okay, I'm not great" (C, p.12).

Participant C noted that in the most recent curriculum revisions the number of topics has been decreasing including "…discrete mathematics being diminished in importance" (C, p.16). While Participant C found nothing wrong with making changes, he did take issue with some of the changes particularly in regard to calculus becoming the terminal Grade 12 mathematics course.

> "It's when you suddenly demand that everybody take the elite calculus, demand everybody take it personally, you have to no longer elite it, so you have to get it watered down. And then a lot of students end up struggling with something that's pointless for them already. So, to me it's an exercise in a waste of time." (C, p.16)

Participant C also had some thoughts on what he would like to see included in future documents. Overall he would "…like the math curriculum to embody to some extent that we don't know everything. It's a big puzzle. It's neat to play with" (C, p.20). He also stated that he "…would like to see as an overriding theme, more on, on the ideas of modelling, including an emphasis on the students building the models…" (C, p.24). Non-guideline courses were something that Participant C saw being used successfully when he worked for the Ministry of Education but no longer exist in the current document. Building on this idea, Participant C would want the Ministry of Education to "…get off the accountability bandwagon thing and give teachers more freedom" (C, p.22).

Participant C had some advice for any future curriculum revision teams. When building a team to create this new curriculum he had two suggestions. The first was to find "…some people with the same philosophical orientation …" (C, p.26) and the second was to have "…teachers who have committed a lot of effort to leading workshops, stuff like that at the board level, school level, really obviously thinkers and hard workers…" (C, p.26). Once a team was built Participant C believes that building a philosophical base as vital.

> "…try and get a philosophical base that you want to build from them and you're comfortable with. Articulate that philosophical base well and then build a curriculum from that and then stick to your guns. Like really be willing to fight it out…" (C, p.18)

Summary

Participant C described a revision process that was influenced by politics and personal opinions. Participant C explained how the 1985 document was the start of teachers trying new things experimenting in their classrooms. He also stated how many of these same individuals were part of the OAME or OMCA which would the lead the writing process of the 1999/2000 curriculum. These two groups had a big influence on the direction of mathematics education in Ontario. Participant C believes that building a strong philosophical foundation is extremely important to begin any future curriculum revision process.

Participant D

Background

Participant D is currently a Professor and Undergraduate Chair at a research-intensive university in southeastern Ontario. He has been a member of the Mathematics Department for the past 50 years and is cross appointed to both the Faculty of Education and The Department of Biology His role at Queen's University includes research in mathematical biology as well as teaching pure mathematics courses at the undergraduate and graduate level. A large part of his current research interest is in the area of mathematics education at the high school level, and he is in the process of developing his own mathematics curriculum for Ontario high schools. He describes this interest and his process on his website

> "…dating back to 1975, I have a strong interest and commitment to mathematics education, particularly developing good activities for the curriculum at the high school and university level. In recent years I have found my time almost exclusively dedicated to this objective, partly because there are many young guys around who can do a much better job at hard science, and partly because the need for a stronger math curriculum seems larger than ever and that's a project requiring experience and wisdom. I can hope that I have acquired some of that.
>
> I should say a bit more about high school math. In the midst of millions of words of confusing rhetoric on what's wrong with math education, my own view is that the problem is with the structure of the curriculum—that this has led to a network of topics and tasks that are of little consequence and totally lack sophistication (my current favorite word for what is lacking). In short, the material we currently work with is not math but is a pale technical shadow of real mathematical activity. And our students (all of them) and our teachers deserve better. My curriculum redesign project Math9-12 seeks to build sophisticated units to replace as many of the standard high school curriculum strands as possible."

Participant D has worked with and been a member of various organizations over his career (including OAME and CMESG), often in a role that involved examining curriculum and teaching. He spent two different 4-year terms as Chair of the Education Committee for the Canadian Mathematics Society (1983-1987 and 2012-2016). He was also Chair of the ***Senate's Academic Plan Task Force*** **,** an 18-month campus-wide collaborative process that developed the university's first Academic Plan that was based on four "Pillars:" fundamental academic skills; a balance between specialized and interdisciplinary knowledge; global awareness and inclusion; and, community health and wellness[11].

Participant D has also been the external examiner for a diverse range of graduate examining committees, for theses and dissertations in subjects from music to drama to mathematics, at many Canadian and international universities. He is currently a member of the Fields Mathematics Education Forum at The Fields Institute for Research in the Mathematical Sciences, and it was through this longstanding role that he first became involved with creating curriculum policy documents for Ontario mathematics.

Experiences with Curriculum Change

Participant D's first experience with secondary mathematics curriculum reform in Ontario was as a member of the writing team that was central to the 1999/2000 mathematics curriculum writing process. Following that he was an author with a major educational publisher, developing textbooks in Calculus, Discrete Mathematics and Geometry for secondary mathematics. Due to eventual changes in the Ontario curriculum, his Geometry textbook was discontinued because the Geometry and Discrete Mathematics course for which it was developed disappeared from the curriculum.

[11] https://www.queensu.ca/strategicplanning/academic

As a member of the 1999/2000 curriculum writing team, Participant D was in the sub-committee that created the Grade 11 and 12 courses. While participant D's focus was on content centred around geometry and discrete mathematics, he also contributed to the advanced functions strand of the senior secondary curriculum. Participant D was also involved with the revision of the mathematics curriculum that was introduced in 2005/2007.

A major focus of Participant D's research has been dedicated to the development his own mathematics curriculum for high school students in Ontario. In 1998, he developed and taught a Grade 12 course based around a modelling approach which embodied a dramatically different style of problem-posing and instructional strategies than typical classroom practice at the time. That experience has allowed Participant D over the years to develop his own curriculum based on the technical progression of the Ontario mathematics curriculum but using a unique approach that is centred around mathematical structures and problem solving and continues today. He is currently in the testing phase of his new curriculum, *RabbitMath.*

Reflections on Experiences

Reflecting on his experience writing the 1999/2000 mathematics curriculum, Participant D described the process as assembling "… a diverse community of experts into a room and you get them to talk and think for two or three months and come up with a new curriculum" (D,p.2). He credits his involvement in the curriculum writing committee to him being "…sort of vocal and talked to colleagues and so forth about all these things [mathematics curriculum issues] … so I was there [Fields Institute] at the time and we had to make a committee and I was part of it" (D, p.5).

One of the experiences that stood out to him within the process of creating the 1999/2000 documents was that he found that it lacked an overall vision of what it really means to teach mathematics.

> "I found the whole process lacked a vision as to kind of where we were going and what we really needed our kids to be able to do. And I think the whole education thing has lacked that vision and it's starting to come now, you're getting people, you're getting new kinds of writing about what our kids need and these little 21st century slogans and stuff. I mean, I think the makings of a new vision are there, but there wasn't really one." (D, p.6).

Participant D recalled some frustration at the time with trying to get the writing team thinking in a broader sense about what it really means to teach mathematics. "I remember at the Fields in 1999/2000, I remember trying to get the group thinking more in that way. And it just, I sometimes had the feeling nobody really understood" (C, p.6). Another frustration came from the Ministry of Educations expectations of what the new curriculum could include. "It was a bit of a frustrating process in that many of the things we wanted to, the Ministry [of Education] wouldn't let us do" (D, p.2). Participant D furthered explained some of the stipulations from the Ministry of Education and the effect it had.

> "So essentially what the Ministry wanted to do was pack five years worth of math into four years. And that's what we did." (D, p.3)

Participant D reflected that this strong push by the Ministry to have Calculus in such a central role was in direct response to external pressures, and in particularl from post-secondary engineering programs.

After the release of the 1999/2000 mathematics curriculum document, Participant D recalled that "…there was lots of negative feedback from the [teaching] community about the curriculum that came out in 2000" (D, p.4). Participant D was a part of the revision process for the 2005/2007 documents and reflected on the group that fixed these problems as being a smaller more focused group as compared to the earlier process. This process led to the geometry and discrete course disappearing and it was also when "…'Calculus' became 'Calculus and Vectors'" (D, p.4).

Thoughts on Changes to Curriculum

Participant D did not believe that elevating the 'Calculus and Vectors' course to its status as the "premier" course in the Ontario mathematics curriculum was in the best interest of students.

> "Everything really, even starting in Grade 10, but certainly in Grade 11 and with the Grade 12 Advanced Functions, everything was pointing to calculus. Which more and more is not the way you want math to be going anyway because we have machines and programs [that] are doing all that stuff. You know, those aren't the skills people need, those aren't the skill students need" (D, p.3).

Further reflecting on his experience as a university professor and students taking calculus in university, he commented that there are "…almost 2000 kids taking first year calculus here. Almost none of them will ever use calculus again in their lives. Why on earth are we teaching them that? Some need it yeah, but not 2000" (D, p.12).

Participant D believes that the current mathematics curriculum in Ontario is both narrow and technical and that the curriculum "…doesn't really work for any of our students" (D, p.13).

He thinks a lot of the flaws in our current system come from the fact that the big question of 'What does it means to teach math?' has not been properly explored.

> "What does it mean to teach math? Which you know, that's the big question…and there are different ways to sort of handle it and think about it, but in many ways that creates, that's responsible for a lot of the flaws in our system. Just not coming to grips with what do we actually want to do here." (D, p.7)

Participant D has started building his own mathematics curriculum based on his answer to what it means to teach mathematics. His curriculum is based on "…the abstract study of structure…beautiful, powerful structures" (D, p.14) and he thinks that "…all kids need to study the analysis of structures, how to take a structure apart, how to see different components interact, how to come to understand how it works" (D, p.15). He also stated that "I think we have to give kids what they need to actually really function creatively in the world" (D, p.19). Participant D is developing problems based on the current technical progression of the Ontario curriculum but they do not currently appear in any Ministry document.

> "The Ministry is not supposed to write the novels that the kids study in English, they're not supposed to give you the problems that the kids study in math, but the teachers accept the Ministry examples as the material to work with. But that's not what they're supposed to do. There are supposed to work with what I would call mathematical novels in order to do that … and who's going to write these novels? Well in English its people who, it's artists who used language and in mathematics it should be the artist who use mathematics or the mathematicians." (D, p.8).

From the *RabbitMath* curriculum Grade 11 outline and guide it states that it aims for "…a curriculum structure that will allow and even encourage students with different interests and abilities to work together on projects that they can all finds, perhaps in different ways, meaningful. The purpose of the *RabbitMath* project is to provide a model for such a curriculum." Some of the main features of *RabbitMath* are a focus on hands-on student engagement, university preparation and an emphasis on collaboration and communication, mathematical modelling and use of technology. A sample from the curriculum is presented in Figure 7 below.

If possible get hold of an old tire. Pump your tire up to P=400 kPa, drill a small hole, and monitor the pressure as it goes down. Predict what you think the graph of P against time t should look like. Discuss what mathematical form it should have.

The idea we develop is that the rate at which molecules escape from the tire is proportional to the number in the tire. We can verify this by measuring the pressure at regular intervals and checking whether the change over the interval is proportional to the pressure at the start of the interval. This will allow us to conclude that the graph of P against time t is exponential.

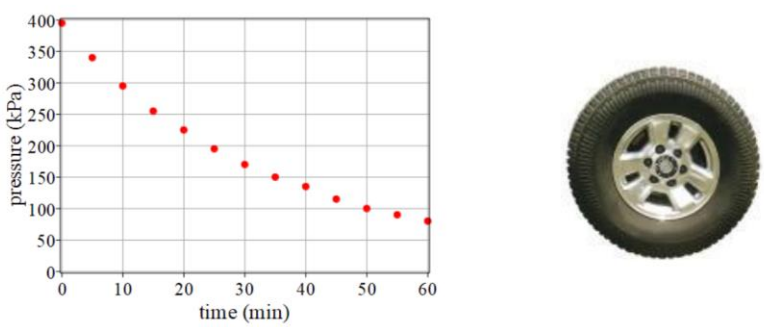


Figure 7: Sample problem from Grade 11 RabbitMath project

Participant D's curriculum is also "…much more oriented towards the future in that we are using technology in a new kind of way, you know, more hands-on way of using it" (D, p.12). Participant D feels that his main contribution to the future of mathematics curriculum in Ontario is his development of this curriculum specifically "…a different curriculum structure than the one that we had before …" (D, p.12).

Over Participant D's 50 year career as a Professor of university-level mathematics and frequent instructor in secondary school classrooms, he believes that there has been a significant decrease in the number sense skills of students.

> "So kids cannot handle numbers. They use their calculators. They use it in an absurd way. They put in absurd, just the numbers from the questions into the calculators, they should be doing it in their heads. They can't really handle percentages or fractions. So that's been a huge change there" (D, p.18).

Participant D does not agree that all students should have to continue taking mathematics as it currently exists in high school.

> "I think a lot of kids should stop taking math, there are kids that don't enjoy it and then find it frustrating. I mean, why are they doing it? I don't see any reason. There's this idea that they're going to ruin their future career if they don't know math, it's a load of [expletive]" (D, p.14)

When giving advice for future curriculum writing committees, Participant D thinks that it should not been done using the same writing method that they used to create the 1999/2000 and the 2005/2007 documents. He feels that the method of large groups sitting down and coming up with a new curriculum is outdated and that new curriculum should be built after testing different curriculum models.

> "You need enough experience of different models … the curriculum committee comes in with one model. It's the old model. It's very hard to move beyond that unless you go out and try new models. So that's what's happening now. Thank goodness" (D, p.17).

Summary

Participant D recalled a curriculum revision process that caused some frustrations. He felt the vision for the 1999/2000 curriculum document was not broad enough and did not get to the heart of what it means to teach mathematics. He also described how guidelines laid out by the Ministry prevented them from doing some ideas they wanted to do and lost topics such as Geometry. Participant D furthered explained his own thoughts on the importance of the right types of problems for mathematics classes and how he is developing his own curriculum to support this.

Cross-Case Analysis

In this section a summary of the main findings from the interview process will be presented. "Cross-case analysis is a research method that facilitates the comparison of commonalities and difference in the events, activities, and processes" (Khan & VanWynsberghe, 2008). There are three main themes that emerged from the interview data. Each of the four participants (Participant A, Participant B, Participant C and Participant D) had an opportunity to describe their experience with mathematics education, their involvement with the curriculum revision process and their thoughts on both their experience and the outcomes of the curriculum revisions process. The previous sections included in-depth profiles of each participant.

The overall finding was that within the curriculum revision process, each participant was given the opportunity to provide significant input and direction to Ontario mathematics and yet they all felt that the process was hindered in one way or another by differing opinions, self-interest or timelines. Despite differing backgrounds and jobs all participants were involved at some stage in the creation of the 1999/2000 mathematics curriculum, and all but Participant B were involved in the 2005/2007 revision. As a result of the participants' experiences, all responses were specific to the creation of the 1999/2000 or 2005/2007 curriculum writing process. It is of interest to note that this is the first time in Ontario mathematics education that a curriculum had been written as a collaboration among different organizations. As Participant C pointed out that "up until the development of the 1999 [curriculum], the Ministry of Education wrote [the curriculum], a committee wrote the curriculum in house with outside people coming in" (C, p.6).

In the following sections, I summarize the highlights of each theme. The three main themes are: (a) Curriculum Revision Process (b) Curriculum Priorities and Focus and (c) External Factors. Theme 1, Curriculum Revision Process will highlight the key stages of developing a new curriculum from the initial background paper to implementation. Theme 2, Curriculum Priorities and Focus gives insights on the reasons behind the changes to the curriculum. This section will specifically look at the philosophy and vision of the curriculum, conceptual influences on the curriculum, reasons for revisions and why certain topics were removed. Finally, theme 3, External Factors will discuss the political nature of developing a new curriculum while giving insights into timelines and government expectations.

