The State of Mathematics Education in Ontario:
Where We Came From and Where We Are

A Report Prepared for the Canadian School Mathematics Forum
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The teaching and learning of mathematics in Ontario has been in a state of continual change over the last 50 years. In the 60's, the "new math," which exposed students to set theory and properties of number systems, emerged. For students who could easily deal with the abstract, this approach worked well, but many had to be satisfied with learning the "facts" and a few algorithms, few of which were based on any "real world" context. Subsequently, problem solving was deemed the cornerstone of effective teaching in mathematics. In 1985, new guidelines were introduced that described approaches to teaching mathematics through inquiry, problem solving, and the use of technology — the main tenets of the most recent documents for curriculum renewal in Ontario.

The following report begins with a history of the elementary and secondary curricula since 1997. It describes both the nature of the curriculum change in terms of content, pedagogy, and assessment and the steps taken to implement these changes across Ontario. The report then highlights and summarizes responses from Ontario teachers, consultants, and professors, based on a short survey taken in early 2003. The final section identifies some of the key issues in mathematics education in Ontario that continue to be controversial.

Curriculum Reformation in Ontario – 1997 to the Present

Elementary

In 1997, the renewal began with the implementation of *Mathematics, The Ontario Curriculum, Grades 1 – 8.* This policy document replaced *The Common Curriculum: Policies and Outcomes, Grades 1 – 9, 1995.* Teachers and parents wanted more clarity about the required learning outcomes for each and every grade while the province wanted a curriculum that was standard across the province. Ideally, the mathematics delivered in a Grade 2 classroom in Thunder Bay would be the same as the mathematics delivered in Grade 2 classrooms in Sarnia or Ottawa. Moreover, as clearly stated in the fourth sentence of the document, "The mathematics curriculum set out in this document is significantly more *rigorous* [my emphasis] and demanding than previous curricula."

The main body of the 1997 curriculum is organized by strands — Number Sense and Numeration; Geometry and Spatial Sense; Measurement, Patterning and Algebra; and Data Management and Probability. Each strand includes general expectations and approximately 80 – 100 specific expectations for each grade. The explanatory text addresses such issues as the role of parents, teachers, and students; the importance of mathematics; the importance of problem solving; pencil-and-paper skills; and the use of calculators and computers.

Leaders representing subject associations, such as OAME (Ontario Association for Mathematics Education) and OMCA (Ontario Mathematics Coordinator's Association), embraced the guiding principles of the curriculum document, in particular, statements such as the following:

> *"Students engage in problem solving in all strands…."*
>
> *"In analyzing problems and presenting solutions, students are expected to use technology effectively."*
>
> *"[Students] should also use problem-solving methods extensively as a means of developing the full range of mathematical skills and knowledge in all strands."*

References to the importance of communication in learning mathematics and the importance of developing positive attitudes toward mathematics were also well received. On the other hand, there was a certain degree of skepticism about the statement, "This provision of detail will eliminate the need for school boards to write their own expectations, will ensure consistency in curriculum across the province, and *will facilitate province-wide testing* [italics mine]."

If one aspect of this document was truly at variance with previous practice, it was the change in the assessment and evaluation paradigm. Assessing and grading was to be based on "Levels of Performance" across four "Categories" (Problem Solving, Understanding of Concepts, Application of Mathematical Procedures, and Communication of Required Knowledge), a shift that could be characterized as a move from a norm-referenced approach to a criterion-referenced approach to assessment and evaluation. Initially, teachers were required to report on all five strands in each of the three terms. This was set to be phased in over a couple of years, but active lobbying by the OMCA and OAME led to a shift in Ministry policy. Teachers in elementary grades are now required to report on each strand a minimum of twice per school year and on at least two different strands each term.

By 1998, the province-wide Grade 3 census testing of mathematics had begun. The Education Quality and Accountability Office (EQAO), an arms-length agency of the provincial government, developed, field-tested, evaluated, and reported the results of the first Grade 3 assessment. Initially, this test was administered over a two-week period. In ensuing years, EQAO introduced both the Grade 6 assessments and the Grade 9 Applied and Academic mathematics assessments.

