

Final Assessment Report

Master of Mathematics for Teachers (MMT)

May 2016

Review Process

The review covers the Master of Mathematics for Teachers (MMT) program, which is housed in the Centre for Education in Mathematics and Computing (CEMC). The review was led by the Director of the MMT, who consulted with the MMT Graduate Committee, with the faculty who teach in the MMT, with the CEMC Administrative Assistant (who also acts as the Graduate Coordinator for the MMT), and with the CEMC Business Manager (who handles finances for the MMT), as well as with the previous and current Associate Deans, Graduate Studies, for the Faculty of Mathematics. Feedback from roughly 50 graduates of the MMT who had previously responded to a post-graduation survey was also incorporated. The MMT was launched in 2010, and so this was the first review of the program, and so there were no previous recommendations to which to respond.

The self-study documents were assembled over the first half of 2015. The MMT external review was undertaken by Dr. Doug McDougall (Professor and Associate Dean, Programs, from the Ontario Institute for Studies in Education at the University of Toronto) and Dr. Gerda de Vries (Professor and Associate Chair, Undergraduate, from the Department of Mathematical & Statistical Sciences at the University of Alberta). The internal reviewer was Dr. Paul Ward from the Department of Electrical and Computer Engineering. The site visit occurred on Friday 29 January 2016.

The Program

The MMT is a part-time, online only, professional Master's program aimed at current high school teachers. The MMT is an outreach program created to strengthen the mathematics abilities of teachers and enrich their appreciation of the breadth and utility of the discipline. Most teachers in the program teach full-time while taking one or more courses each term. The primary goal of the program is to help current teachers deepen their knowledge of mathematics. A secondary goal is to help teachers become aware of the breadth of the mathematical sciences.

The MMT is housed in the CEMC, which is a unit within the Faculty of Mathematics. The CEMC aims to increase enjoyment, confidence and ability in these disciplines among students and teachers in Canada and internationally. Through contests, face-to-face workshops, online courseware and resources, and this online Master's degree, the CEMC provides curricular and enrichment support to elementary and secondary schools. The activities of the CEMC emphasize the relevance and importance of mathematics and computer science in the 21st century. Each year, the CEMC reaches hundreds of thousands of students and teachers through its contests and website, and tens of thousands through its face-to-face workshops.

The faculty members who participate in the MMT come from almost all units in the Faculty of Mathematics. Each of these faculty members has primary duties within his or her home unit, and then participates in the MMT with consent from his or her Chair/Director. Despite the fact that there are no faculty members whose primary responsibility is to the MMT, the program receives strong support and commitment from across the Faculty, chiefly in the form of support from units in allowing some of their

best instructors to participate in MMT course development and instruction and in providing many of their highest-rated teaching assistants to MMT courses.

The faculty members who have developed MMT courses, regularly teach in the MMT, and/or participate in MMT oversight represent a broad cross-section of the members of the Faculty of Mathematics, from Lecturers with no research or supervision component to their appointment to full Professors with active research and supervision programs. This spectrum is crucial to the success of the MMT, as it allows courses to be created and taught from a variety of different perspectives, each of which is of value to the audience.

It is worth noting that among the 15 core faculty members, there are four winners of the University's Distinguished Teacher Award and four winners of the Faculty of Mathematics Award for Distinction in Teaching. This demonstrates quite ably the care for and abilities in education among those with important roles in the MMT.

Since the MMT is a course-based, part-time, professional Master's program, there is no explicit traditional research component to the program, nor is funding available from the University to MMT students. Most of the faculty members associated with the MMT are Lecturers with no research component to their appointment, but with strong interests and abilities in teaching and education.

The MMT does have a "supervision component" through its capstone project, which is a required component of the program taken by each student through the course MATH 699. Through their work in MATH 699, students will design a mini-course on an approved subject in mathematics. As part of their project, students are required to design lessons and create problems and solutions to accompany these lessons. The capstone project is designed to give students an opportunity to work on an independent project that demonstrates their knowledge of the subject matter that they teach and/or the knowledge that they have gained in the program and to provide a forum for bringing that knowledge into their own classroom. Each student working on his or her capstone project is assigned a capstone reviewer. Because the MMT is an online program, this review is done remotely. Because of the "school" focus of these projects, this supervision/review is done in a non-standard way, using a combination of faculty members (some of whom are also involved in the program in other ways) and retired secondary school teachers.