Theme 1: Curriculum Revision Process

The creation of the 1999/2000 and 2005/2007 curriculum was a collaborative effort among three main organizations; OAME, OMCA and the Field's Institute Education Forum. The 1999/2000 curriculum development was the result of a substantial collaboration that included committee members from across the province. The 2005/2007 curriculum was a revision of the 1999/2000 document and the team that worked on it was only a "focused small group fixing the problems" (D, p.4). All participants (A, B, C and D) were active members of at least one of these organizations at the time the 1999/2000 curriculum was written. Three of the four participants (A, B and D) were directly involved with the main writing process in 1999/2000. Participant C, having written the background paper for the 1999/2000 curriculum, was "…barred from being on the committee because [he] had been in the previous stage" (C, p.9). Despite this he said that if "…he had been on the committee we would have written something pretty similar" (C, p.9). Participant C shared that the writing of a new curriculum was "…a multi-step process and the first one is going to be a series of background papers, one in each curriculum area to create a sort of overview" (C, p.2). Once this overview had been created by Participant C, the Ministry of Education moved onto the next phase.

Creating a Proposal

After the background paper had been written, the Ministry of Education sent out a Request for Proposal (RFP). Participant B described the process;

> "The way the government managed the writing of the 1999/2000 curriculum was to ask for qualified groups to make proposals and then they chose the one they liked. It was a contract, it was separate and it wasn't written by the Ministry. It was written by this group that was approved and hired." (B, p.9)

Participant B remarked on the initial confusion behind the term "qualified group" and what it could mean for mathematics education in Ontario;

> "…anyone could, any qualified group, whatever that meant, could make a proposal. And so, you know, there's this big discussion in mathematics education groups. Well, we could have an American group make a proposal and write it. Like who is going to do this?" (B, p.12)

Participant C recalled that the Ministry of Education at the time was unsure of exactly what type of proposals they would be receiving and from whom. He remarked that some within the government may had been hoping for corporations to submit proposals.

> "The Ministry didn't know what they were going to get other than what they got. They got a proposal, which had a rough outline, but they didn't really know what they were going to get… (C, p.7)

Partly due to this uncertainty of an external group taking direction and lead of the Ontario mathematics curriculum and due to some previous work on new directions in mathematics, a group of Ontario mathematics educators collaborated to create and submit a proposal.

> "And so, we thought teachers know about students and what's working and what's not working. Through the OAME and the assistance of the OMCA, a lot of work had been done around new directions of mathematics education. We had the image. We had people like Person E and Person B who were ready to lead in new directions and so we thought we have to make a proposal. And so, a small group of us got together and it wasn't just OAME/OMCA, we had people from colleges and universities with us and we sat down and decided how we wanted to do it. And we wrote up a proposal. The Fields Institute was with us at that point, they were housing us, sponsoring us. They were the financial sponsor for our bid and under their umbrella we put the proposal together and submitted it, [and] got the contract." (B, p.12)

This is how the OAME, OMCA and Field's Institute came together to lead the creation of the 1999/2000 Ontario secondary mathematics curriculum.

OAME/OMCA/Field's Institute Collaboration

The OAME wanted to take the lead on writing the new curriculum but were unable to make this a reality by themselves. Collaborating with the OMCA and the Field's Institute allowed them ultimately to be successful in receiving the contract to write the 1999/2000. Participant C said;

> "…[in] so many ways the committee was a product of OAME but unofficially, because just mounting such a thing, just knowing how to write a proposal, how to get people the people together, all that stuff was something that you need to have some history…[the] OAME who made the proposal…they did it through the Field's Institute " (C, p.7).

Participant A further elaborated on how the OAME lacked the funds needed to support the number of people they had on the committee and how the Field's Institute was the financial backer;

> "We had 72 people on our committee and OAME did not have the financial structure for the Ministry to pay for the writing because you have to get all these people together and you have to pay some of them travel, some of them stay overnight, you have to pay meals, all that sort of stuff. And so, we joined up with the Fields Math Education Forum…they agreed to be our partners and so we wrote at Fields and they paid. We didn't, I don't think, I didn't get paid. I don't believe I got paid, but all my expenses were covered." (A, p.6)

Participant B was part of the curriculum writing committee and said that the committee did all of their work and hosted all of their meetings at the Field's Institute, "I [was part of] that [curriculum writing] and we were working out of the Field's Institute" (B, p.9). Participant D corroborated this while describing the actual writing process;

> "…in 1998 and 1999 the work was done at Field's. Um, and that was the old style in my view of how to make, how to change curriculum, which is to get a diverse community of experts into a room and you get them to talk and think for two or three months to come up with a new curriculum" (D, p.2)

Participant D explained in more detail how the writing of the curriculum happened,

> "We cut the curriculum up into pieces fairly soon. We had a great 9/10 group and a Grade 11/12 group. I was part of the Grade 11/12 group and we did special tasks that we worked on" (D, p.4)

Participant A was also on the Grade 11/12 team and she described her role within the team,

> "I was on the 11/12 team. And so Person J was the head, the head writer and I ended up, um, mostly on the 12 team. And so I got into great discussions of calculus, data management, all of those sorts of things and the kinds of topics that we would choose to be as part of our curriculum and those kinds of discussions." (A, p.7)

Once the draft curriculum was finished it was distributed for feedback. Participant C described this process and how quick it was.

> "[the committee] have pdf versions and [were] setting up websites so people could go and give feedback. You had forms that you filled in to give feedback… very open, except that in many cases you get this 100 page document [that] was put up on the web [or] an email was sent out through various channels and you had to give feedback in a week's time because the government was in a big hurry. And so only committed people were involved." (C, p.8)

Implementation of Curriculum

After the feedback had been received and the final edit of the 1999/2000 curriculum was complete it was released directly to the public. There was no field testing of the curriculum so the first time the curriculum was used in a classroom it was being taught all across the province. Participant A explained how this was not always the case when developing new curriculum and what happened when they field tested the curriculum in 1985,

> "…so they [the writing committee] knew what was working, what kids were getting at, what was it [like]? There was no field testing anymore [in 1999]. It was like bam." (A, p.8)

Participant B was happy with release of the curriculum and the initial implementation in the years that followed,

"I think we accomplished the goal of getting it [mathematics education] moving and the implementation opportunities that followed for about eight or nine years were very significant and I believe successful with some teachers" (B, p. 16)

Participant C said "…when the guidelines came out, we were able to have workshops…" (C, p. 13) and Participant A "…spent a whole summer going all over the province during that [time]. [She did] lots of workshops on implementation for many years" (A, p.1). Participant A also "…did lots of presentations to our [department] heads group letting them know what was coming down the pipe, what was new, what we should be focusing on…"(A, p. 1) as well as going "…all across the province to all the different sections to promote TIPS" (A, p.13).

Participant A was one of the creators of the TIPS documents and she recalled that it was a direct response to the fact that "we knew that people didn't understand the implementation [of the new curriculum]" (A, p.13). Having participated heavily in the implementation phase of the

1999/2000 curriculum, Participant A did not feel that it was successful overall and had suggestions for future curriculum revisions.

> "…we tried to train the trainers, right. We tried them all and the train the trainer model didn't work as well [as other models]. So I don't know how you'd get it [new curriculum] into the classroom grassroots. I know it has to happen with mentors in the classroom, helping teachers do it, not sitting at a workshop and saying this would be wonderful if you could do this because they're all, they get all pumped up, then they go home and they face their class and they don't have to do it and they don't take the time to prepare how to do it because it take a lot of prep and to me its pays off and it's worth it…let's suppose they're going to revise the curriculum one more time. They can't just send it out there. They have to train teachers how to implement. We implemented the new curriculum with very little training. We didn't help teachers understand and we didn't give them ways [to understand]" (A, p.26).

Theme 2: Curriculum Priorities and Focus

All four participants' involvement with the writing of the 1999/2000 and/or the 2005/2007 curriculums puts them in a unique position to explain both the priorities and the focus of the writing team. The priorities and focus of the team can shed light on the decision-making process that led to the changes in the curriculum and curriculum documents. This theme will explore the philosophies, vision and goals for the new curriculum, the reasoning behind these vision and goals, and the topics that were removed from the curriculum.

Philosophy and Vision for a New Curriculum

All four participants agreed that there is a strong need to have a clearly articulated vision and philosophical base when creating a new curriculum. It is interesting to note then that the participants had differing opinions of what the vision was for the 1999/2000 curriculum. Participant B said;

> "The vision [of the 1999/2000 curriculum] was students constructing their own learning. That's what is was. The assumption being that through that process they would better understand mathematics" (B, p.4)

Participant B explained further that she believed the "…goal [of the 1999/2000 curriculum was] opening doors and making it possible for people[teachers] to do [new] things" (B, p.16). Participant A recalls the 1999/2000 curriculum having a different purpose;

> "…the purpose of the new curriculum was to get, was to reach all of the students and a belief that all the kids could learn some stuff. Not all the students I taught were capable of doing a really good job in calculus that's, that's not even fair to say, but all kids could learn some math at whatever level you are teaching" (A, p.5).

Participant A did make note that one of the reasons she wanted to participate in the writing process was because she "…has a strong passion for the subject and I have a vision about what we should be doing" (A, p.12). Participant A's vision for the curriculum appears to be based more on a personal vision rather than the vision of the committee. Participant C did note that this was common as he described that "some people's vision about what the future is going to be…it's more like I've been doing this for years or the school system has been doing it for years. We should keep doing it" (C, p.11).

Participant D reflected that he found that the process lacked a comprehensive vision and that the process was instead only focused on a technical progression.

> "it [the 1999/2000 curriculum] was very narrow, the objectives were very narrow in terms of just technical competence." (D, p.6).

Despite the fact that Participants A, B and D were all part of the same writing committee they all recall differing visions and purposes. While this difference could be due to participants simply remembering things differently, it could also mean that the committee was never actually in agreement of the vision and purpose of the 1999/2000 curriculum.

Teachers Efforts at Using New Methods

Participant C found that after the 1985 curriculum was released there was "…a lot of experimentation from 1985 to the mid 1990s" (C, p.14). The 1985 curriculum had encouraged teachers to try new ways of teaching and there were some that were doing that and many of these teachers would later join the 1999/2000 writing committee. Participant A said "…most of the people who were on our writing team [for 1999/2000] were teaching mathematics differently with lots of technology, with lots of experiments…" (A, p.7). Reflecting on the writing of the 1999/2000 documents Participant B found that "…there were many different intended documents on the far end, or rather the really leading end for people who were ready for a completely experiential curriculum, and there was really no one on the other opposite end where chalk and talk is just fine…" (B, p. 14). This shows that a lot of the new methods teachers on the committee were exploring were showing up during the writing process in 1999/2000. Participant C thinks that it is important to allow teachers to explore and try new things so that when you build a new curriculum you have these people to tap into.

> "If everybody's been forced to do the [same] stuff, then there aren't any outliers and not many [teachers] you can sort of tap into. Whereas in the 1985 to 1998, 1999 [timeframe] we had all these outliers we could tap into when we wanted something different" (C, p.15).

Conceptual Influences on the Writing Process

In the 1985 document, the front matter was seen as having a great effect on moving mathematics forward for a certain set of teachers. As Participant D says about the current document's front matter "…if you look into the Ministry document, the first almost half the book has all that stuff[methodologies] in it and that's the good stuff" (D, p.8). Participant B explained that the interesting thing about the 1985 curriculum guidelines was that "…the first 23 pages or there about of that booklet talked about methodologies that had never been seen before" (B, p.2). These methodologies covered use of technology in the curriculum and the mathematical processes. These concepts would influence the 1999/2000 curriculum document.

On the technology front, Participant B remembered that "…back in 1985 we were really just beginning to use scientific calculators really effectively. It was a very different era. The technology just wasn't there to make it happen" (B, p.2). The use of technology would be mandated as part of the 1999/2000 curriculum and Participant C recalled that due to this "…there was probably some hesitancy [from the Ministry] about the more direct mandate of the use of technology…" (C, p.11).

The mathematical processes were something that the 1999/2000 curriculum writing team wanted to better incorporate into the curriculum. Reflecting on what happened with the mathematical processes in the 1985 document, Participant A said

> "…the actions of mathematics they're at the front of the document...We talked about that because we said, well, we know what happened when in the 1985 curriculum, when all those good things were at the front, they didn't get paid attention to." (A, p.20)

Participant A explained the struggles the writing team had with trying to include the process verbs directly into the curriculum

> "We really struggled hard with the words to get the meaning of, and we learned a lot by the second review. We learned that overall we were supposed to assess in the final assessment, we were supposed to assess the overalls and we're supposed to teach to the specifics and we found when we looked back on it that we had verbs in the overalls, like explore, discover, and they didn't belong there because that's the final assessment." (A, p.18)

Participant A also found that even though the team tried to get the mathematical process verbs right into the document she still thinks that it has not translated well into the classroom.

> "Although we did try to get words like 'justify', 'communicate' and 'connect' right into the curriculum document…it was hard because all of those five processes should have been paid attention to almost every day. And I don't think that that's, I don't think that that's translated well in some classrooms…in lots of classrooms." (A, p.20)

Deletions from Curriculum

The 1999/2000 curriculum and the subsequent revision in 2005/2007 saw a reduction in the number of discrete topics covered. A major reason for this was due to the removal of the OAC or Grade 13 year with the 1999/2000 curriculum. This had been in the works for a long time as Participant B explained "…the Ministry was looking seriously at removing Grade 13 even then [1985]" (B, p.1). Participant C recalled how "there was a provision in those days [pre 1999 curriculum] for non-guideline courses" (C, p.25) that was also removed for the 1999/2000 curriculum. All Participants agreed that the mathematics curriculum has lost topics with the 1999/2000 and 2005/2007 curricula. Participant A said

> "Yes, we lost. We lost just about all of our geometry… and all of that stuff [conics and imaginary numbers] disappeared. I mean we were teaching trig using angles in Grade 11,

like if you're going to delete, I said if you're going to get rid of anything, really angles because they're a made-up measurement and go with radians right from the very beginning" (A, p.10)

Participant B said

> "We had to leave some things out that people got upset they were left out. There was a subsequent review of the curriculum where they put them [topics that were lost] in another way and I'm not sure if anything has ever worked well because of that" (B, p.18)

Participant C said

> "The number of discrete topics has definitely decreased…rigor in the same way has somewhat disappeared…" (C, p.21)

Participant D when describing the move from five to four years said

> "…and we lost a lot. And what we lost was playing with some of the rich problems. The curriculum became just, you know, cover, cover, cover, cover, technical, technical, technical, technical, and because of having to get kids ready for calculus in Grade 12. Yeah, it's too early. But there you are." (D, p.3)

While Participant C mentioned he believed rigor had decreased along with the decrease in topics, Participant A did not agree with that. She explained "I don't believe there's a decrease in rigor. I think you have to be rigorous…you have to teach differently, and you have to have problem solving and it can be very rigorous" (A, p.23).

With so many topics being removed, Participant C thought there would be complaints about the downplaying of calculus. "When calculus was downplayed, you know, I expected a major complaint. Wasn't anything [complaints] until after [it was released]" (C, p.16).

Finally, one of the topics that was drastically reduced from the 1985 to 1999/2000 curriculum was financial mathematics, only appearing in Grade 11 for the academic stream. Participant A explained some of the thinking behind it and the outcome of that decision.