Implementation of the Elementary Curriculum

On paper, the curriculum appeared to be a positive step forward. However, curriculum implementation is a process, not an event, and everyone, from Ministry officials to mathematics consultants, coordinators, and teachers, agreed that full implementation would take at least five years and that its success would depend on:

- inservice for teachers to build awareness about the structure and content of the new curriculum document,

- inservice for teachers with respect to the pedagogy of effective mathematics teaching [based on research and the key principles as outlined in the explanatory text of the document],
- inservice for teachers about the shift in the approach with respect to assessment and evaluation of student work,
- availability of text and other print resources based on the new curriculum,
- availability of the manipulatives necessary to deliver a meaningful mathematics program,
- availability of technology and the training necessary to help teachers use it effectively in the mathematics classroom, and
- support for pre-service programs to ensure that teacher training would be based on the tenets of the new curriculum.

If there was a master plan for implementation, it was not evident. Nonetheless, some aspects of implementation did occur in a timely manner. Textbooks were provincially approved and funds were provided to schools for their purchase. (Two books were published for Grades 1 – 6 courses and four books were produced for Grades 7 and 8.) There continues to be significant controversy over the effectiveness and usability of these new texts. Although some teachers have embraced the new resources, many teachers have simply shelved them and resorted to older resources. For the new books to be effective, teachers required high-quality training that, often, was not readily available. In fact, inservice of the new curriculum in general was uneven across the province. School boards that had centrally assigned curriculum specialists in mathematics and budgets for both after-school and during-school workshops were able to start to sow the seeds of change, but many boards (especially rural and northern boards), had few, if any, central mathematics subject specialists and few resources available for inservice. Furthermore, the implementation of the new mathematics curriculum paralleled the implementation of curricula for most other subject areas, all at a time when boards across the province were forced to cut spending to meet the provincial funding formula.

Is there evidence today that changes have been made to curriculum substance and delivery? The answer is yes. Despite the spotty approach to teacher training, organizations such as the OAME and OMCA worked very hard to support the implementation of the new curriculum through publications, conferences, and workshops, and EQAO ensured that all province-wide testing instruments were developed by teachers, field tested by teachers, and marked by teachers. Eighty percent of the Grade 3 and Grade 6 mathematics tests comprised full response tasks that, up until last year, were marked holistically by levels of performance. (The remaining twenty percent consisted of multiple choice questions.) The impact this had on teaching can be attributed to two factors. First, all Grade 3 and 6 teachers administering the test needed to become familiar with the style and substance of full-response tasks that addressed **all strands and categories**. Second, the training of large numbers of developers and markers has proven to be of great value to the implementation of the new curriculum. For two weeks each summer, nearly 2000 teachers are engaged in the language of categories, strands, and levels of performance. Furthermore, they discuss the qualities of hundreds of student responses in order to arrive at a consensus for grading. Teachers, more often than not, return to their classrooms better prepared to deliver the intended curriculum. Regrettably,

the results of EQAO tests have been badly used by the press and misinterpreted by the public, especially where schools are ranked by results without reference to confounding factors.

Recently, there have been two major developments in the implementation of the elementary mathematics curriculum. First, at least four publishers are actively preparing new textbooks that will meet the needs of the new curriculum and respond to the concerns about the books that were originally released in the late nineties. Second, the Ministry of Education has entered the fray by initiating the *Early Math Strategy*. This well-funded program provides for in-depth training for a lead primary mathematics teacher in every elementary school in Ontario. An average of $2000 will be provided to every elementary school in Ontario to purchase manipulatives, calculators, and other teacher resources. Furthermore, teachers and administrators will receive training that will help them analyze report card and EQAO data in order to set targets for improvement.

Secondary

Secondary curriculum renewal in Ontario began in earnest in early 1997. In Geoffrey Roulet's background research paper entitled "Mathematics Curriculum for Ontario Secondary Schools: Issues, Choices and Options," he identifies three visions for teaching and learning mathematics — instrumentalism, formalism, and problem solving or social-constructivism. Dr. Roulet asserts that curriculum writers must be clear about which philosophy will underpin their writing and must be consistent and true to it.