As an online program, the MMT does not have laboratory facilities, computing facilities, or graduate student space.

Specific Learning Outcomes

The CEMC expects that every graduate of the MMT can:

- Demonstrate broad understanding of several areas of the mathematical sciences and their applications in the real world and apply this knowledge to their professional practice
- Demonstrate a deep understanding of one or more areas of the mathematical sciences and their applications in the real world and apply this knowledge to their professional practice
- Analyze and create solutions to problems and formal arguments using curriculum topics taught in secondary school and using mathematical topics that underpin the secondary school curriculum
- Understand connections between diverse fields in mathematics and how these relate to the curriculum they are teaching

- Communicate, to their colleagues, their students, and their students' parents, the importance of mathematics, both for its inherent beauty and for its applicability to other fields and to society
- Produce self-contained, rigorous and effective activities and mini-courses designed for enrichment and curricular use, including teaching materials and student tasks
- Evaluate their own mathematical strengths and weaknesses, understand the limits of their own knowledge in fundamental areas of mathematics, and develop ongoing strategies to improve their abilities

MMT Courses

Since its launch in September 2010, the MMT has progressed from a single online course to a suite of 24 online courses that were offered by Winter 2016. Most MMT courses have an enrollment of between 30 and 60 students, although some classes have been as large of 100.

Students access course materials through LEARN. Lectures are available as videos that can be watched online or downloaded to the student's computer. In most course offerings, all lecture material is available at the beginning of the course. Assignments and other resources are posted on LEARN and can be downloaded. Courses use a combination of electronic assignments (multiple choice quizzes) and written assignments that are completed by the students and uploaded to LEARN. Written assignments are electronically hand-marked by graduate students in the Faculty of Mathematics and returned, with comments, to the students through LEARN. LEARN also has Discussion Boards where students can post questions and respond to other students' questions. Course instructors and teaching assistants can post responses to questions on the Discussion Boards. Students also communicate with instructors through email. MMT instructors respond to virtually all questions via email and Discussion Boards within 24 hours. Because of the assessment structure of MMT courses, there have been occasional concerns raised about academic integrity; after a number of conversations within the program and within the faculty, we are satisfied that this is not a significant concern.

Most MMT courses are offered once per year or once every second year. The MMT has a single entry point (Fall) which allows all incoming students to take MATH 600 (Mathematical Software) and MATH 692 (Mathematical Proofs) in their first term. These consecutive six-week courses help to give all students in the program the tools that they need to continue and succeed. MATH 699 (Capstone Project) is normally offered in both Winter and Spring each year. In most terms, the MMT offers between 1.5 and 2.5 units of courses.

Students

Since Fall 2010, more than 400 students have started the MMT. As of Spring 2016, there are more than 180 graduates with 190 students currently in the program. Retention for each cohort of students admitted to date is between 85% and 91%. Roughly half of the students in the program live and work in Ontario, and roughly 20% live and work outside of Canada. Many of these "international" students are in fact Canadian citizens working in international schools abroad.

In practice, the range of backgrounds of mathematics teachers in the province of Ontario and across the country is enormous. While some such teachers have mathematics degrees or science degrees in a more technical field, many more are teaching secondary school mathematics (and are even teaching senior courses such as Calculus) with only three or four post-secondary mathematics courses in their academic background. As a result, the program has adopted the approach of admitting teachers with at least three or four mathematics courses in their post-secondary background whose academic and professional backgrounds suggest that they have a chance of success in the program, and letting them

determine whether or not they have the ability to succeed. Since most applicants to the program have been away from formal learning for at least a few years, their academic background seems to be less correlated to their success in the program than their willingness to learn and work. It is also worth noting that, from the perspective of trying to improve mathematics education in Ontario and in Canada, it is likely those with the weakest backgrounds who gain the most from their pursuit of and success in the MMT.

In each of Fall 2014 and Fall 2015, roughly 100 applications to the MMT were received and roughly 70 students began in the program. We anticipate similar numbers in Fall 2016.