> "…so we figured everybody, you have to have three credits, everybody has to get Grade 11. What happened I think, in Grade 11 university and [Grade 11] university/college in particular sequences and series were often the very last topic and it went fast and they didn't have time for the financial applications they were learning. So the financial applications were missed." (A, p. 21)

Reflecting on the task of reducing five years of curriculum into four, Participant B said "I think it was successful. It was far from a perfect curriculum, but I think given that we had to put five into four and find some way of doing all that calculus in 4 years [it was good]" (B, p.15)

Reason for Revisions

The 1999/2000 document was only out for a few years before a revision process was initiated to address issues. A feedback process was in place during the creation of the 1999/2000 curriculum document, but as Participant C mentioned earlier he didn't think there was much oppositional feedback. Explaining further, Participant C believed that the majority of the feedback received was reinforcing

> "The opportunity for feedback was there, but it was largely reinforcing because, it was my experience anyway, that most people providing feedback were people who would have written, who could have been on the committee…the oppositional feedback that did appear appeared after the curriculum was published and in place" (C, p.9)

Participant A explained the Ministry was getting negative feedback from focus groups they were conducting after the curriculum was released

"…random teachers that they would invite from all over the province [would participate]. So they'd have a focus group in the Windsor area, they have a focus group in another area and they were talking to real teachers who were reluctant to make changes" (A, p.10)

University programs also started to complain about changes after the 1999/2000 curriculum had been released and Participant C explained how the university programs had a history of not paying attention to the changes as they occurred

"It[the revisions] was a response to the feedback on the 1999 curriculum by a bunch of people who in some cases hadn't paid attention at all and the university crowd they don't pay attention, like with universities, I mean I was involved in '85 implementation and the number of times I would go to committees that had university people and they'd be talking about students not knowing something. I said, well, that's never been in our curriculum or in other cases well it was in the previous curriculum, but that's gone. So, you shouldn't be expecting it. "What do you mean it's gone?". Well, it was in the drafts that went out, you know" (C, p.17)

EQAO results for Grade 9 students, especially at the applied level, were showing that the students were not achieving at the standard for the grade after the release of the 1999/2000 curriculum document. This was a main reason for the revision of the applied curriculum.

"It [Grade 9 applied] was too, it was too abstract and EQAO results showed it. And so when the EQAO results were so dismal, they [Ministry of Education] said we've got to revise this, especially nine applied. And so, when they revised, I think they [Ministry of Education] only intended to revise nine and ten, but once you start revising that, then they revised all of it [secondary math curriculum]. We hadn't even had a chance to implement it [1999/2000 curriculum] and we're already revising. So that was problematic, the applied courses needing to be revised. So the nine curriculum, a lot of effort was spent on nine because its EQAO" (A, p.9)

Participant D said all this negative feedback led to the Ministry deciding very quickly that it was time for a revision of the 1999/2000 document to try and fix the issues.

"… the Ministry decided it needed a revision and that was the revised version of that that came out in 2005…and essentially, we wrote the current [2005/2007] document trying to fix the problem[s]" (D, p.4)

Theme 3: External Factors

This theme covers the many external factors and challenges faced by the participants during their time on the curriculum writing committee. As with any large committee differing ideas and visions will arise and this caused internal conflict to play a part in the writing process. Dealing with internal strife was a challenging role that Participant B likened to "herding cats" (B, p.17). On top of the differences of opinions that arose, the writing committee had to follow guidelines and expectations set out by the Ministry of Education. These guidelines covered everything from writing committee composition, timelines to complete tasks and specific expectations for the final product.

Writing Committee Composition

One of the stipulations from the Ministry of Education was that the writing committee would be representative of all stakeholders of mathematics education in Ontario. Participants A, B and C all addressed the wide-ranging composition of the committee they were required to have. Participant C mentions how in previous curriculum revisions, the region in which someone lived was often the deciding factor on being included in a committee but there are more selection criteria now.

> "In those days [pre-1999], geography was the biggest thing. Now there's more sensitivity to other things. Probably more gender balanced, probably some racial balance" (C, p.4)

Participant B recalled that when creating her committee for the 1999/2000 curriculum "we had a whole set of criteria for team composition, so we had to have that. We had to have someone who is bilingual" (B, p.9). Participant A expanded on some of the many stipulations

> "You had to have people who had experience with Special Education, people had experience at university, people who had been teaching first year mathematics courses, people who had experience in Faculties of Education, people who had experience in the classroom. So you can imagine there were a lot of people we had to have. We put together a team to make sure we covered all of those spaces. I mean we had to cover equity. We had to cover so many things. Assessment, everything." (A, p.6)

Despite the challenge of constructing a committee that met all the stipulations set out by the Ministry of Education, Participant B felt that the committee was successful and worked together well.

> "…we covered all of the [bases], we had all of the stakeholders including people that I wouldn't have thought to have on the team. So I would want to work on a team very much like that again" (B, p.26)

Timelines

Participant B explained that when they got the contract to write the new curriculum "…we had timelines and we had penalties" (B, p.8). The timeline to get everything done was only one year and Participant A noticed that they Ministry of Education wanted it done quickly.

Participant A further expand on why she thought the curriculum was released in chunks instead of Grades K-12.

> "For some reason it was if they went K-12, it takes two years to revise the curriculum. But if you do K-8, you can get it out in one year and then you can get the next one out in the next year. So it's problematic when you're in a rush" (A, p.8).

As previously mentioned by Participant C even the feedback portion of the curriculum was rushed. The rushed process may have been a contributing factor to having to complete a curriculum revision so soon after the release of the 1999/2000 document.

Constraints on the Writing Process

There were many constraints on the writing process that prevented the writing team from doing everything it wanted to do. One of the major constraints on the 1999/2000 curriculum was the removal of the OAC year. All participants identified that as a major challenge. Participant B said

> "'Five into four don't go' to begin with. That had an influence on the secondary school math curriculum. The need to have calculus within four [years]." (B, p.18)

Participant C found that there was pressure to keep all the same topics even though they were removing a year from the curriculum. "So now we're writing 11 and 12 and everybody wants all the old things that were in the OAC courses and we have two years to do them and we couldn't" (A, p.8). The directive to fit high school into 4 years came from the Ministry of Education and the writing committee had to comply as Participant B explained

> "The government of the day sets the general expectations and what they said was 'you have to fit high school in four years'. So, Grade 13 you have to pull it all back in. That's their direction and the professional educators from the very top down make a broad

guideline of how that needs to happen and a set of rules [of things] you can and can't do" (A, p.16)

Pressure was also exerted by the Ministry of Education and Universities to make Calculus the focal point of the 1999/2000 and 2005/2007 curriculums. Participant C noted that this pressure coming from the universities was "mainly from science and engineering…because they want to be able to use Calculus as a tool in their first year[course]" (C, p.17). Participant D also shared the same thoughts

> "So that's a whole other story…Why was the ministry so keen on having calculus? Because they asked the engineering schools for input and the engineering schools insisted on Calculus, because they were used to taking students who had had Grade 13 that already knew Calculus and now they realized they were taking students a year earlier but they were not prepared to change their courses."(D, p.3)

Participant C said that "there is a lot of politics involved in this [curriculum writing]" (C, p.4). He expanded on this thought by adding that the only reason the Deputy Minister of Education may look at the curriculum before it is released is to ask, "is this going to get the present-day government in a lot of trouble or not?" (C, p.10).

Participant B compared her experience as leader of the 1999/2000 committee to that of her colleague who was the leader of the 1985 committee.

> "My colleague who was the leader of the 1985 guidelines, he talked about his experience in that role and it was totally different than my experience because his Minister [of Education] was very supportive of the efforts that were being made and it was a trust of the educators involved to do the work. Whereas after that, it became something different.

The Ministry was imposing its philosophy on what happened, your curriculum has to reflect the current leadership of the government" (B, p.22).

Participant B would suggest trying to "make education non-political" (C, p.21). All of these constraints did have an effect on the final Ontario mathematics curriculum produced in 1999/2000. Participant B stated that "if we could have written the 1999/2000 guidelines separate from those influences, that [the curriculum] would have been different" (C, p.23)

Opinions

The large and diverse writing committee for the 1999/2000 curriculum had many different opinions. As participant B highlights

"At the time, there was a wide spectrum of feelings about what mathematics should be taught and how mathematics should be taught. A very wide spectrum and a lot of firmly held positions. So it was a very political time" (B, p.3).

Coming into the writing process, Participant C felt that "…people had ideas that were often in silos…" (C, p.2) where they had a lot of strong ideas about one and only one topic. Participant B noticed that "…different people had different intentions" (B, p.15) as to what the purpose of the curriculum was. As leader of the committee she found it important to "respect the opinions that you hear people sincerely express" (B, p.17). Expanding further on how she brought everyone together she said

"We had to find a middle point that would allow those who are ready to really create, while at the same time not losing the people who were not ready yet. I'm finding a way to bring them along. That was the purpose of the 1999/2000 curriculum was to open that door and make it possible to move ahead" (B, p.3).

Participant C summarized his thought on how opinions have an effect on the curriculum and curriculum writing process.

> "…what has stood out over the years is just how lacking in rationality the whole thing is. Like it is large, there is a lot of ego, a lot of just self-interest, a lot of personal history that gets stuck in there and it's not a, you know, some group of people doing a very careful analysis of what's needed about brain mechanisms and such" (C, p.12)

This chapter presented the data from the document analysis and interview analysis. The document analysis looked at each curriculum revision process to describe changes to themes, front matter and content. The documents trended to more experiential learning, the front matter expanded to include different methodologies and the movement from a five to four year program saw the loss of many topics. The interview section presented a profile of each participants and compared and contrasted their response in a cross-case analysis. Their responses covered three main themes (a) Curriculum Revision Process (b) Curriculum Priorities and Focus and (c) External Factors. Theme 1, Curriculum Revision Process highlighted the key stages of developing a new curriculum from the initial background paper to implementation. Theme 2, Curriculum Priorities and Focus gave insights on the reasons behind the changes to the curriculum. Theme 3, External Factors discussed the political nature of developing a new curriculum while giving insights into timelines and government expectations. The next chapter discusses the results.

CHAPTER 5: DISCUSSION

The purpose of this descriptive study was to document the changes to the Ontario secondary mathematics curriculum and analyze its alignment since the 1960s. This was done in two phases by examining historical curriculum documents (Phase One) and interviewing leaders from the mathematics education community who were involved in the change process (Phase Two). The previous chapter, *The Presentation of Data,* described the changes to the curriculum policy documents (Phase One results) and described the experiences of four leaders with the curriculum revision process as well as external influences and constraints on and limitations to the process (Phase Two results). This first section of this chapter relates the findings of the document analysis (Phase One) to the findings of the interview analysis (Phase Two). The second section relates the findings of both phases to the existing body of literature. The third section discusses the limitations and strengths of the study. The fourth section poses recommendations for further research and policies. Finally, the thesis comes to an end with concluding thoughts.

Connections Between Document Analysis and Interview Analysis

In this section, key findings from the document analysis will be related to findings from the interview analysis. The interview analysis gave context and a rationale for a number of changes that occurred to the Ontario Mathematics Curriculum detailed through the document analysis. The changes that will be highlighted in this section are (a) Number of Discrete Topics Decreasing, (b) Front Matter Growing, (c) Change in Structure of Documents and (d) Focus on Calculus.

Number of Distinct Topics Decreasing

The steady reduction in the number of topics specified in the written curriculum is a relatively recent phenomenon. Up to and including the 1985 policy document, it was common for topics to increase or decrease in importance with each revision process; however, the content and concepts remained steady overall. Prior to 1985, topics were moved to different grades or strands, and occasionally new topics were added, e.g., Statistics and Financial Mathematics. The number of mathematics courses offered in high school increased over time and by the release of the 1985 document, 21 different secondary school mathematics courses were offered. The practice of small changes and the introduction of new content came to an abrupt halt with the introduction of the 1999/2000 Ontario mathematics curriculum and the removal of high school's fifth year in Ontario. The number of courses in the 1999/2000 curriculum was 14 which represented a decrease of 33% in available options from the 1985 menu. This change was hugely disproportionate across levels. In 1985, those in the Advanced stream had the option of taking seven mathematics courses over five years. In 1999/2000, the equivalent Academic/University stream had six courses over four years which represented a loss of only one course. In 1985, the General and Basic streams had 14 different courses while in 1999, the equivalent Applied/College stream had just seven courses—a decrease of 50% to available options. A further reduction to the available options for Applied stream students became evident when one of the Grade 12 College courses required an Academic course as a mandatory prerequisite. In the 2005/2007 revision, two Locally Developed courses were added, and some pathways were added for students to move from the Applied Stream to the Academic stream but, overall, still more topics were removed.

As of the most recent document (2005/2007), topics that have disappeared or have been heavily de-emphasized since the 1985 curriculum include: Discrete Geometry, Conics, Complex Numbers, Logic, Proofs, Integrals, Matrices and Personal Finance. By removing many of these topics, the current curriculum has shifted its focus to one that builds toward Calculus. This shift toward Calculus will be further highlighted in the section that follows.

During the interviews, all participants agreed that the number of distinct topics in the mathematics curriculum had decreased. Participants identified two major factors that contributed to the removal of many topics: the removal of the fifth year of secondary school and a shift in focus to make calculus the premier course. According to all participants, these two factors were directives given to them by the Conservative government of that time and were not choices made by the writing committee. The decisions regarding the choice of topics to remove were ultimately made by the writing committee, but they were greatly influenced by these two directives.

Financial mathematics is one of the topics that has seen the greatest level of de-emphasis since 1985. Entire secondary mathematics courses in 1985 were devoted to personal finance and financial mathematics. In the 2005/2007 curriculum, the concepts are included minimally. For example, Academic stream students only learn financial mathematics as part of the sequences and series unit in the Grade 11 University Preparation Course. Applied students spend one unit on personal finance in both Grade 11 and 12. Participant A described the reason they placed Financial Mathematics in the Grade 11 courses was because they figured that since all students have to take three mathematics courses to graduate, they will all have to take Grade 11 and therefore have some exposure to the main concepts. No participant mentioned any substantial debate over the handling of Financial Mathematics.

Focus on Calculus

As introduced in the previous section, the 2005/2007 curriculum has a strong focus on Calculus. The document analysis showed that many of the topics removed in the creation of the 2005/2007 curriculum were from areas other than functions or Calculus. Document analysis also revealed that the current Calculus course lacks the number of topics and suggested number of classes that some of the previous Calculus courses included. For example, Calculus concepts such as the integral were part of pre-1999 courses but do not appear in the current documents. The interview process gave insight to these results.

All of the participants agreed that moving from a five- to four-year curriculum reduced the overall number of topics they could include and even though Calculus was a priority, it still lost some topics. Participant D remarked that having Calculus in Grade 12 was developmentally too early for many students, but it was the directive of the government to include it.

The directive to put a heavy focus on Calculus came from the Conservative government in 1999/2000 and from the Liberal government in 2005/2007. All Participants made it clear that one of the expectations when creating the new curriculum was that calculus had to be done within the four years. Participants C and D gave further insight, noting that university Science and Engineering departments were pressuring the government to have the curriculum focus on calculus because Faculty members wanted to continue to use calculus as a tool in their first-year courses without having to redesign their programs. The interviews illuminated that one of the key factors in the move to a calculus-focused curriculum was attributable to pressures from post-secondary science and engineering departments who demanded certain pre-requisite knowledge and skills in first year undergraduate programs.

Front Matter Growing

The curriculum documents from the 1960s had a front matter that consisted of only a few pages that outlined the rationale for the document and a brief outline of the course of study. Document analysis showed that over time, the front matter continuously grew with each revision: adding sections on assessment, evaluation, inclusive teaching, current teaching strategies, mathematical processes, experiential learning and career education. Two pages of front matter in the 1960s expanded to 39 pages in the 2007 document. The 1960s documents were comprised of a brief booklet that told teachers “what to teach” while the most recent documents have an increased focused on “how to teach.”

Both the interview process and document analysis shed some light on this development. Participant B and D both reflected that the view of the writing committee for the 1999/2000 document was that much of the “good stuff” from the 1985 document was in the front matter. They described the methodologies introduced in the 1985 document as allowing teachers to experiment with their teaching. Participant C mentioned that many teachers on the 1999/2000 writing committee had been experimenting with non-traditional approaches to instruction (e.g., using technology, problem-based learning, cooperative grouping) and thus were able to bring a wealth of different ideas and experiences to the writing process. The positive feelings about the importance of the material included in the front matter gives insight into the continual development and expansion of the definition of “curriculum” over time. “Curriculum” was seen as a whole that included inseparable elements: subject content, instructional methodologies, teaching resources, the nature of the student, and strategies for appropriate assessment and evaluation.