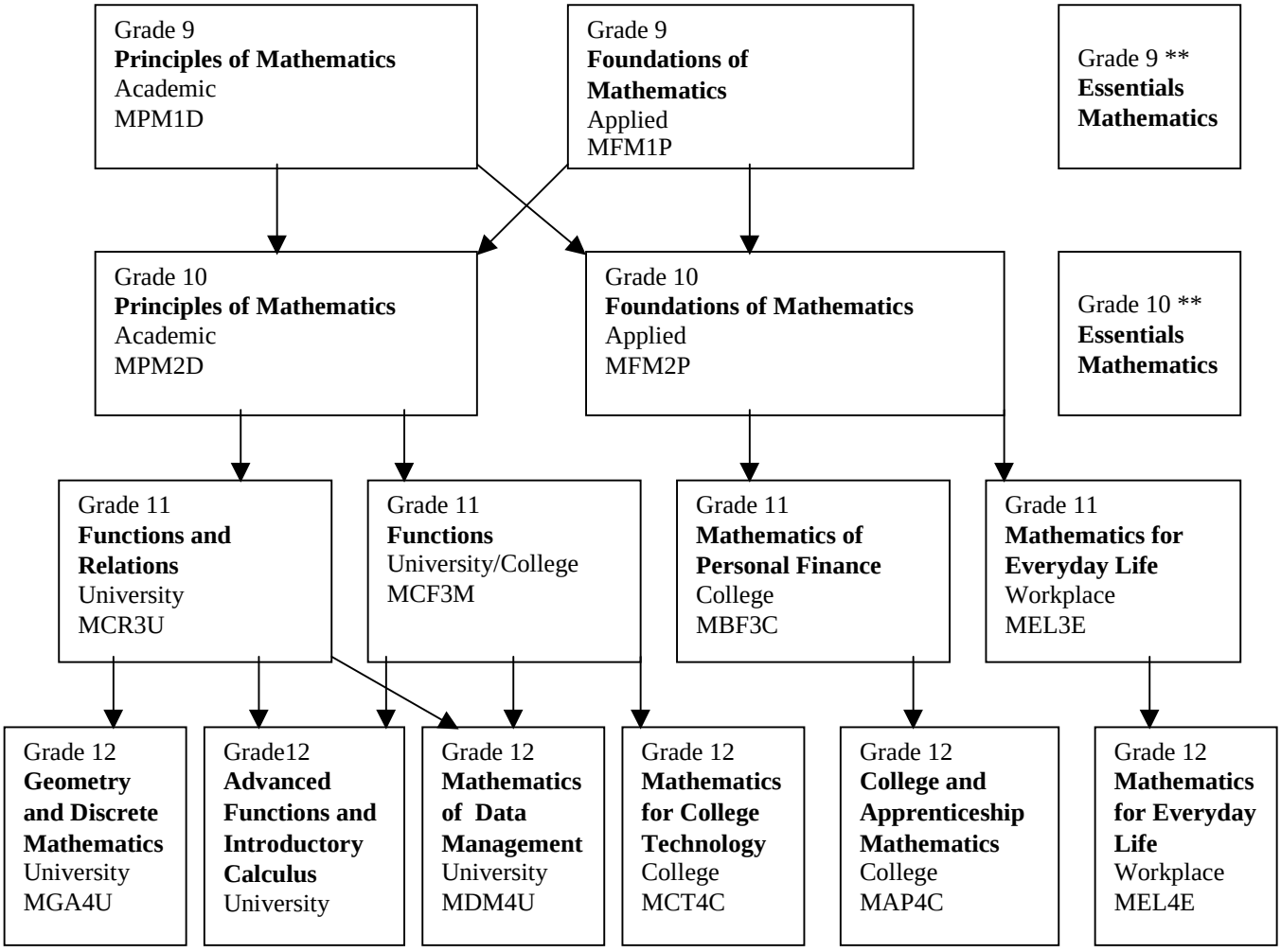
Curriculum renewal in Ontario has been evolving since the publication of the NCTM *Curriculum and Evaluation Standards for School Mathematics* in 1989. The OAME, OMCA, and more recently, the Field's Institute Mathematics Education Forum have been actively engaged in the conversation about secondary school mathematics curriculum. Consensus-building among mathematics teachers, secondary mathematics department heads, board consultants and coordinators, university and college professors, faculty of education professors, parents, Ministry officials, and other interested parties has been, at the very least, difficult. Nonetheless, an expert panel was formed to construct a framework for a new curriculum. The panel consisted of representatives from secondary schools, board coordinators and consultants, college and university professors, and workers from business and the professions. The expert panel's report highlighted the importance of inquiry-based learning, investigations, mathematical communication, mathematical modelling, appropriate use of technology, and the importance of proper implementation — tenets very much aligned with the NCTM (National Council of Teachers of Mathematics) *Standards.*

The Field's Institute successfully applied to the Ministry of Education to manage the secondary mathematics writing team. Two documents were produced:

Mathematics: The Ontario Curriculum, Grades 9 and 10 (1999)
Mathematics: The Ontario Curriculum, Grades 11 and 12 (2000)

Implementation of these policy statements was to be staged — Grade 9 in 1999, Grade 10 in 2000, Grade 11 in 2001, and Grade 12 in 2002 — unlike the elementary mathematics curriculum, where all eight grades were introduced simultaneously.

It is important to look at the structure of the course offerings* from Grades 9 to 12 to see how they fit the Ministry's vision for Secondary School Reform.



* Crossover and transfer courses are available to enable students to change from one pathway to another. (These, for the most part, have not been marked on this flowchart.)

** These two courses were not part of the original curriculum documents. They were added to meet the needs of students who traditionally had enrolled in "Basic Level" courses.

The1985 documents, *Mathematics Part One (Basic), Mathematics Part Two (General),* and *Mathematics Part Three (Advanced),* and the 1995 document entitled *The Common Curriculum: Policies and Outcomes, Grades 1 – 9* were replaced and the mathematics program was changed from five years to four. Many students under the old curriculum

took most of their Ontario Academic Credits in their fifth year (Grade 13). Very few topics in the five-year program were eliminated, the most notable being trigonometric differentiation and integration from the new Calculus, Advanced Functions and Introductory Calculus. Hence, the new curriculum has often been described as a compressed version of the former. The second noteworthy change was the shift to "destination-based" exit courses, which meant that courses would be designated as University, University/College, College, or Workplace.

In general, the structure of each course was similar to that of the elementary curriculum. Each course comprises three or four strands. For example, the Grade 10 *Foundations of Mathematics* course is organized by the following strands: Proportional Reasoning, Linear Functions, and Quadratic Functions. Each strand includes overall and specific expectations.

The expectations, as written, reflect some of the key requirements for the effective teaching and learning of mathematics. The following fragments of expectations from a single Grade 9 course are indicative of many of the expectations in the courses overall.

Students will:

- *determine, from the examination of patterns, the exponent rules for* …[By asking students to seek patterns, "active learning" approaches are encouraged.]
- *communicate solutions to problems in appropriate mathematical forms and justify the reasoning used in solving the problems...* [By requiring students to communicate and justify their answers, teaching and learning for understanding is expected.]
- *use algebraic modelling as one of several problem-solving strategies* … [This expectation legitimizes mathematical modelling and the problem-solving approach to learning mathematics.]
- *collect data, using appropriate equipment and/or technology (e.g., measuring tools, graphing calculators, scientific probes, the Internet)* … [This expectation requires the use of technology in the mathematics classroom.]
- *graph lines, using graphing calculators or graphing software* ... [This expectation requires the use of technology in the mathematics classroom.]
- *solve and/or pose problems* … [This expectation establishes the need for an inquiry-based approach to learning mathematics.]

As with the elementary curriculum, the most significant shift in the secondary curriculum was in the area of assessment and evaluation. Student work must be judged using the criteria and levels of performance outlined in the mathematics Achievement Chart. Each of the four categories (Knowledge and Understanding; Thinking, Inquiry, and Problem Solving; Communication; and Application) must be taken into account in order to determine the student's grade. This shift from a "norm-referenced" to a "criterion-referenced" approach has been highly controversial in the mathematics community.

Implementation of the Secondary Curriculum

The greatest divergence in implementation of the elementary and secondary curricula was in the area of Ministry support. While there was little support for elementary mathematics teachers until more recently, secondary mathematics teachers were provided with numerous resources and opportunities for inservice. However, certain significant issues were not addressed.

A number of textbook publishers were quick to provide resource packages (i.e., textbooks, test banks, blackline masters, teacher resource material, online support, etc.) for mainstream mathematics courses, such as Grade 9 and 10 *Principles of Mathematics* (Academic) and *Advanced Functions and Introductory Calculus*. The Ministry of Education provided funds for all high schools to purchase textbooks, and in 1999, funds were also provided for graphing calculators, motion sensors, and other technology peripherals. The Ministry also commissioned the development of "Course Profiles." The contents of these resource documents included a "scope and sequence" by clustering expectations and providing a lesson plan with a student activity. While full profiles (for both public and Catholic systems) were written for the Grade 9 Applied and Academic mathematics, only partial profiles were provided for other courses. No profiles were provided for the "locally developed" Grade 10 Essentials course. Other useful resources were provided as well. Grade 9 "Exemplars" were produced to inform assessment and evaluation, and *t*he OAME and OMCA published resources such as the CARE package that was created to assist teachers with teaching, learning, and assessment and evaluation techniques. Currently, the OAME is producing its "vision" of mathematics that will include a statement of principles, a video to show the continuum of learning in the Mathematics classroom from Kindergarten to Grade 12, and various teacher support materials. A number of school boards have been active in creating these materials.