Participant A highlighted that even though “wonderful things” were in the front matter, the 1999/2000 curriculum writing team was aware that the front matter was often ignored by teachers. To ameliorate this reality, there was an attempt to integrate some of the front matter content throughout the document, resulting in some changes to the structure and tone of the document. These changes are discussed in the next section.

Change in Structure of Documents

Each document has had different ways of visually presenting the curriculum content, but up until the 1985 documents, the basic organizational structure of the document had remained constant. Document analysis showed that this basic structure was broken down into two distinct parts. The first part of the policy document was the front matter which included all the rationales, methodologies and processes. The second part was comprised of detailed descriptions of the courses of study which included a list of mandatory topics, as well as optional topics that students would be required to or could have the opportunity to learn. This would start to change with the 1985 curriculum, when process verbs began to be included in the list of topics, objectives and expectations. Thinking words[12] like “relating” and “representing” started to appear in the 1985 documents courses section when listing topics. By the 1999/2000 document the mathematical process verbs such as “representing,” connecting,” “investigating,” “interpret,” “compare,” “investigate” and “problem solve” were prevalent throughout the course objectives and descriptions. The list of content/concepts/specific mathematical topics had been renamed to “specific expectations” with each strand (formerly a curriculum unit) in a course having overall expectations. Included in the expectations were specific expectations that required the use of

[12] Bloom’s Taxonomy, as first described in *Taxonomy of educational objectives: The classification of educational goals,* classifies educational learning objectives into different levels of complexity. Words such as *label* or *identify* would represent the lowest level of thinking with words such as *compare* or *connect* representing more complex thinking processes.

technology; this in effect mandated the use of scientific calculators and computers (equipped with spreadsheets, dynamic geometry software and algebra tools) in the day-to-day teaching of secondary mathematics.

The interview analysis provides context for these changes. As mentioned in the previous section, the writing team in 1999/2000 was aware that the front matter was being ignored by many teachers—those who skipped directly to the course content descriptions. Participant A explained that in an effort to remedy this situation, the curriculum writing team worked hard to bring the mathematical processes directly into the rest of the curriculum. Participant C explained that despite some probable hesitancy from the Ministry of Education, the use of technology was also mandated by including it directly in the expectations that were to be evaluated. All Participants mentioned that they viewed the front matter to be important and agreed that these structural changes were positive steps to include key ideas from the front matter into the 'nuts and bolts' of the curriculum.

The curriculum documents do not list changes made from previous documents or provide any rationale for why the changes were made. Through document analysis, many significant changes were identified and recorded in this study. The interview analysis provided context to these changes, particularly in regards in the 1999/2000 and 2005/2007 documents. This section used the interviews analysis to give context to the following changes (a) Number of Discrete Topics Decreasing, (b) Focus on Calculus, (c) Change in Structure of Documents and (d) Front Matter Growing.

Connections with the Literature

Through document analysis, changes in the content and organization of the Ontario curriculum policy documents were identified. In this section, curriculum changes will be related to historical movements in mathematics education through the existing body of literature.

The analysis of the interviews led to the emergence of three themes. These themes (a) The Curriculum Revision Process, (b) Curriculum Priorities and Focus and (c) External Factors, are presented, and an account of each theme is interwoven with comparisons to the available body of research.

Historical Mathematics Movements

The launch of *Sputnik 1* by the Soviet Union in 1957 resulted in the Americans taking a critical examination of its mathematics education (Fey & Graeber, 2003) resulting in the mathematical movement known colloquially as "new math." The mathematics program in Ontario at this time had remained essentially the same as it was 50 years prior (Coleman, 1999). In response to both "new math" and the lack of change, the Ontario Mathematics Commission was formed in 1958 to examine the teaching of mathematics. The work of this commission resulted in the 1961/1964 curriculum policy documents and eventually the 1972 senior mathematics policy document. Since document analysis started with the 1961/1964 documents, any content changes prior to this time were not included.

Document analysis from the beginning of the timespan under examination was able to identify that at that time, the three terminal courses focused on functions, analytic geometry and trigonometry. Part of the work done by the Ontario Mathematics Commission was a rework of the Grade 13 terminal math courses (O'Shea, 2003). Document analysis of the 1972 curriculum shows that the four new Grade 13 mathematics courses were *Relations and Functions*, *Calculus*, *Algebra* and the *Mathematics of Investment*. Examination of the 1972 curriculum highlighted that the policy allowed for experimental courses that would match the interest of students, allow the use of computational machines, encourage a focus on practical applications and support the introduction of streaming. These all represented major ideas of "new math" as described by Russel, Howard & Robinson in 1975.

The 1980 curriculum policy was shown to build on ideas introduced in the 1972 document while introducing new ones such as experiential learning and a stronger focus on problem solving. Document analysis revealed that the 1980 intermediate course of study was split into three different streams in Grades 9 and 10 : Basic, General and Advanced. The Basic stream, as its named suggested, focused on very fundamental mathematics while the Advanced stream focused on more abstract concepts. Topics such as linear equations, matrices, transformations, probability, statistics, vectors, rational numbers, conics, slope, functions, and geometric proofs were all added to the Grade 9 and 10 syllabus. A study was commissioned by the Ministry of Education in 1974 for recommendations for a revised intermediate (Grade 7 to 10) program (O'Shea, 2003) and the changes in the 1980 documents match the recommendations of this study. These changes represent the reform movement known as "back to basics" in a response to what had been seen as the failure of the "new math" movement. It is interesting to note that the "back to basics" era was characterized by a return to more traditional instructional methods (Fey et al., 2003) yet the 1980s curriculum in Ontario continued to push forward with the introduction of experiential learning embedded directly into the document.

The *Agenda for Action* was released by the National Council of Teachers of Mathematics in 1980, outlining a new vision for mathematics. This vision recommended (a) problem solving be a focus of mathematics education, (b) drills be de-emphasised, (c) a wide range of student outcome measures be validated, and, (d) increased emphasis be placed on mathematical processes (i.e., connecting, reasoning, reflecting, representing, and selecting tools and computational strategies). Empirical examination of the 1985 curriculum shows that these recommendations were embraced by the writing team. The 1985 document addressed many of these recommendations through the inclusion of a revamped front matter section that included topics ranging from an introduction describing the vision for mathematics education, a rationale for using cross-curricular applications, a detailed outline for the specific content of all courses, instructional methodologies, expanded descriptions of the process components of mathematics and best practices for assessment and evaluation. It is clear that the *Agenda for Action* had an effect on the creation of the 1985 document. The 1980s would come to a close with the NCTM releasing the *Curriculum and Evaluation Standards* in 1989 followed by the *Professional Standards for Teaching Mathematics* in 1991. These documents outlined standards-based education that included an emphasis on problem solving and applications of mathematics, new emphasis on topics such as statistics and discrete mathematics, reduced emphasis on written computational procedures and increased use of technology, less emphasis on proofs in geometry and more opportunities for deductive arguments and finally more emphasis on real world mathematics (McLeod, 2003).

The NCTM *Standards* document and a new political environment resulted in many changes to the Ontario Mathematics Curriculum during the 1990s. It is interesting to note that up until the 1995 curriculum, all previous Ontario mathematics curriculum policy documents examined for this study were developed under a Conservative government. The 1995 curriculum was developed under the first NDP government in Ontario's history. Document analysis showed that in the 1995 document, assessment appears often. Much of the front matter is dedicated to defining what the 'standards' are and how they could be used as well as providing a framework for assessment. An entire portion of the 1995 curriculum document is dedicated to providing different assessment strategies that can be utilized by teachers. Instead of listing topics or expectations, many of the curriculum topics were actionable items that students could do such as investigations and conferences. This reflects recommendations from a joint OMCA and OAME report (*Focus on renewal of mathematics education: Guiding principles for the early, formative and transition years)* in 1993 that interpreted the NCTM *Standards* for Ontario (O'Shea, 2003). The report specifically mentions that emphasis be placed on student actions rather than the course content (Roulet, 1997).

The NDP were defeated in 1995 and the (then) new Conservative government initiated the creation of a new curriculum citing low support for the 1995 curriculum. The result was the 1999/2000 curriculum. Document analysis revealed many changes that occurred in this curriculum. These include the program being reduced from five to four years, the curriculum content being presented as defined learning objectives called specific and overall expectations, an Academic and Applied stream were created, a focus on mathematical processes and many topics removed from the curriculum. In 1995, the *Royal Commission on Learning* released a report on a comprehensive review of the Ontario education system. Recommendations from this report included creation of expected learning outcomes in all grades, abolishing Grade 13, reconstitution of the secondary program into two streams, and the creation of standardized report cards linked to defined learning (Anderson & Jaafar, 2003). A clear connection can be seen between the changes to the curriculum discovered from document analysis and the recommendations of the report. Following the election of a Liberal government in 2003, the 1999/2000 curriculum was revised due to complaints about the 1999/2000 document. Document analysis showed this revision is mostly a relocation of topics while the spirit of the 1999/2000 policy document remained.

Curriculum Revision Process

Many different models to carry out a curriculum revision exist in the literature. The choice of model will depend on the goals and breadth of the curriculum being developed. Generally, as a process, curriculum development is concerned with reviewing, planning, developing, implementing and maintaining curriculum while ensuring that the stakeholders engaged in this process have a high level of commitment to and ownership of the curriculum (Beauchamp & Parsons, 2012). Figure 8 shows how this process happens for a provincial level curriculum review. This figure was adapted from the Government of Alberta's development process which is analogous to past Ontario curriculum revision processes.

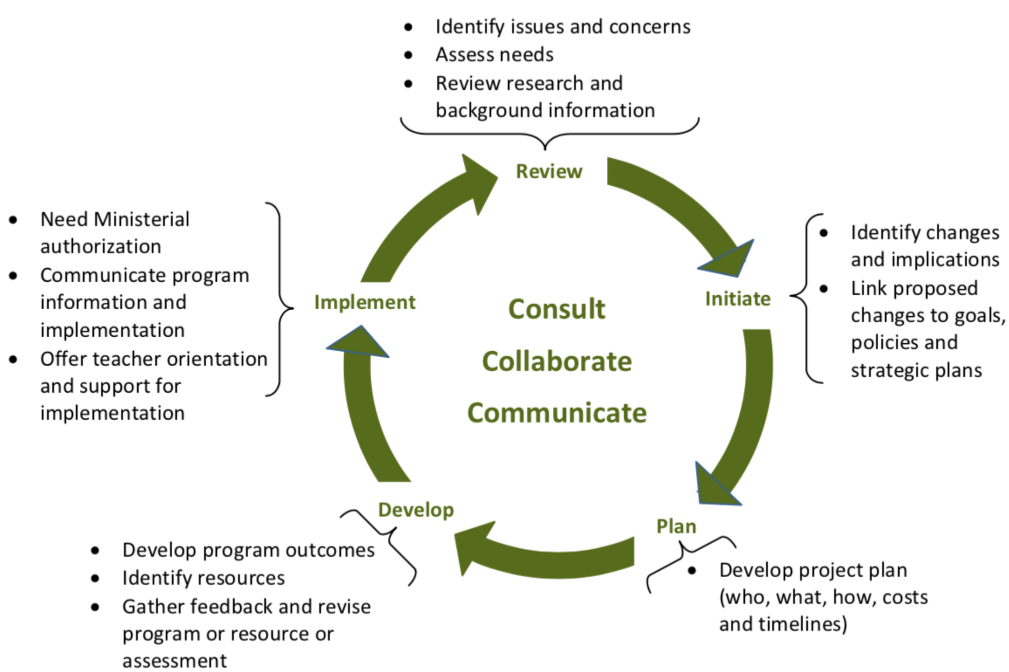


Figure 8: A traditional curriculum development process, from *From Knowledge to Action: Shaping the Future of Curriculum development in Alberta (*Beauchamp & Parsons, 2012*)*

Typically, a curriculum revision process is initiated by a triggering event. Beauchamp & Parsons (2012) suggest the following as potentially triggering events: changes in government policy, emerging socioeconomic issues, influence of research findings, age of existing curriculum, stakeholder and educator feedback, significant changes in the subject material. This study has identified likely triggering events for each curriculum revision. The 1961/64 curriculum was in response to *Sputnik* and "new math" (socioeconomic issues) and lack of revisions (age of existing curriculum) for the previous 50 years (Coleman, 1999). The 1972 curriculum was a continued response to "new math" (socioeconomic) and the result of a report from the Ontario Mathematics Commission (government policy). The 1980 curriculum was in response to a Ministry of Education study published in 1974 (influence of research findings), backlash to "new math" and a call for "back to basics" (stakeholder and educator feedback). The 1985 document was created in response to NCTM's *Agenda for Action* (influence of research findings). Both the 1995 and 1999/2000 documents were in response to the NCTM *Standards* (influence of research findings) and political policy change during the mid-1990s (socioeconomic). Finally, the 2005/2007 curriculum revision was in response to negative feedback regarding the 1999/2000 document (stakeholder and educator feedback).

Through the interview process, this study determined that all documents previous to the 1999/2000 curriculum were developed in-house by the Ministry of Education who took the lead for the entire process. Starting with the 1999/2000 curriculum, the Ministry of Education were no longer involved with the development and implementation of the curriculum due to financial cutbacks (Puk & Haines, 1998). As a result, a Request for Proposal was put out by the government to have outside people create the new curriculum. The OAME and OMCA came together to submit a proposal. The OAME and OMCA were two large provincial mathematics education organizations. This study determined through the interviews that the OAME and OMCA lacked the necessary funds to get the task done which led to the collaboration with the Field's Education Forum. This collaboration brought together many highly respected and experienced mathematics educators who shared a vision for the future of mathematics education in Ontario. It is important to note that some members of the writing team had participated in previous curriculum revisions. Sahlberg (2006) states that when considering curriculum development, it is important to have a consensus-based strategy, a defined curriculum purpose and expertise on curriculum development processes. This collaboration was able to bring together a group that satisfied these criteria.

Through the interviews, this study found that two components of the curriculum development process shown in Figure 8 where either rushed or insufficient. Interview participants noted that the feedback portion of the 1999/2000 process happened very quickly and as a result, the minimal feedback received was often agreeable in nature. No substantial field testing occurred even though participants noted that in previous iterations, the curriculum revision process sometimes included multiple years of field testing. Finally, interview participants noted that the curriculum was implemented quickly across the province with little support for teachers. Participants noted that further professional resources such as TIPS had to be developed in the following years because the intended curriculum outlined in the documents were not translating well to the classroom as the implemented curriculum. Failure to fully commit to the implementation steps of the process could be one of the reasons for the substantial negative feedback received from the community of stakeholders within mathematics education that led to another revision process only a few years later. This study identifies that it is important to fully commit to each step of the curriculum review process. While it will always be open to interpretation, it can be surmised that had the feedback and implementation process unfolded differently, there may not have been a need for the 2005/2007 revision.

Sahlberg (2006) suggests that curriculum development is an ongoing process and not just a product. Further, curriculum development can no longer be viewed as a project that has a start and an end. In today's rapidly changing world, the curriculum designed today and implemented in the years to come could still be responsive and relevant in five years conceptually, but specific facts may not be so. Curriculum should be viewed as a "living, organic instrument to help teachers and schools to find optimal ways to educate" students" (Sahlberg, 2006, p.8). This statement was echoed by one of the participants in the study, when she remarked that she considered the process described in this section and in literature as "the old way." The participant believes that new ideas and problems should constantly be tested and if proven to be successful, integrated into the curriculum. Ongoing minor revisions based on fieldwork does present an interesting alternative to the large scale and resource intensive revision process that has historically taken place in Ontario.