The following list provides a sample of funding, workshops, inservices, and conferences and is indicative of the piecemeal approach that has been taken to help secondary teachers implement the new curriculum.

- Over the past few years, the Ministry of Education has provided funds for teacher inservice (primarily for release time). For example, in 1999, funding to inservice the Grade 9 curriculum was provided, in 2000, funding was provided for the Grade 10 curriculum, and so on.
- The OAME and OMCA have developed and delivered Ministry-funded summer institutes in 13 locations across Ontario to support the use of graphing calculators in mathematics classrooms.
- Support has been provided for summer institutes aimed at helping mathematics teachers integrate dynamic geometry software (Geometer's Sketchpad) and dynamic statistics software (Fathom) into their programs.
- Workshops have been provided by school boards with central program staff and sufficient budgets.
- The OAME and OMCA have continued to sponsor annual mathematics conferences.

EQAO (province-wide) testing for Grade 9 students was introduced three years ago. The vision was to provide an instrument that would include multiple choice, short response, and long response questions, as well as an "investigation" that would involve the use of technology (e.g., dynamic geometry software or graphing calculators). However, EQAO expressed concern about the fairness of a technology-based investigation because the availability and implementation of technology across Ontario was so uneven. Consequently, the technology-based investigation was never implemented as a scored element of the test.

At very best, implementation of the new curricula has been spotty. Are teachers addressing the expectations in the new curriculum? In general, they are, but as with the introduction of any new course, the timing and the organization require fine-tuning and adjustment over time. Have the pedagogical and assessment tenets of the new curriculum been widely adopted? In some departments and by some individuals they have been. There is, however, substantial anecdotal evidence that teachers are facing challenges in adopting the use of technology, building investigations and inquiries into the their programs, employing an active learning approach, and implementing a criterion-based approach to assessment and evaluation.

One key reason for the sluggish implementation of the new curricula is the very low morale among secondary school teachers in the province. Teachers see larger classes, inadequate resources, materials that do not meet the needs of all students (particularly ESL students and "low-functioning" students), fewer department heads, fewer math "specialists" in the classrooms, Ministry policies being "dumped' on them (Secondary School Reform policies that cut across all subject areas), and massive changes in the approach to assessment and evaluation. Many say that the pace and depth of change has been unreasonable and unworkable. Finally, teacher attitudes have been tainted by the political backdrop that has existed in Ontario for the last eight years. Most feel that they have been demeaned, or at the very least, unappreciated. Many feel that they have been working in an environment of mutual mistrust.

Responses from the Field

In preparing this report, a questionnaire was sent to secondary school teachers, Mathematics Department Heads, Curriculum Consultants, Faculty of Education professors, and professors of mathematics. The surveys consisted of two questions that were tailored to each respondent's area of influence, such as elementary or secondary, university or college, or pre-service or inservice. For example, high school teachers were asked:

1. Do you find that the students in your classes today are:

    - stronger or weaker in terms of their mathematical skills than students in the past?
    - stronger or weaker in terms of problem-solving abilities than students in the past?

- more confident or less confident about doing mathematics than students in the past?

In what ways? Why do you think this is so?

2. Are you confident that young people are learning the mathematics they need in order to pursue their post secondary interests or careers and to become numerate citizens? Please explain.

Student Knowledge, Understanding, and Confidence

A common refrain among teachers who responded could be summed up by the following statement: "Students are better at problem solving, particularly in groups that promote discussion and open-ended thinking. However, in many cases, their fundamental skills seem to have suffered." One teacher observed that "…many students lack the intellectual maturity to grasp and understand the mathematical skills that are being introduced earlier in the new curriculum." Yet another teacher observed that students in her Grade 10 Academic class "... seemed more comfortable with problem solving than [those in] previous Grade 10 classes. The most striking difference was their insistence on understanding their work…." It seems that the jury is still out in terms of the impact of the new curriculum on students' abilities to do and understand mathematics.