Curriculum Priorities and Focus

A major challenge for curriculum development is to define the components that will comprise the curriculum, and the three major planning elements involve content, purpose and organization of learning (van den Akker, 2007). The interview process gave insights into the priorities and focus of the curriculum writing teams in 1999/2000 and 2005/2007. The study found that the vision and purpose of the curriculum was to move teachers beyond traditional teaching methods. Some participants specifically mentioned the method of "chalk and talk" as a teaching approach from which they wanted to move teachers away. This traditional method involves the teacher lecturing at the front of the class using a chalkboard, often with no student involvement. Studies, such as one done by Anderson & McCarthy (2000), suggest that students who are engaged in the lesson and actively participate in their learning will retain the information just as well, if not better, than if they learned in a passive model. Interview participants talked about the fact that many teachers on the writing committee were themselves trying new teaching methods in their own classrooms that engaged students more actively. This push for newer methodologies when developing the curriculum was highlighted by all participants. Participant A furthered this when she described the effort and struggles the team faced as they tried to include action verbs directly into the expectations. Literature shows that overall curricula of today are striving to be “more challenging and intrinsically motivating” and move toward instruction that is more meaningful and autonomous (Thijs & van den Akker, 2009). This study has found that the writing team was clearly attempting to make a more meaningful curriculum through its vision and actions.

Participants’ responses in this study gave insights into why curriculum topics were removed and explained reasons for curriculum revisions. The major reason for the loss of topics in the 1999/2000 curriculum was the removal of the fifth year of high school, and in 2005/2007 from a directive from the government to focus on calculus. While the interviews did not cover past revisions where topics were added to the curriculum, literature does shed some light on reasons for topics to be added. Public pressure, resulting from unfavourable media reports on students’ supposedly inadequate knowledge of something, often leads to the addition of content in curriculum or the development of too many separate courses that most schools are unable to offer (Levin, 2007). It is interesting to note that it was pressure caused by the feedback from educators and post-secondary Science and Engineering departments that initiated the curriculum review for 2005/2007 and yet this revision did not result in additional content.

Removing and adding content to the curriculum is necessary as time progresses to keep the curriculum current and responsive. This study has shown that the Ontario curriculum has changed often, and that sometimes the changes were large scale and at other times, minor. The curriculum in Ontario has not changed dramatically since 1999/2000, and the most recent revision process documents were released in 2005/2007. The report *Spotlight on Science Learning: The High Cost of Dropping Math and Science* from *Let's Talk Science* (2013) states the education landscape has changed dramatically in the last few decades; however, in general, the way mathematics and science is taught in secondary schools has not kept pace, thus revisiting curricula to foster a classroom experience that is relevant and interesting to today's students is important. This suggests that another review of the mathematics curriculum in Ontario could be needed in the near future.

Another trend that developed over time was the extent to which the curriculum documents became much more precise in describing what teachers must teach. Optional topics were removed from the curriculum and there was little room for interpretation of what must be taught. Teacher flexibility in delivering a more personalized curriculum was impacted by this trend.

During the interviews, one of the participants suggested the move to making mathematics a non-compulsory course in high school. The same report from *Let's Talk Science* (2013) showed that many teenagers choose their post-secondary path without realizing the magnitude of the decision they are making until they are in their mid-20s and by not choosing non-compulsory mathematics, science and technology courses in secondary school, their career options are severely limited and they have limited flexibility to change career paths. In Ontario, as with most other provinces, science courses are optional after Grade 10 and mathematics becomes optional after Grade 11. *Let's Talk Science* (2013) described that as result "…the average annual percentage of secondary school graduates, across a selection of provinces, completing Grade 11 or 12 level mathematics and science courses is less than 50 percent" (p.5). The report found that "70 percent of top jobs required STEM education, including the skilled trades" (p.6) and that students who do not take mathematics in Grade 11 and 12 "can expect to be excluded from over half of community college programs" (p.8). Clearly the literature suggests that mathematics should remain compulsory at the secondary level until graduation.

External Factors

This study found that the 1999/2000 curriculum revision process had a very large committee that was required to be as diverse and inclusive as possible. Some participants suggested this was to avoid offending any groups of stakeholders, but literature suggests a large diverse group is required. Thijs & van den Akker (2009) suggest that the composition of the team involved in the development process can have an impact on the product. For example, an individual working alone or a small team has more latitude for creativity but may be restricted by the amount of experience and knowledge he or she may have on pedagogy and practice. On the other hand, larger teams of developers lend themselves more readily to an instrumental and/or communicative development model. Having a large pool of experience to draw from is helpful as Thijs & van den Akker (2009) state that curriculum developers face many uncertainties in a complex task undertaken within very dynamic contexts.

Within large groups of people, opinions will always differ. This study showed that it was no different on the curriculum writing teams. Participants mentioned that differences in opinions were often due to personal preferences in how one should teach a subject. Participants suggested that other writing team members often lobbied for topics based on the fact they liked to teach that topic and had good lessons developed. Literature suggests that this is common in the curriculum development process. Beauchamp & Parsons (2012) described the curriculum development process as often being complicated by a long process that involves many stakeholders, often with their own perspectives and interpretations. Further to this, Levin (2007) states this process can be further compounded by teams of experts who want different elements of their own disciplines and subject areas included in the curriculum. Literature clearly suggests both benefits and challenges with large curriculum committees and this study has shown examples of both.

Finally, this study has shown that demanding expectations and unrealistic timelines were imposed on the curriculum writing committee by those in authority at the Ministry of Education. Participants all noted that these expectations, particularly the directive to focus on calculus, had an effect on the decisions made by the committee. Participants also noted that the process was rushed: allowing only one year to develop and release the curriculum provincially. Literature would suggest that this was not enough time to complete a thorough process. Caskey (2002) states that a coherent, integrative and democratic curriculum requires a great deal of thought and notes that it is a time-intensive activity. He does not specifically state the time it should take but given the participants' responses about feeling rushed in the development of the 1999/2000 document, it can be deduced that the process happened too quickly. The simple fact that substantial negative feedback after the 1999/2000 document release triggered a revision a few years later supports this deduction.

Revisiting the Purpose

This study documents the changes to the Ontario secondary mathematics curriculum and its alignment since the 1960s. Using historical secondary mathematics curriculum policy, major changes to content and frameworks between the sequential curriculum iterations was identified. To provide context to these changes four leaders in mathematics education, who were responsible for the development and implementation of the Ontario curriculum documents, were interviewed regarding the revision process and underlying principles for the curriculum documents. In talking with these leaders, the researcher was able to gain a better understanding of the curriculum revision process in Ontario.

Answering the Research Questions

Comparisons between earlier research and the findings of this study demonstrate that there are some associations to be made with the broader body of literature. While it is imperative that the findings of this study are compared to the present body of literature, it is also important to describe how the findings answer the research questions addressed in Chapter 1 of this thesis. The overall objective of this study was to document the change cycles for the secondary mathematics curriculum in Ontario on the basis of official policy documents and from the perspective of members of the mathematics education community who were leaders in the change process. This overall objective was complemented through the following sub-objectives:

1. To record changes to content in the Ontario secondary mathematics curriculum policy document between 1960 and 2017.
2. To align these changes to particular historical events and educational movements
3. To provide contextual support for changes to the Ontario secondary mathematics curriculum policy document by giving voice to the leaders in the mathematics community to contributed to the change process(es).

Objective 1: Changes to Curriculum Documents

This study documented changes to the Ontario mathematics curriculum documents from 1960 until 2005/2007. Many changes were made in each revision process, ranging from simple visual changes to large scale re-arrangement of topics and courses. Over the entire timescale of this study three main trends stood out. The first trend saw a change of the documents from a list of “what to teach” to documents that covered “how to teach.” Each revision process saw mathematics education methodologies and mathematical processes increasingly added. These were first added to the ever growing front-matter and later they were incorporated directly into the curriculum expectations. The second trend saw an increased use of technology, eventually becoming mandated in the 1999 document. Curriculum topics that focused on computation were slowly removed in favor of technological methods. Finally, the third trend was a move towards a focus on calculus and functions across the curriculum. This resulted in numerous topics and courses, especially in geometry, being removed from the Ontario curriculum.

Objective 2: Aligning Document Changes to Historical Event and Movements

Literature suggests that curriculum revision processes are often triggered by certain events. Using both the existing body of literature surrounding mathematics education and the insights of the interview participants this study was able to identify possible triggers for each revision process. The 1961/64 curriculum was in response to *Sputnik* and “new math” (socioeconomic issues) and lack of revisions for the previous 50 years (age of existing curriculum). The 1972 curriculum was a continued response to “new math” (socioeconomic issues) and the result of a report from the Ontario Mathematics Commission (government policy). The 1980 curriculum was in response to a Ministry of Education study published in 1974 (influence of research findings) and backlash to "new math" and a call for "back to basics" (stakeholder and educator feedback). The 1985 document was created in response to NCTM's *Agenda for Action* (influence of research findings). The 1995 and 1999/2000 documents were both in response to the NCTM *Standards* (influence of research findings) and political policy change during the mid 1990s (socioeconomic). Finally, the 2005/2007 curriculum revision was in response to negative feedback regarding the 1999/2000 document (stakeholder and educator feedback).

Objective 3: Context to Document Provided by Leaders

Mathematics education leaders in Ontario who were involved in the curriculum revision process were able to give context to the writing process. This study found that the interview responses covered three main themes as described in Chapter 5; (a) Curriculum Revision Process, (b) Curriculum Priorities and Focus and (c) External Factors. The participants were able to give the most context about the 1999/2000 and 2005/2007 process. The 1999/2000 process was described extensively by participants from proposal stage at the beginning to the ending implementation stage. When participants responses were compared to a theoretical revision process from the literature it was found that the feedback and implementation stages were lacking due to a rushed timeline as described by participants. The priorities and focus of the team in 1999/2000 was to move teachers beyond traditional teaching methods which matches what literature was saying needed to happen to mathematics education at the time. Finally, participants all described various external factors that had an effect on the writing process. These were found to include quick timelines, government directives such as the one to focus on calculus, lack of funding and differing opinions.

Limitations and Strengths of Study

The main limitation of this study was the limited and small sample size of interview participants. There was also a substantial gap in time between the participants' involvement in the curriculum revision process and the timing of this study. The small sample size could limit transferability. Many individuals who participated in an earlier curriculum revision process are no longer alive to speak to their experiences or are retired and did not wish to speak about their experiences. This left a small group of people available to interview about the later curriculum revisions which in turn limited the interview portion of this study to mostly experiences regarding the 1999/2000 and 2005/2007 revisions. The use of a larger sample size may expand the scope of data and introduce new information not present in the current study. Unfortunately, as time passes, the ability to obtain this data surrounding past curriculum revisions will become increasingly difficult.

As this study covered changes to the Ontario curriculum and experiences of education leaders from Ontario, this does limit its generalizability of results to other provinces. However, there may exist a transferability of the methods to produce results for other mathematics curricula or even other subjects within the Ontario curriculum.

This study contributes to the history of mathematics education in Ontario, specifically surrounding the curriculum change in Ontario. This study specifically has identified major changes within each curriculum revision. It has also provided context to the changes by comparing it to previous literature about mathematics movements at the time and through interviews with mathematics leaders involved in the revision process. This study gives voice to mathematics education leaders who participated in the curriculum writing process. It generated a list of experiences and challenges they faced when writing a curriculum that can be reviewed by future committees.

Recommendations

Recommendation for Future Curriculum Revisions

Based on the results of this study, the experiences of the interview participants and the traditional framework for curriculum development by Beauchamp & Parsons (2012) the following recommendations can be made.

The first step of a curriculum revision process should involve a wide-ranging provincial scoping survey. This survey should include as many different stakeholders in mathematics education from across the province as possible including teachers, university professors, college professors, parents, students, principals, mathematics consultants, mathematics facilitators and others with a stake in mathematics education. This survey should seek to get the opinions of each group to find out what they think is working, what they think isn't work and where they think mathematics education should be going.

The second step should be to assemble a diverse team to create this curriculum. This study found that a diverse group was assembled for the writing of the 1999/2000 document. Thijs & van den Akker (2009) suggest that having a small team can restrict the amount of experience and knowledge the team may have on pedagogy and practice. Thus, assembling a diverse team which can bring many different ideas to the committee would be an important second step.

The third step should involve sufficient time to build a document from the vision all the way to field testing. Caskey (2002) states that a coherent, integrative and democratic curriculum requires a great deal of thought and is a time-intensive activity. This study found that there was a great amount of negative feedback to the 1999/2000 document. The 1999/2000 revision process was described as taking one year to create with limited feedback time and no field testing. This would suggest that in order to avoid having to revise a document soon after release as with the 2005/2007 revision document, taking an adequate amount of time is necessary. There is no prescribed amount of time that can be suggested as perfect, but this study suggests that no step of the curriculum development process be rushed as they are all equally important.

Finally, the last step should involve a clear implementation and roll out plan. This study showed that workshops and resources were developed for years after the 1999/2000 document was released, because as the interview participants stated, teachers in general were not understanding nor accepting of the vision of the curriculum. These workshops and resource should be developed and presented prior to, during and after the curriculum has been released. Sahlberg (2006) states that "curriculum development is an ongoing process and not just a product. Once a final document is created this should not be viewed as the end of the curriculum development process."

Further building on the "ongoing process" described by Sahlberg and the comments of Participant D, it could also be suggested that rather than having large scale curriculum revision process it could eventually move to a more iterative model where frequent small changes are made based on different teaching models being used across the province. In this model it would be important to back any changes with research, but it could inspire creativity around the province as different models were explored.

Recommendations for Future Study

Results of this study indicate some possible interesting extensions that could warrant further research. Building in a parallel Developmental Evaluation into the revision process (which aids in identifying promising practices during the process) could be an area of further research. In both this study and literature, it has been shown that the composition of a curriculum writing team is important to curriculum development. Further research into curriculum committee compositions in Ontario could give more insights into the writing process. Using both the literature and document analysis specific triggering events were suggested for each curriculum revision in this study. Further research in this area could be done by comparing the timeline for mathematics curriculum revisions across the country to determine if certain triggering events were local or national in nature.

Finally, the methods used in this study could be replicated and used to produce similar research as this study about other curriculum subjects in Ontario. The same methods could also be applied to curriculum subjects in other provinces or countries.

Concluding Thoughts

This study documents the changes to the secondary Ontario Mathematics curriculum. This was achieved through analyzing the curriculum documents from 1960 to 2007 and by interviewing individuals involved with the writing process. This study has shown that curriculum revision processes were often in response to a triggering event. Changes made to the curriculum have often come from external or political factors and not a scientific approach to how students actually learn. This study has also highlighted the drastic effect that moving from a five to four year curriculum in Ontario had on the mathematics program. The loss of many topics and an increased focus on Calculus were a direct result of this change.

As I come to the end of this thesis, I contemplate my experiences and questions that led me to do this research. Some of the curriculum changes described in this thesis were something that I experienced in real time as a high school student in Ontario. I recall five years after graduating high school, when I was in my Bachelor of Education year, learning that the mathematics curriculum was different. I remember wondering why these changes were made: was there something wrong with what I learned? As I moved into my teaching career, I heard older teachers all talk about older versions of curriculum and how "back then" it was either better or worse. When I looked for answers I found very little: older documents were not readily available, the current documents did not describe what they changed, and there was a lack of literature around these changes.

By completing this study, I have not only answered my own questions but have created a document that outlines these changes for any others who may have the same questions. Curricula should be living documents, always changing and adapting to the needs of its students. I believe that as the mathematics curriculum continues to evolve into the future it is imperative to remember its past, so that educators of the future can continue to build on the curriculum's successes and avoid past shortcomings.

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APPENDICES

Appendix A: Recruitment Email

Hello,

My name is Steven Mueller and I am currently completing research for my Master of Education theses, entitled "**A Historical Examination of the Secondary Mathematics Curriculum in Ontario through two lenses: Curriculum Policy Documents and the Reflections of Leaders in the Field**". The purpose of this study is to describe the changes to the Ontario secondary math curriculum since the 1960's from the perspective of mathematics leaders. It aims to do this through the analysis of historical curriculum documents and through interviews with mathematics education leaders in Ontario.

You have been identified as a leader in the field of mathematics education in Ontario, and as such, I would like to invite you to participate in this research.

If you agree, the research would entail taking part in a single one hour interview regarding your background, experiences and opinions about changes to the Ontario secondary school mathematics curriculum. This interview would be in person at a public location of your choosing. After the completion of the interview, the complete interview will be transcribed and emailed to you for you to review, should you wish.

Every effort will be made to protect your anonymity throughout the study. You, and any identifying demographical data about you, will be assigned pseudonyms.

There is no remuneration for participation in this study.

Please find attached the Letter of Information and Consent for the study. This should answer any additional questions you may have. However, if they do not, or you wish to ask me (the principal researcher) any additional questions, please do not hesitate to call me on my cell phone at 613-328-0161 or email me at steven.mueller@queensu.ca.

Please let me know by August 31, 2017 whether you would like to participate in the study.

Thank you for your consideration and I hope to hear from you soon.

-Steven Mueller
Master of Education Candidate
Queen's University, Faculty of Education
Duncan MacArthur Hall
511 Union Street, Kingston, ON, Canada
K7M 5R7

Appendix B: Combined Letter of Information and Consent Form

Study Title: *A Historical Examination of The Secondary Mathematics Curriculum in Ontario through two lenses: Curriculum Policy Documents and the Reflections of Leaders in the Field*
Name of Student Researcher: Steven Mueller, Faculty of Education, Queen's University
Name of Supervisor: Dr. Lynda Colgan, Faculty of Education, Queen's University

I am Steven Mueller, a master's student in the Faculty of Education, working under the supervision of Dr. Lynda Colgan. I am asking leaders in the math education field to take part in a research study examining the history of the secondary math curriculum in Ontario. If you agree to take part, I will interview you for one hour at a public location of your choosing. The interview will be audio-recorded and later transcribed. There are no known risks for taking part in this study. While there are no direct benefits to you as a participant, study results will help inform how future mathematics curriculum and policies could be written.

There is no obligation for you to say yes to take part in this study. You don't have to answer any questions you don't want to. You may withdraw from the study up until December 31, 2017 by contacting me at steven.mueller@queensu.ca

I will keep your data securely for at least five years. Your confidentiality will be protected to the extent possible by replacing your name with a pseudonym for all data and in all publications. The code list linking real names with pseudonyms will be stored separately and securely from the data. Other than me, only a transcriber who has signed a Confidentiality Agreement will have access to any of the data.

I hope to publish the results of this study in my master's thesis and academic journals and present them at conferences. I will include quotes from some of the interviews when presenting my findings. However, I will never include any real names with quotes, and I will do my best to make sure quotes do not include information that could indirectly identify participants. During the interview, please let me know if you say anything you do not want me to quote.

If you have any ethics concerns please contact the General Research Ethics Board (GREB) at 1-844-535-2988 (Toll free in North America) or chair.GREB@queensu.ca.

If you have any questions about the research, please contact me, Steven Mueller, at steven.mueller@queensu.ca or my supervisor, Dr. Lynda Colgan, at lynda.colgan@queensu.ca.

This Letter of Information provides you with the details to help you make an informed choice. All your questions should be answered to your satisfaction before you decide whether or not to participate in this research study.

Keep one copy of the Letter of Information for your records and return one copy to the researcher, Steven Mueller.
By signing below, I am verifying that: I have read the Letter of Information and all of my questions have been answered.

Name of Participant: ____________________________________

Signature: ____

Date: ____

Appendix C: General Research Ethics Board Approvals

August 14, 2017

Mr. Steven Mueller
Master's Student
Faculty of Education
Queen's University
Duncan McArthur Hall
511 Union Street West
Kingston, ON, K7M 5R7

GREB Ref #: GEDUC-867-17; TRAQ # 6021611
Title: "GEDUC-867-17 A Historical Examination of the Secondary Mathematics Curriculum in Ontario Through Two Lenses: Curriculum Policy Documents and Reflections of Leaders in the Field"

Dear Mr. Mueller:

The General Research Ethics Board (GREB), by means of a delegated board review, has cleared your proposal entitled "GEDUC-867-17 A Historical Examination of the Secondary Mathematics Curriculum in Ontario Through Two Lenses: Curriculum Policy Documents and Reflections of Leaders in the Field" for ethical compliance with the Tri-Council Guidelines (TCPS 2 (2014)) and Queen's ethics policies. In accordance with the Tri-Council Guidelines (Article 6.14) and Standard Operating Procedures (405.001), your project has been cleared for one year. You are reminded of your obligation to submit an annual renewal form prior to the annual renewal due date (access this form at http://www.queensu.ca/traq/signon.html/; click on "Events"; under "Create New Event" click on "General Research Ethics Board Annual Renewal/Closure Form for Cleared Studies"). Please note that when your research project is completed, you need to submit an Annual Renewal/Closure Form in Romeo/traq indicating that the project is 'completed' so that the file can be closed. This should be submitted at the time of completion; there is no need to wait until the annual renewal due date.

You are reminded of your obligation to advise the GREB of any adverse event(s) that occur during this one year period (access this form at http://www.queensu.ca/traq/signon.html/; click on "Events"; under "Create New Event" click on "General Research Ethics Board Adverse Event Form"). An adverse event includes, but is not limited to, a complaint, a change or unexpected event that alters the level of risk for the researcher or participants or situation that requires a substantial change in approach to a participant(s). You are also advised that all adverse events must be reported to the GREB within 48 hours.

You are also reminded that all changes that might affect human participants must be cleared by the GREB. For example, you must report changes to the level of risk, applicant characteristics, and implementation of new procedures. To submit an amendment form, access the application by at http://www.queensu.ca/traq/signon.html; click on "Events"; under "Create New Event" click on "General Research Ethics Board Request for the Amendment of Approved Studies". Once submitted, these changes will automatically be sent to the Ethics Coordinator, Ms. Gail Irving, at the Office of Research Services for further review and clearance by the GREB or GREB Chair.

On behalf of the General Research Ethics Board, I wish you continued success in your research.

Sincerely,

Joan Stevenson

Joan Stevenson, Ph.D.
Interim Chair
General Research Ethics Board

c: Dr. Lynda Colgan, Co-investigator
Dr. Richard Reeve, Chair, Unit REB
Mrs. Erin Rennie, Dept. Admin.

August 03, 2018

Mr. Steven Mueller
Master's Student
Faculty of Education
Queen's University
Duncan McArthur Hall
511 Union Street West
Kingston, ON, K7M 5R7

Dear Mr. Mueller:

GREB TRAQ #: 6021611
Title: "GEDUC-867-17 A Historical Examination of the Secondary Mathematics Curriculum in Ontario Through Two Lenses: Curriculum Policy Documents and Reflections of Leaders in the Field"

The General Research Ethics Board (GREB) has reviewed and cleared your request for renewal of ethics clearance for the above-named study. This renewal is valid for one year from August 14, 2018. Prior to the next renewal date, you will be sent a reminder memo and the link to ROMEO to renew for another year. You are reminded of your obligation to submit an Annual Renewal/Closure Form prior to the annual renewal due date (access this form at http://www.queensu.ca/traq/signon.html/; click on "Events;" under "Create New Event" click on "General Research Ethics Board Annual Renewal/Closure Form for Cleared Studies"). Please note that when your research project is completed, you need to submit an Annual Renewal/Completed Form in Romeo/traq indicating that the project is 'completed' so that the file can be closed. This should be submitted at the time of completion; there is no need to wait until the annual renewal due date.

You are reminded of your obligation to advise the GREB of any adverse event(s) that occur during this one-year period. An adverse event includes, but is not limited to, a complaint, a change or unexpected event that alters the level of risk for the researcher or participants or situation that requires a substantial change in approach to a participant(s). You are also advised that all adverse events must be reported to the GREB within 48 hours. To submit an adverse event report, access the application at http://www.queensu.ca/traq/signon.html/; click on "Events;" under "Create New Event" click on "General Research Ethics Board Adverse Event Form."

You are also reminded, that all changes that might affect human participants must be cleared by the GREB. For example, you must report changes in study procedures or implementation of new aspects into the study procedures. Your request for protocol changes will be forwarded to the appropriate GREB reviewers and/or the GREB Chair. To submit an amendment form, access the application at http://www.queensu.ca/traq/signon.html; click on "Events;" under "Create New Event" click on "General Research Ethics Board Request for the Amendment of Approved Studies."

On behalf of the General Research Ethics Board, I wish you continued success in your research.

Yours sincerely,

Dean Tripp, Ph.D.
Chair, General Research Ethics Board

c.: Dr. Lynda Colgan, Supervisor
Dr. Benjamin Bolden, Chair, Unit REB
Mrs. Erin Rennie, Dept. Admin.

July 24, 2019

Mr. Steven Mueller
Master's Student
Faculty of Education
Queen's University
Duncan McArthur Hall
511 Union Street
Kingston, ON, K7M 5R7

Dear Mr. Mueller:

GREB TRAQ #: 6021611
Title: "GEDUC-867-17 A Historical Examination of the Secondary Mathematics Curriculum in Ontario Through Two Lenses: Curriculum Policy Documents and Reflections of Leaders in the Field"

The General Research Ethics Board (GREB) has reviewed and cleared your request for renewal of ethics clearance for the above-named study. This renewal is valid for one year from August 14, 2019. Prior to the next renewal date, you will be sent a reminder memo and the link to ROMEO to renew for another year. You are reminded of your obligation to submit an Annual Renewal/Closure Form prior to the annual renewal due date (access this form at http://www.queensu.ca/traq/signon.html/; click on "Events;" under "Create New Event" click on "General Research Ethics Board Annual Renewal/Closure Form for Cleared Studies"). Please note that when your research project is completed, you need to submit an Annual Renewal/Completed Form in Romeo/traq indicating that the project is 'completed' so that the file can be closed. This should be submitted at the time of completion; there is no need to wait until the annual renewal due date.

You are reminded of your obligation to advise the GREB of any adverse event(s) that occur during this one-year period. An adverse event includes, but is not limited to, a complaint, a change or unexpected event that alters the level of risk for the researcher or participants or situation that requires a substantial change in approach to a participant(s). You are also advised that all adverse events must be reported to the GREB within 48 hours. To submit an adverse event report, access the application at http://www.queensu.ca/traq/signon.html/; click on "Events;" under "Create New Event" click on "General Research Ethics Board Adverse Event Form."

You are also reminded, that all changes that might affect human participants must be cleared by the GREB. For example, you must report changes in study procedures or implementation of new aspects into the study procedures. Your request for protocol changes will be forwarded to the appropriate GREB reviewers and/or the GREB Chair. To submit an amendment form, access the application at http://www.queensu.ca/traq/signon.html; click on "Events;" under "Create New Event" click on "General Research Ethics Board Request for the Amendment of Approved Studies."

On behalf of the General Research Ethics Board, I wish you continued success in your research.

Yours sincerely,

Chair, General Research Ethics Board (GREB)
Professor Dean A. Tripp, PhD
Departments of Psychology, Anesthesiology & Urology Queen's University

c.: Dr. Lynda Colgan, Supervisor
Dr. Pamela Beach, Chair, Unit REB
Haven Jerreat-Poole, Dept. Admin.

Appendix D: Three Pages of Sample Transcript

Speaker 1:	00:14:35	Okay. Um, curriculum a bit here. So there's a curriculum change process. Were there other members of the teams that you're part of? What were their roles?
Speaker 2:	00:14:46	We had to do an RFP, do you know what that is?
Speaker 1:	00:14:49	No
Speaker 2:	00:14:49	The proposal to the ministry to get writing project and Person A and Person B, lead that. And they wrote the proposal and there were many, many, many steps. You had to have people who had experience with Special Ed, people had experienced at university. People had, who the teaching mathematics first year courses, people who had experience in the faculties of education, people had experienced in the classroom, people who had experienced. So you can. So you can imagine like there's a lot we had, we put together a team to make sure we covered all of those spaces. I mean we had to cover equity. We had to cover so many things. Um, assessment, everything. We had 72 people on our committee and OAME did not have the financial structure for the ministry to pay for the writing because you have to get all these people together and you have to pay some of them travel, some of them stay overnight, you have to pay meals, all that sort of stuff. And so we joined up with the Fields math ed forum, but I don't know if you know very much about. Yeah, yeah. And, and um, and that's another thing. I've been a part of Fields for, since 1999 I think, or no before that 95, 96 and they agreed to be our partners and so we wrote at fields and they paid a fields and we didn't, I don't, I didn't get paid. I don't believe I got paid, but all my expenses were covered. But I think Person A and Person B got paid. So Person A was the lead for um, this was the secondary curriculum only, not the elementary. This was secondary. Only Person A was the lead, lead for 11 and 12. And I'm trying to think who the leader was for 9/10. And I can't right off the top of my head. I can't remember.
Speaker 1:	00:16:46	That's fine.
Speaker 2:	00:16:46	I was on the 11/12 team. And so Person B was the head, the head writer and I ended up, um, mostly on the 12 team.

And so we got into great discussions of calculus, data management, all of those sorts of things in. And the kinds of topics that we would choose to be as part of our curriculum and the kinds of discussion. Um Person C and I don't know if you know him, , I think he's long since retired. He was really, really passionate about the direction that we have to take as was Person D because Person D even back then was teaching mathematics differently and most of the people who were on our writing team, were teaching mathematics differently with lots of technology, with lots of experiments with lots of, you know, those kinds of things. Not for me, the thinking tasks and the separation of community and application of those that wasn't being done because we haven't been explicit about those things yet. But some of those things were happening implicitly. And then when we wrote the curriculum it became clear how you could do a better job at that and how you could get much stronger at it. And so that was, um, we wrote all one summer and then Person A was seconded to the ministry to finish because it clearly wasn't finished and she had to align with the French writers. And the French team felt a lot more like you do or did then we did cause they wanted, they didn't want to lose any of their topics and they, although they agreed with us about how the instruction should happen, they were really hard. It was really hard to give up topics and we had many fights over calculus and, but they held a lot of sway. They were way, way smaller. Their team was way, way smaller, but they had a big influence because the ministry wanted to present this as a joint effort. And so Person A did a lot of rewriting and some of us and I was one got called down to the ministry as she rewrote calculus and rewrote the Grade 11 course and those sorts of things. And then they did something that I'm never going to quite understand. They wanted to get the new curriculum out quickly. So they released, back then it was one to eight complete. And so I think they'd done that before we started writing the secondary and we couldn't touch those courses. So if we wanted kids to have a better understanding of percent before Grade nine, we couldn't touch. There was nothing we could

Speaker 1:	00:19:22	So you had to work off of whatever you're getting.
Speaker 2:	00:19:24	Whatever was leftover and then. And then there was pressure from the ministry. They talked about changing the

curriculum and they decided that if they released nine and 10 separately, then we could build into a 11 and 12 and then the, the current 11, 12 and OAC could continue and, and without much, without expecting, you know, we wouldn't have to use new curriculum because things are changing. And so the 9 and 10 we came off the table, so now we're writing 11 and 12 and everybody wants all of the old, old things that were in the OAC courses and we have two years to do them and we couldn't

Speaker 1:	00:20:05	Because you're working off whatever nine, 10 is at this point, you can't.
Speaker 2:	00:20:08	Yeah. If we had been allowed to work from one to 12, we might've been able to download some of those things in a different way. And we, we, we got rid of spiraling because there wasn't time which was hurtful to the students who needed to repeat. Um, and like for instance, we didn't teach integers anymore in Grade 9. We didn't, we just use them. We didn't take all those sorts of things that we were used to spiraling because we were cramped to try to get to
Speaker 1:	00:20:39	So your condensing 3 years into 2?
Speaker 2:	00:20:39	Instead of, instead of five years into four or five years is like or 13 years into 12, totally different ways of writing the curriculum. So when they were reviewing, we went at it again, fields took a really, really took a strong voice in that and said, okay, let's go k to 12, let's go k to 12, let's do it all at once. And they didn't, they went, they went K to 8.
Speaker 1:	00:21:06	Was their any communication between the groups at the start?
Speaker 2:	00:21:09	Yes, yes, we heard they had lots of, um, lots of communication. But for some reason it was if they went k to k to 12, it takes two years to revise the curriculum. But if you do k to eight, you can get it out in one year and then you can get the next one out and the next year. So it's, it's problematic when you're in a rush. And, and I mean when they had the 85 curriculum, they field tested all the texts for three years before they publish them. So they knew what was working, what kids were getting at, what was it? There was no field testing anymore. It was like Bam.