Two responses seemed to epitomize the depth of concern (yet sense of hope) about student knowledge and their level of confidence in doing mathematics. One teacher in a large "full service" school (serving ESL, Special Education, and enriched students, as well as the general population), who cares passionately about his students and how they will cope with life's challenges outside the high school classroom, provided the following comments:

- **"Kids want to memorize, not understand** [respondent's emphasis]. It is what they have been rewarded for."
- "The problem, as I see it, is a malaise amongst most high school students about their learning in general."
- They care more about marks than learning."
- "There is too much to be done to have kids 'discover' higher math concepts."
- "If it is true that 70% of our population is not really interested in academic learning, what can be realistically expected of their math literacy? I doubt if much more than arithmetic will be possible, for it seems they do not want the knowledge."
- "… the new policy in Ontario [that implemented] Applied and Academic [courses] is completely out of touch with the real circumstances in our schools. They have said that Applied [level] kids need hands-on learning, but so many of our schools are not prepared to provide this type of instruction."
- "I feel it should be the aim of a school system to not only go through the motions of educating kids, but to stretch them a bit; to take them places (figuratively and concretely) that they would otherwise never have gone."

- "Many of our academically remarkable students are completely ignored by the system."
- "Teachers rightly feel 'out of the loop' and are practically never consulted on major reforms. There are no bonuses for good ideas placed in a 'suggestion box' and we constantly have 'new' ideas forced upon us."

Another respondent has been a leader in mathematics education for many years. She has garnered deep insights from her experience as a coordinator for a school board, as a leader in provincial testing, and as a developer in publishing. Her responses were based on the question, "Are you confident that young people are learning the mathematics they need in order to pursue their post secondary interests or careers and to become numerate citizens?"

- "NO, because mathematics instruction is still, "Do this, follow me, and do whatever I say, and you, too, will know math."
- "They are not learning how mathematicians work, think, interact, explore, pursue ideas, draw conclusions, etc."
- "They are not learning about interesting mathematics that can help them relate to and understand their world."
- "They are not learning how their own ideas are mathematical in nature."
- "They are not learning to make sense of math and how it is all interconnected."
- "There is not enough discourse in most math classrooms. … The questions are not rich enough."
- "When we find the occasional "Thinking Classroom" with co-operative problem solving going on all day in every bit of the learning the students do, it is chilling – gives me goose bumps. … Mathematics learning happens in a social context – like Vygotsky said it should."

Although, some teachers have indicated that they have begun to observe improvements in students' problem solving, both from the point of view of skill and perseverance, others have stated that they have significant reservations. It is not enough that a revised curriculum provide rich mathematical content and builds in pedagogical approaches that have been shown to be effective. Students must be taught from Kindergarten to Grade 12 in a way that will motivate them to learn and do mathematics. Teachers must create exciting and productive learning environments. The problem is that many students, by the time they are in high school, are not interested in learning mathematics for its own sake. They want only to receive the marks they need to pursue their goals. To compound the problem, many teachers have continued to teach the way in which they were taught. Hence, the vicious circle is perpetuated, and too many students continue to lack any real interest in learning mathematics.

Teacher Knowledge, Understanding, and Confidence

A number of consultants and coordinators responded to the survey. These statements highlight some of their observations based on the question, "Are you confident that teachers are sufficiently well prepared to facilitate their students' learning of

mathematics?" The initial statements represent the opinions of those consultants who work primarily with elementary school teachers, and the latter ones represent the opinions of consultants who primarily work with secondary school teachers:

- "They do not get it. They tell us they don't get it."
- "No, because they cannot answer their kids' questions on the fly."
- "Not at all! The primary teachers I work with really don't have knowledge of mathematics beyond early elementary. In fact, I would describe the majority of teachers as having only 'rote' understanding of the mathematics they are required to teach."
- "Teachers of Grade 7/8 mathematics are generally weaker [with respect to mathematical skills]…. I don't believe that these teachers experience a lot of genuine problem solving. … They are confident about teaching mathematics but struggle with trying to teach math in a "reformed" way. … However, I am very impressed with the dedication and commitment of the teachers I work with."
- "I have noticed a decline in the number of teachers who have strong backgrounds in mathematics."
- "I am confident that teachers [secondary], on the whole, possess the skills and knowledge to facilitate learning. However, teachers, like other professionals, need to have consistent support, training, updating, and useful tools to manage the tasks."
- "Too often, teachers and students fall into lock-step approaches to solving problems… Secondary teachers seem to be quite confident about doing mathematics, but less so about teaching mathematics."
- "There is a fundamental lack of creativity and diversity in the way problems are solved by teachers. … The more open-ended and technology-rich mathematics classes become, the higher the level of discomfort for mathematics teachers. … The teacher is cast in the role of "learner"' which unsettles teachers. … We are missing a systematic approach to supporting ALL teachers in Ontario [who want] to improve their capacity to understand and facilitate true student learning."