Appendix E: Document Analysis Category Charts

CATEGORY: Analytic geometry (constructions, bisectors, parallel lines, congruence, chords, locus etc)

	1961 Gr11-13 1964 9 &10	**1972 Senior Grades**	**1980 Interm- ediate Grades**	**1985 Gr. 9-12 Basic**	**1985 Gr. 9-12 General**	**1985 Gr. 9-13 Advanced**	**1995 Common Curriculum (Gr9 only)**	**1999 Gr 9-10 (Academic) 2000 Gr 11-12**	**1999 Gr 9-10 (Applied) 2000 Gr 11-12**	**2005 Gr 9-10 (Academic) 2007 Gr 11-12**	**2005 Gr 9-10 (Applied) 2007 Gr 11-12**
Grade 9	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Grade 10			✓		✓	✓		✓		✓	
Grade 11	✓				✓	✓					
Grade 12		✓			✓	✓		✓			
Grade 13											

CATEGORY: Sum of interior angles/exterior angles of shapes, angle properties

	1961 Gr11-13 1964 9 &10	**1972 Senior Grades**	**1980 Interm-ediate Grades**	**1985 Gr. 9-12 Basic**	**1985 Gr. 9-12 General**	**1985 Gr. 9-13 Advanced**	**1995 Common Curriculum (Gr9 only)**	**1999 Gr 9-10 (Academic) 2000 Gr 11-12**	**1999 Gr 9-10 (Applied) 2000 Gr 11-12**	**2005 Gr 9-10 (Academic) 2007 Gr 11-12**	**2005 Gr 9-10 (Applied) 2007 Gr 11-12**
Grade 9						✓	✓	✓	✓	✓	✓
Grade 10	✓										
Grade 11	✓										
Grade 12											
Grade 13											

CATEGORY: Proofs (inductive or deductive)

	1961 Gr11-13 1964 9 &10	1972 Senior Grades	1980 Interm-ediate Grades	1985 Gr. 9-12 Basic	1985 Gr. 9-12 General	1985 Gr. 9-13 Advanced	1995 Common Curriculum (Gr9 only)	1999 Gr 9-10 (Academic) 2000 Gr 11-12	1999 Gr 9-10 (Applied) 2000 Gr 11-12	2005 Gr 9-10 (Academic) 2007 Gr 11-12	2005 Gr 9-10 (Applied) 2007 Gr 11-12
Grade 9											
Grade 10			✓			✓					
Grade 11	✓					✓					
Grade 12	✓	✓				✓		✓			
Grade 13	✓	✓				✓					

CATEGORY: Function and relations (notation, linear and quadratic functions, inverse, domain, range)

	1961 Gr11-13 1964 9 &10	**1972 Senior Grades**	**1980 Interm- ediate Grades**	**1985 Gr. 9- 12 Basic**	**1985 Gr. 9-12 General**	**1985 Gr. 9-13 Advanced**	**1995 Common Curriculum (Gr9 only)**	**1999 Gr 9-10 (Academic) 2000 Gr 11-12**	**1999 Gr 9-10 (Applied) 2000 Gr 11-12**	**2005 Gr 9-10 (Academic) 2007 Gr 11-12**	**2005 Gr 9-10 (Applied) 2007 Gr 11-12**
Grade 9			✓			✓					
Grade 10	✓		✓			✓					
Grade 11						✓		✓		✓	
Grade 12		✓				✓		✓		✓	
Grade 13		✓									

CATEGORY: Ratios and Proportion

	1961 Gr11-13 1964 9 &10	**1972 Senior Grades**	**1980 Interm- ediate Grades**	**1985 Gr. 9-12 Basic**	**1985 Gr. 9-12 General**	**1985 Gr. 9-13 Advanced**	**1995 Common Curriculum (Gr9 only)**	**1999 Gr 9-10 (Academic) 2000 Gr 11-12**	**1999 Gr 9-10 (Applied) 2000 Gr 11-12**	**2005 Gr 9-10 (Academic) 2007 Gr 11-12**	**2005 Gr 9-10 (Applied) 2007 Gr 11-12**
Grade 9			✓	✓	✓	✓	✓	✓	✓	✓	✓
Grade 10	✓				✓						
Grade 11	✓					✓					
Grade 12											
Grade 13											

CATEGORY: Powers and Roots

	1961 Gr11-13 1964 9 &10	**1972 Senior Grades**	**1980 Interm- ediate Grades**	**1985 Gr. 9-12 Basic**	**1985 Gr. 9-12 General**	**1985 Gr. 9-13 Advanced**	**1995 Common Curriculum (Gr9 only)**	**1999 Gr 9-10 (Academic) 2000 Gr 11-12**	**1999 Gr 9-10 (Applied) 2000 Gr 11-12**	**2005 Gr 9-10 (Academic) 2007 Gr 11-12**	**2005 Gr 9-10 (Applied) 2007 Gr 11-12**
Grade 9			✓	✓	✓	✓	✓				
Grade 10	✓				✓	✓					
Grade 11		✓			✓	✓		✓		✓	
Grade 12	✓	✓			✓	✓		✓		✓	✓
Grade 13		✓									

CATEGORY: Quadratics (factoring quadratics, quadratic equations, solving quadratic equations, discriminant)

	1961 Gr11-13 1964 9 &10	**1972 Senior Grades**	**1980 Interm-ediate Grades**	**1985 Gr. 9-12 Basic**	**1985 Gr. 9-12 General**	**1985 Gr. 9-13 Advanced**	**1995 Common Curriculum (Gr9 only)**	**1999 Gr 9-10 (Academic) 2000 Gr 11-12**	**1999 Gr 9-10 (Applied) 2000 Gr 11-12**	**2005 Gr 9-10 (Academic) 2007 Gr 11-12**	**2005 Gr 9-10 (Applied) 2007 Gr 11-12**
Grade 9											
Grade 10								✓	✓	✓	✓
Grade 11		✓				✓					✓
Grade 12	✓	✓							✓		
Grade 13											

CATEGORY: Indices

	1961 Gr11-13 1964 9 &10	1972 Senior Grades	1980 Interm-ediate Grades	1985 Gr. 9-12 Basic	1985 Gr. 9-12 General	1985 Gr. 9-13 Advanced	1995 Common Curriculum (Gr9 only)	1999 Gr 9-10 (Academic) 2000 Gr 11-12	1999 Gr 9-10 (Applied) 2000 Gr 11-12	2005 Gr 9-10 (Academic) 2007 Gr 11-12	2005 Gr 9-10 (Applied) 2007 Gr 11-12
Grade 9											
Grade 10											
Grade 11											
Grade 12											
Grade 13	✓										

CATEGORY: Logarithms

	1961 Gr11-13 1964 9 &10	**1972 Senior Grades**	**1980 Interm- ediate Grades**	**1985 Gr. 9- 12 Basic**	**1985 Gr. 9-12 General**	**1985 Gr. 9-13 Advanced**	**1995 Common Curriculum (Gr9 only)**	**1999 Gr 9-10 (Academic) 2000 Gr 11-12**	**1999 Gr 9-10 (Applied) 2000 Gr 11-12**	**2005 Gr 9-10 (Academic) 2007 Gr 11-12**	**2005 Gr 9-10 (Applied) 2007 Gr 11-12**
Grade 9											
Grade 10											
Grade 11		✓									
Grade 12	✓	✓				✓		✓	✓	✓	
Grade 13	✓					✓					

CATEGORY: Arithmetic and Geometric Series and sequences

	1961 Gr11-13 1964 9 &10	**1972 Senior Grades**	**1980 Interm- ediate Grades**	**1985 Gr. 9- 12 Basic**	**1985 Gr. 9-12 General**	**1985 Gr. 9-13 Advanced**	**1995 Common Curriculum (Gr9 only)**	**1999 Gr 9-10 (Academic) 2000 Gr 11-12**	**1999 Gr 9-10 (Applied) 2000 Gr 11-12**	**2005 Gr 9-10 (Academic) 2007 Gr 11-12**	**2005 Gr 9-10 (Applied) 2007 Gr 11-12**
Grade 9											
Grade 10											
Grade 11		✓				✓		✓	✓	✓	
Grade 12	✓	✓									
Grade 13	✓					✓					

CATEGORY: Permutations and Combinations (binomial theorem)

	1961 Gr11-13 1964 9 &10	**1972 Senior Grades**	**1980 Interm- ediate Grades**	**1985 Gr. 9- 12 Basic**	**1985 Gr. 9-12 General**	**1985 Gr. 9-13 Advanced**	**1995 Common Curriculum (Gr9 only)**	**1999 Gr 9-10 (Academic) 2000 Gr 11-12**	**1999 Gr 9-10 (Applied) 2000 Gr 11-12**	**2005 Gr 9-10 (Academic) 2007 Gr 11-12**	**2005 Gr 9-10 (Applied) 2007 Gr 11-12**
Grade 9											
Grade 10											
Grade 11											
Grade 12								✓		✓	
Grade 13	✓	✓				✓					

CATEGORY: Mathematics of investment (annuities, mortgages etc)

	1961 Gr11-13 1964 9 &10	**1972 Senior Grades**	**1980 Interm-ediate Grades**	**1985 Gr. 9-12 Basic**	**1985 Gr. 9-12 General**	**1985 Gr. 9-13 Advanced**	**1995 Common Curriculum (Gr9 only)**	**1999 Gr 9-10 (Academic) 2000 Gr 11-12**	**1999 Gr 9-10 (Applied) 2000 Gr 11-12**	**2005 Gr 9-10 (Academic) 2007 Gr 11-12**	**2005 Gr 9-10 (Applied) 2007 Gr 11-12**
Grade 9											
Grade 10											
Grade 11		✓				✓		✓	✓	✓	
Grade 12					✓						
Grade 13	✓	✓									

CATEGORY: Slope of a line, coordinate system

	1961 Gr11-13 1964 9 &10	1972 Senior Grades	1980 Interm- ediate Grades	1985 Gr. 9- 12 Basic	1985 Gr. 9-12 General	1985 Gr. 9-13 Advanced	1995 Common Curriculum (Gr9 only)	1999 Gr 9-10 (Academic) 2000 Gr 11-12	1999 Gr 9-10 (Applied) 2000 Gr 11-12	2005 Gr 9-10 (Academic) 2007 Gr 11-12	2005 Gr 9-10 (Applied) 2007 Gr 11-12
Grade 9								✓	✓	✓	✓
Grade 10			✓		✓	✓		✓	✓	✓	✓
Grade 11		✓			✓						
Grade 12		✓									
Grade 13	✓										

CATEGORY: Conics (circle, hyperbola, ellipse)

	1961 Gr11-13 1964 9 &10	1972 Senior Grades	1980 Interm- ediate Grades	1985 Gr. 9- 12 Basic	1985 Gr. 9-12 General	1985 Gr. 9-13 Advanced	1995 Common Curriculum (Gr9 only)	1999 Gr 9-10 (Academic) 2000 Gr 11-12	1999 Gr 9-10 (Applied) 2000 Gr 11-12	2005 Gr 9-10 (Academic) 2007 Gr 11-12	2005 Gr 9-10 (Applied) 2007 Gr 11-12
Grade 9			✓								
Grade 10											
Grade 11		✓						✓			
Grade 12		✓				✓					
Grade 13	✓	✓									

CATEGORY: Trigonometry (solving triangles)

	1961 Gr11-13 1964 9 &10	**1972 Senior Grades**	**1980 Interm-ediate Grades**	**1985 Gr. 9-12 Basic**	**1985 Gr. 9-12 General**	**1985 Gr. 9-13 Advanced**	**1995 Common Curriculum (Gr9 only)**	**1999 Gr 9-10 (Academic) 2000 Gr 11-12**	**1999 Gr 9-10 (Applied) 2000 Gr 11-12**	**2005 Gr 9-10 (Academic) 2007 Gr 11-12**	**2005 Gr 9-10 (Applied) 2007 Gr 11-12**
Grade 9											
Grade 10	✓		✓		✓			✓	✓	✓	✓
Grade 11		✓			✓			✓		✓	✓
Grade 12					✓				✓		✓
Grade 13	✓										

CATEGORY: Trigonometry (functions, identities and radians)

	1961 Gr11-13 1964 9 &10	**1972 Senior Grades**	**1980 Interm-ediate Grades**	**1985 Gr. 9-12 Basic**	**1985 Gr. 9-12 General**	**1985 Gr. 9-13 Advanced**	**1995 Common Curriculum (Gr9 only)**	**1999 Gr 9-10 (Academic) 2000 Gr 11-12**	**1999 Gr 9-10 (Applied) 2000 Gr 11-12**	**2005 Gr 9-10 (Academic) 2007 Gr 11-12**	**2005 Gr 9-10 (Applied) 2007 Gr 11-12**
Grade 9											
Grade 10											
Grade 11		✓						✓		✓	
Grade 12		✓			✓	✓			✓	✓	✓
Grade 13	✓	✓				✓					

CATEGORY: Statics(forces, gravity, newtons third law)

	1961 Gr11-13 1964 9 &10	**1972 Senior Grades**	**1980 Interm- ediate Grades**	**1985 Gr. 9- 12 Basic**	**1985 Gr. 9-12 General**	**1985 Gr. 9-13 Advanced**	**1995 Common Curriculum (Gr9 only)**	**1999 Gr 9-10 (Academic) 2000 Gr 11-12**	**1999 Gr 9-10 (Applied) 2000 Gr 11-12**	**2005 Gr 9-10 (Academic) 2007 Gr 11-12**	**2005 Gr 9-10 (Applied) 2007 Gr 11-12**
Grade 9											
Grade 10											
Grade 11		✓									
Grade 12					✓						
Grade 13	✓										

CATEGORY: Computation (fractions, decimals, rounding, exponent, number systems)

	1961 Gr11-13 1964 9 &10	**1972 Senior Grades**	**1980 Interm- ediate Grades**	**1985 Gr. 9-12 Basic**	**1985 Gr. 9-12 General**	**1985 Gr. 9-13 Advanced**	**1995 Common Curriculum (Gr9 only)**	**1999 Gr 9-10 (Academic) 2000 Gr 11-12**	**1999 Gr 9-10 (Applied) 2000 Gr 11-12**	**2005 Gr 9-10 (Academic) 2007 Gr 11-12**	**2005 Gr 9-10 (Applied) 2007 Gr 11-12**
Grade 9	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Grade 10	✓		✓	✓	✓						
Grade 11					✓						
Grade 12					✓						
Grade 13											

CATEGORY: Rational and Irrational Numbers

	1961 Gr11-13 1964 9 &10	**1972 Senior Grades**	**1980 Interm- ediate Grades**	**1985 Gr. 9-12 Basic**	**1985 Gr. 9-12 General**	**1985 Gr. 9-13 Advanced**	**1995 Common Curriculum (Gr9 only)**	**1999 Gr 9-10 (Academic) 2000 Gr 11-12**	**1999 Gr 9-10 (Applied) 2000 Gr 11-12**	**2005 Gr 9-10 (Academic) 2007 Gr 11-12**	**2005 Gr 9-10 (Applied) 2007 Gr 11-12**
Grade 9			✓			✓					
Grade 10	✓		✓								
Grade 11					✓						
Grade 12		✓			✓						
Grade 13											

CATEGORY: Personal Finance (interest, buying, renting, taxes etc)

	1961 Gr11-13 1964 9 &10	**1972 Senior Grades**	**1980 Interm- ediate Grades**	**1985 Gr. 9-12 Basic**	**1985 Gr. 9-12 General**	**1985 Gr. 9-13 Advanced**	**1995 Common Curriculum (Gr9 only)**	**1999 Gr 9-10 (Academic) 2000 Gr 11-12**	**1999 Gr 9-10 (Applied) 2000 Gr 11-12**	**2005 Gr 9-10 (Academic) 2007 Gr 11-12**	**2005 Gr 9-10 (Applied) 2007 Gr 11-12**
Grade 9			✓	✓							
Grade 10	✓			✓	✓						
Grade 11		✓		✓	✓				✓		✓
Grade 12				✓	✓				✓		✓
Grade 13											

CATEGORY: Vectors (2 space, dot product, working with vectors)

	1961 Gr11-13 1964 9 &10	**1972 Senior Grades**	**1980 Interm- ediate Grades**	**1985 Gr. 9-12 Basic**	**1985 Gr. 9-12 General**	**1985 Gr. 9-13 Advanced**	**1995 Common Curriculum (Gr9 only)**	**1999 Gr 9-10 (Academic) 2000 Gr 11-12**	**1999 Gr 9-10 (Applied) 2000 Gr 11-12**	**2005 Gr 9-10 (Academic) 2007 Gr 11-12**	**2005 Gr 9-10 (Applied) 2007 Gr 11-12**
Grade 9											
Grade 10	✓		✓			✓					
Grade 11		✓									
Grade 12					✓			✓		✓	✓
Grade 13		✓				✓					

CATEGORY: Polynomials (tables of values, collecting like terms, degrees, graphing higher polynomials)

	1961 Gr11-13 1964 9 &10	**1972 Senior Grades**	**1980 Interm- ediate Grades**	**1985 Gr. 9-12 Basic**	**1985 Gr. 9-12 General**	**1985 Gr. 9-13 Advanced**	**1995 Common Curriculum (Gr9 only)**	**1999 Gr 9-10 (Academic) 2000 Gr 11-12**	**1999 Gr 9-10 (Applied) 2000 Gr 11-12**	**2005 Gr 9-10 (Academic) 2007 Gr 11-12**	**2005 Gr 9-10 (Applied) 2007 Gr 11-12**
Grade 9	✓		✓		✓	✓	✓	✓	✓	✓	✓
Grade 10	✓		✓		✓	✓		✓	✓	✓	✓
Grade 11		✓			✓	✓		✓		✓	
Grade 12		✓			✓	✓		✓	✓	✓	✓
Grade 13											

CATEGORY: Exponential Functions

	1961 Gr11-13 1964 9 &10	1972 Senior Grades	1980 Interm-ediate Grades	1985 Gr. 9-12 Basic	1985 Gr. 9-12 General	1985 Gr. 9-13 Advanced	1995 Common Curriculum (Gr9 only)	1999 Gr 9-10 (Academic) 2000 Gr 11-12	1999 Gr 9-10 (Applied) 2000 Gr 11-12	2005 Gr 9-10 (Academic) 2007 Gr 11-12	2005 Gr 9-10 (Applied) 2007 Gr 11-12
Grade 9											
Grade 10											
Grade 11		✓				✓		✓	✓	✓	✓
Grade 12		✓						✓	✓	✓	✓
Grade 13						✓					

CATEGORY: Statistics

	1961 Gr11- 13 1964 9 &10	**1972 Senior Grades**	**1980 Interm- ediate Grades**	**1985 Gr. 9-12 Basic**	**1985 Gr. 9-12 General**	**1985 Gr. 9-13 Advanced**	**1995 Common Curriculum (Gr9 only)**	**1999 Gr 9-10 (Academic) 2000 Gr 11-12**	**1999 Gr 9-10 (Applied) 2000 Gr 11-12**	**2005 Gr 9-10 (Academic) 2007 Gr 11-12**	**2005 Gr 9-10 (Applied) 2007 Gr 11-12**
Grade 9			✓		✓	✓	✓	✓	✓	✓	✓
Grade 10			✓	✓	✓	✓					
Grade 11		✓		✓	✓						✓
Grade 12		✓			✓	✓		✓	✓	✓	✓
Grade 13		✓				✓					

CATEGORY: Probability

	1961 Gr11-13 1964 9 &10	1972 Senior Grades	1980 Interm-ediate Grades	1985 Gr. 9-12 Basic	1985 Gr. 9-12 General	1985 Gr. 9-13 Advanced	1995 Common Curriculum (Gr9 only)	1999 Gr 9-10 (Academic) 2000 Gr 11-12	1999 Gr 9-10 (Applied) 2000 Gr 11-12	2005 Gr 9-10 (Academic) 2007 Gr 11-12	2005 Gr 9-10 (Applied) 2007 Gr 11-12
Grade 9			✓	✓		✓	✓				
Grade 10			✓	✓		✓					
Grade 11		✓									✓
Grade 12		✓						✓		✓	
Grade 13						✓					

CATEGORY: Polar Coordinates

	1961 Gr11-13 1964 9 &10	1972 Senior Grades	1980 Interm-ediate Grades	1985 Gr. 9-12 Basic	1985 Gr. 9-12 General	1985 Gr. 9-13 Advanced	1995 Common Curriculum (Gr9 only)	1999 Gr 9-10 (Academic) 2000 Gr 11-12	1999 Gr 9-10 (Applied) 2000 Gr 11-12	2005 Gr 9-10 (Academic) 2007 Gr 11-12	2005 Gr 9-10 (Applied) 2007 Gr 11-12
Grade 9											
Grade 10											
Grade 11											
Grade 12		✓									
Grade 13		✓									

CATEGORY: Slide Rule

	1961 Gr11-13 1964 9 &10	1972 Senior Grades	1980 Interm-ediate Grades	1985 Gr. 9-12 Basic	1985 Gr. 9-12 General	1985 Gr. 9-13 Advanced	1995 Common Curriculum (Gr9 only)	1999 Gr 9-10 (Academic) 2000 Gr 11-12	1999 Gr 9-10 (Applied) 2000 Gr 11-12	2005 Gr 9-10 (Academic) 2007 Gr 11-12	2005 Gr 9-10 (Applied) 2007 Gr 11-12
Grade 9											
Grade 10											
Grade 11											
Grade 12	✓	✓									
Grade 13	✓										

CATEGORY: Complex Numbers

	1961 Gr11-13 1964 9 &10	**1972 Senior Grades**	**1980 Interm-ediate Grades**	**1985 Gr. 9-12 Basic**	**1985 Gr. 9-12 General**	**1985 Gr. 9-13 Advanced**	**1995 Common Curriculum (Gr9 only)**	**1999 Gr 9-10 (Academic) 2000 Gr 11-12**	**1999 Gr 9-10 (Applied) 2000 Gr 11-12**	**2005 Gr 9-10 (Academic) 2007 Gr 11-12**	**2005 Gr 9-10 (Applied) 2007 Gr 11-12**
Grade 9											
Grade 10											
Grade 11								✓			
Grade 12		✓									
Grade 13		✓				✓					

CATEGORY: Transformations (translation, rotation, reflection, dilation of functions)

	1961 Gr11-13 1964 9 &10	**1972 Senior Grades**	**1980 Interm-ediate Grades**	**1985 Gr. 9-12 Basic**	**1985 Gr. 9-12 General**	**1985 Gr. 9-13 Advanced**	**1995 Common Curriculum (Gr9 only)**	**1999 Gr 9-10 (Academic) 2000 Gr 11-12**	**1999 Gr 9-10 (Applied) 2000 Gr 11-12**	**2005 Gr 9-10 (Academic) 2007 Gr 11-12**	**2005 Gr 9-10 (Applied) 2007 Gr 11-12**
Grade 9			✓			✓	✓				
Grade 10			✓			✓					
Grade 11											
Grade 12											
Grade 13		✓									

CATEGORY: Matrices

	1961 Gr11-13 1964 9 &10	1972 Senior Grades	1980 Interm-ediate Grades	1985 Gr. 9-12 Basic	1985 Gr. 9-12 General	1985 Gr. 9-13 Advanced	1995 Common Curriculum (Gr9 only)	1999 Gr 9-10 (Academic) 2000 Gr 11-12	1999 Gr 9-10 (Applied) 2000 Gr 11-12	2005 Gr 9-10 (Academic) 2007 Gr 11-12	2005 Gr 9-10 (Applied) 2007 Gr 11-12
Grade 9											
Grade 10			✓			✓					
Grade 11											
Grade 12								✓			
Grade 13		✓				✓					

CATEGORY: Logic

	1961 Gr11-13 1964 9 &10	1972 Senior Grades	1980 Interm-ediate Grades	1985 Gr. 9-12 Basic	1985 Gr. 9-12 General	1985 Gr. 9-13 Advanced	1995 Common Curriculum (Gr9 only)	1999 Gr 9-10 (Academic) 2000 Gr 11-12	1999 Gr 9-10 (Applied) 2000 Gr 11-12	2005 Gr 9-10 (Academic) 2007 Gr 11-12	2005 Gr 9-10 (Applied) 2007 Gr 11-12
Grade 9											
Grade 10											
Grade 11											
Grade 12											
Grade 13		✓									

CATEGORY: Derivatives (limits, First, second, applications)

	1961 Gr11- 13 1964 9 &10	1972 Senior Grades	1980 Interm- ediate Grades	1985 Gr. 9- 12 Basic	1985 Gr. 9-12 General	1985 Gr. 9-13 Advanced	1995 Common Curriculum (Gr9 only)	1999 Gr 9-10 (Academic) 2000 Gr 11-12	1999 Gr 9-10 (Applied) 2000 Gr 11-12	2005 Gr 9-10 (Academic) 2007 Gr 11-12	2005 Gr 9-10 (Applied) 2007 Gr 11-12
Grade 9											
Grade 10											
Grade 11											
Grade 12								✓		✓	
Grade 13		✓				✓					

CATEGORY: Set Notation

	1961 Gr11-13 1964 9 &10	**1972 Senior Grades**	**1980 Interm-ediate Grades**	**1985 Gr. 9-12 Basic**	**1985 Gr. 9-12 General**	**1985 Gr. 9-13 Advanced**	**1995 Common Curriculum (Gr9 only)**	**1999 Gr 9-10 (Academic) 2000 Gr 11-12**	**1999 Gr 9-10 (Applied) 2000 Gr 11-12**	**2005 Gr 9-10 (Academic) 2007 Gr 11-12**	**2005 Gr 9-10 (Applied) 2007 Gr 11-12**
Grade 9											
Grade 10											
Grade 11											
Grade 12										✓	
Grade 13		✓									

CATEGORY: Planes (vectors in 3 space, working with planes)

	1961 Gr11- 13 1964 9 &10	**1972 Senior Grades**	**1980 Interm- ediate Grades**	**1985 Gr. 9- 12 Basic**	**1985 Gr. 9-12 General**	**1985 Gr. 9-13 Advanced**	**1995 Common Curriculum (Gr9 only)**	**1999 Gr 9-10 (Academic) 2000 Gr 11-12**	**1999 Gr 9-10 (Applied) 2000 Gr 11-12**	**2005 Gr 9-10 (Academic) 2007 Gr 11-12**	**2005 Gr 9-10 (Applied) 2007 Gr 11-12**
Grade 9											
Grade 10											
Grade 11											
Grade 12								✓		✓	
Grade 13		✓				✓					

CATEGORY: Linear equations (y=mx+b form, linear systems)

	1961 Gr11-13 1964 9 &10	**1972 Senior Grades**	**1980 Interm-ediate Grades**	**1985 Gr. 9-12 Basic**	**1985 Gr. 9-12 General**	**1985 Gr. 9-13 Advanced**	**1995 Common Curriculum (Gr9 only)**	**1999 Gr 9-10 (Academic) 2000 Gr 11-12**	**1999 Gr 9-10 (Applied) 2000 Gr 11-12**	**2005 Gr 9-10 (Academic) 2007 Gr 11-12**	**2005 Gr 9-10 (Applied) 2007 Gr 11-12**
Grade 9							✓	✓	✓	✓	✓
Grade 10			✓		✓	✓		✓	✓	✓	✓
Grade 11					✓						
Grade 12					✓				✓		
Grade 13											

CATEGORY: Measurement (area, perimeter, length, mass, volume, units)

	1961 Gr11-13 1964 9 &10	**1972 Senior Grades**	**1980 Interm- ediate Grades**	**1985 Gr. 9-12 Basic**	**1985 Gr. 9-12 General**	**1985 Gr. 9-13 Advanced**	**1995 Common Curriculum (Gr9 only)**	**1999 Gr 9-10 (Academic) 2000 Gr 11-12**	**1999 Gr 9-10 (Applied) 2000 Gr 11-12**	**2005 Gr 9-10 (Academic) 2007 Gr 11-12**	**2005 Gr 9-10 (Applied) 2007 Gr 11-12**
Grade 9	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Grade 10			✓	✓		✓					
Grade 11				✓	✓						
Grade 12				✓					✓		✓
Grade 13											

CATEGORY: Differential Equations/Antidifferentiation

	1961 Gr11-13 1964 9 &10	**1972 Senior Grades**	**1980 Interm- ediate Grades**	**1985 Gr. 9-12 Basic**	**1985 Gr. 9-12 General**	**1985 Gr. 9-13 Advanced**	**1995 Common Curriculum (Gr9 only)**	**1999 Gr 9-10 (Academic) 2000 Gr 11-12**	**1999 Gr 9-10 (Applied) 2000 Gr 11-12**	**2005 Gr 9-10 (Academic) 2007 Gr 11-12**	**2005 Gr 9-10 (Applied) 2007 Gr 11-12**
Grade 9											
Grade 10											
Grade 11											
Grade 12											
Grade 13						✓					

CATEGORY: Curve sketching

	1961 Gr11-13 1964 9 &10	**1972 Senior Grades**	**1980 Interm- ediate Grades**	**1985 Gr. 9-12 Basic**	**1985 Gr. 9-12 General**	**1985 Gr. 9-13 Advanced**	**1995 Common Curriculum (Gr9 only)**	**1999 Gr 9-10 (Academic) 2000 Gr 11-12**	**1999 Gr 9-10 (Applied) 2000 Gr 11-12**	**2005 Gr 9-10 (Academic) 2007 Gr 11-12**	**2005 Gr 9-10 (Applied) 2007 Gr 11-12**
Grade 9											
Grade 10											
Grade 11											
Grade 12								✓		✓	
Grade 13						✓					

Appendix F: Interview Guideline

Part One: Background

1. What is your current role within the math education community? How long have you been in this role?
2. What other types of roles have you had in the math education community? How long did you spend in those roles?

Part Two: Experiences with Curriculum Change

1. What Ontario math curriculum changes have you been a part of?
2. What was the nature of your roles in those changes and your specific responsibilities?

   Sub questions: Were you working full-time, was there a secondment?
3. Who were the other members of the team? What were their roles and background?
4. How did the curriculum change process work? Where did your role fall within the larger project?
5. How did you initially get involved with the curriculum writing process in Ontario? What was your motivation to get involved?

Part Three: Reflections on Experiences

1. As you think back on your participation on the curriculum writing process what experiences stand out for you?
2. What do you think was your most significant contribution to the curriculum writing team?

3. How would you compare the intended document from the curriculum writing team to the actual final released product?
4. How do you feel about the final product and how it was implemented?
5. What advice would you give for future curriculum revision committees?

Part Four: Questions that emerged from Phase One

1. It is commonly believed that with each review process there has been a decrease in the number of topics and the rigor of the math curriculum. How would respond to this statement based on your own experience.
2. If you were in a position to advise the Minister of Education right now what advice would you give to improve the learning experience of Ontario's high school students?

   Sub questions: Were they previously included and removed?

   If new, why should this topic be included?
3. If you could write your own ideal math curriculum, who would be on your team and what would be your priorities?