Many elementary teachers in Ontario struggle with the mathematics they teach. As noted above, they may be able to present algorithms and facts based on their own rote understanding, but many are unable to respond to students who provide alternate mathematical solutions or approaches. This problem is even more acute in the middle grades, where the mathematics becomes quite sophisticated. Secondary teachers, on the other hand, are generally confident with the mathematics but appear to be far less willing to change their teaching and learning approaches, even when research has shown such techniques (visual approaches to learning, creating environments that are conducive to rich discourse, the appropriate use of technology) to be effective. Many teachers (consciously or subconsciously) believe that if *they* were able to learn mathematics in a traditional way, so can their students. Another significant problem in Ontario high schools is the increasing number of "non-specialist" teachers who are being forced to teach mathematics because so few qualified teachers are available. The number of qualified mathematics teachers is expected to decrease even further in the future.

University Student Knowledge, Understanding, and Confidence

Both university professors and faculty of education professors provided comments about their recent experience with their students.

- "This is always a difficult question because one romanticizes the distant past. I have seen little change in mathematical skills or problem-solving ability, certainly nothing to write home (or to the CMS) about. One important change is that I find students more anxious and more mark-oriented than they used to be … It is imperative that we make the curriculum at all levels more attractive."
- "Unfortunately, the distribution of the strength of mathematics major students is bimodal. … On the other hand, the weak students continue to rely completely on their algorithmic skills. … I am very optimistic that the students coming out of the new Grade 12 program will have better problem-solving skills. … I have grave concerns about the mathematics preparation of mathematics teachers at all levels…."
- "Current Ontario graduates are weaker than comparable Quebec graduates in terms of problem solving and confidence in mathematics. … I attribute the difference to three features: (a) Quebec students begin high school with somewhat specialized math teachers in Grade 7. (b) The Quebec curriculum has emphasized problem solving for a much longer time. (c) [The existence of] the college system, with a continuing province-wide curriculum and small classes.
- Why are students not following mathematics? Because we do not engage their cognitive and affective abilities appropriately."
- "We obviously have quite a void of math specialists in elementary schools …"
- "…Instruction in mathematics methodology is quite varied from faculty to faculty. … In most cases, elementary teachers need more time with mathematics in their pre-service program."
- "Paradoxically, having "more math" doesn't seem to have dramatically increased their mathematical skills. … Many of my students (primary/junior candidates) still express high degrees of math anxiety. Everywhere I go, it seems that there is a shortage of qualified mathematics teachers."
- "I would say, in general, that the teacher candidates in the elementary program are poor in terms of mathematics skills. [Many] students who end up teaching math have come through a very inappropriate program (i.e., one tailored to those who will use higher math, not one tailored to those who must 'unpack' basic mathematical ideas."

These comments reflect a genuine concern about both undergraduate mathematics students and faculty of education candidates. In Ontario, there are still students who enroll in mathematics who possess understanding, but there are also those students who graduate from our high schools who have succeeded on the basis of their procedural knowledge and have been rewarded with marks. These weaker students will be "at risk" in any university mathematics program that demands problem solving and requires students to think "outside of the box."

There are even deeper concerns about those students entering faculties of education, particularly those candidates enrolling in the primary/junior or junior/intermediate

programs. Even if the faculty requires two university-level credits for entrance, it is unlikely that these course offerings will be useful to those who wish to become teachers.

Summary of Key Issues in Mathematics Education in Ontario

Implementation

Neither the elementary curriculum, introduced in 1997, nor the secondary curriculum (introduced in 1999), has been fully implemented. Although teachers have generally constructed their programs around the expectations listed in the policy documents, many are struggling with the philosophical underpinnings and the practical implementation. The required change from norm-referenced to criterion-referenced assessment and evaluation has been a source of great angst and resistance. Many teachers are also hesitant to apply some of the "best practices" and current thought about learning and teaching mathematics. Learning through inquiry, using manipulatives and technology, and employing teacher-student or student-student discourse in large or small groups are all examples of techniques shown to be effective in contrast to the traditional "chalk and talk." Much of the reluctance to adopt new methods is either due to teachers' lack of confidence in their own mathematical abilities (particularly in the elementary panel) and/or their unfamiliarity with current information about how children learn mathematics.

Only recently has the Ministry of Education committed to significant resources to provide inservice for elementary school teachers (The Early Math Strategy). Support for secondary school mathematics has been ongoing, but in a rather piecemeal fashion. The quality of inservice, and the time devoted to it, has been dependent on each individual school board. Some boards have well funded program departments while others do not, but even in those boards where significant resources have been poured into training, it is unclear to what degree teachers have moved forward. Publishers and organizations such as the OMCA and OAME have attempted to fill the gaps by developing a variety of resources and by providing workshops, institutes, and conferences.

Technology

It is important to take a special look at the use of technology in the Ontario mathematics classroom. At all levels of instruction, calculators and other rich technologies can be used effectively to improve instruction. Students from the very youngest to those about to graduate from high school are universally "tuned into" the use of technology in their every day lives. Many students are motivated to learn when they are invited into a technological world: They can "see" mathematics when using graphing calculators, "kinesthetically feel" mathematics when using motion detectors, and can "sense" the limitless possibilities when dynamically exploring geometry or statistics in a high-quality software program.

One of the more positive developments in mathematics education in Ontario has been the province-wide licensing of dynamic geometry and statistics software packages (Geometer's Sketchpad and Fathom) by the Ministry of Education. However, there is evidence to suggest that the adoption rate of these and other powerful technology tools has been relatively low. Not nearly enough teachers have received the in-depth training required to be comfortable with the technology (i.e., pushing the buttons) and most are unfamiliar with the ways in which they can create an effective learning environment with technology. Many teachers have also stated that they have insufficient access to such programs because there is rarely enough dedicated computer time for mathematics instruction.

Teacher Shortage

The Ontario College of Teachers has publicly stated that there is a looming shortage of qualified secondary school mathematics teachers. Graduates from university mathematics programs are opting for more lucrative opportunities in business and technology. Even where remuneration is not the driving force behind their decision, the constant assault on teachers by governments and various factions in society is a compelling factor. Teacher morale is at an all-time low and this has prompted many excellent teachers to seek early retirement or alternative careers.

Although the shortage of teachers at the elementary level is not as acute, the proportion of those who enjoy mathematics, understand the content, and know how children learn is disturbingly small. This is particularly problematic in middle schools in Ontario.

On-Line Learning

The Ministry of Education and many boards have been quick to decide that students should have opportunities to learn mathematics online. The Field's Institute Mathematics Education Forum has sponsored two symposia to discuss issues that need to be addressed by any provider that offers on-line mathematics courses. The consensus is that on-line learning may be beneficial in small doses (modules to enhance the mathematics classroom), but for the vast majority of students, full courses taken online would not be conducive to effective learning.

The Public

The public's view of mathematics and mathematics education is subject to a variety of influences. First, many perceive that the way **they** were taught mathematics is the way children should be taught mathematics today, not only in terms of the methodology (a rote approach to learning), but also, in terms of content. Oddly enough, many of these same people also profess to have a great distaste for mathematics or are even "phobic" about it. Another significant influence on the public is the media. Editorials, feature stories, and interviews quite often focus on the supposed failure of mathematics education (based on ostensibly poor EQAO results or Ontario's past rankings in international testing). Frequently, writers and broadcasters get on the "back to the basics" bandwagon, even when research suggests that understanding, not rote learning, is key.

Although those involved in mathematics education have been successful in convincing the public that mathematics is an important component of every child's education, they have done a relatively poor job at helping the public understand how children best learn mathematics and what it is to be a "numerate" citizen.

Conclusions

Following full implementation of the new curriculum, it is generally thought that students will become better problem solvers, but that some of their arithmetic and algebraic skills may not be as strong. There is a strong belief that improvement in student learning lies in more comprehensive and systematic teacher training; attracting more qualified teachers into the system; improvements in (and availability of) textbooks, manipulatives, and supplementary resources, such as rich tasks and activities, calculators, and computer software; and changing the public's perception of modern mathematics — how it is practiced, how it should be used, and how it is best learned.

Survey Respondents

This list represents respondents to an informal survey distributed in the February, 2003:

Henri van Bemmel. Secondary School Teacher, Toronto District School Board
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Mathematics: The Ontario Curriculum, Grades 1 - 8, 1997
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