Strengths and Challenges

Some of the strengths identified in the self-study document were:

- Meeting a clearly identified need among mathematics educators
- The focus of the program on the broadening and deepening the mathematical knowledge of teachers thus instilling greater understanding and confidence in their mathematical skills, and thereby enhancing their classroom teaching
- Some of the best instructors in the Faculty of Math as course authors and instructors
- Willingness of the instructors in the program to be available for frequent online questions, especially during evenings and on weekends, at which times professional teachers are most likely to be working on their course material
- The high quality of courses available, both in terms of content and production values
- The suitability of the courses to the audience consisting of a broad range of abilities and backgrounds and a broad range of times since last formal education
- Reasonable cost of program compared to other programs and courses for teachers, and reasonable rewards for completion
- Commitment at the Faculty and University level to support the program and its goals
- High success and low attrition rates in courses and program
- Size of program in terms of enrollments (allowing for greater course diversity)
- Geographic diversity of students

Some of the challenges identified in the self-study document were:

- Creating and maintaining community difficult with students who never or rarely meet each other face-to-face, and then maintaining contact and relationships with MMT alumni
- Maintaining quality and size of application pool; reaching teachers to promote the program
- Maintaining and enforcing academic integrity in a program with no formal examinations
- Uncertainty in future funding and availability of on campus resources, particularly from the Centre for Extended Learning (CEL)
- Targeting course materials to teachers who teach using a different style than Universities do
- Working within University policies and procedures not always well-suited to off-campus, online, professional graduate programs (eg. policies for consecutive inactive terms, drop/refund deadlines for half-term and Winter terms courses)

Recommendations from Reviewers and Responses from the MMT

The reviewers made the following recommendations (in boxes) to which the MMT has responded (in italics). No additional resources will be required at the program level to implement any of these recommendations. A few of these changes will require formal approval through the proper channels.

Recommendation a)

Consideration should be made to separating the role of the program coordinator from the Director of CEMC. There are too many expectations in each of the roles for one person. It would also allow for greater cohesion if the tasks were divided.

The MMT sees advantages (workload) and disadvantages (removal of single-point of contact for relationship building with educational community) to this. The CEMC/MMT Director finishes his current term on 30 June 2017 and so the conversation about the Directorship of the MMT will occur while future governance of the CEMC is discussed.

Timeline: To be completed by mid-2018

Recommendation b)

The regulations and guidelines within the Graduate Studies Office should be reviewed to better match the living experiences of part-time online students. It should be possible for MMT students to elect one, two or three term absences without penalty. The part-time online professionals (normally teachers) have different needs than full-time on campus students.

Since the review was completed in early 2017, practices in the Graduate Studies Office appear to have been relaxed somewhat. There still are some policies and procedures (eg. refund deadlines) which are not as friendly as they could be towards students in this type of program. The MMT will raise these concerns again in the near future.

Timeline: To be completed by the end of 2017

Recommendation c)

We suggest that the Faculty of Mathematics investigate the possibility that the part-time online model of the MMT be used for expanding to other markets for different fields within Mathematics. However, it should be recognized that the online model does not scale easily: interactions with students through email and discussion boards takes significant time. That is, the online model works well only with relatively small class sizes (unless there is significant additional instructional support).

The question about further programs is beyond the scope of the MMT. The MMT will continue to monitor class sizes and to seek out best practices for managing class sizes in an online environment.

Timeline: Ongoing

Recommendation d)

The wording of the admission requirements posted on the MMT website (<http://cemc.uwaterloo.ca/mmt/mmt-admissions.html>) should be reviewed, with an eye to aligning the wording with current practice and encouraging any applicant who is actively teaching in mathematics, science, or computer science (not just those with a Bachelor's degree in a STEM field) to apply provided they have taken at least 3-4 post-secondary courses in mathematics.

The MMT will review its formal admissions criteria and propose changes through the proper channels.

Timeline: To be completed by the end of 2017

Recommendation e)

The development of a curriculum map to visualize the co-/prerequisite structure of the courses in the MMT program would be helpful.

This will be done in conjunction with recommendation f).

Timeline: To be completed by the end of 2017

Recommendation f)

Now that the program is mature and there is a good selection of courses available, it is worth considering whether the program would benefit from establishing a set of core requirements to ensure as complete a coverage of the GDLEs as possible. Core requirements should include at least MATH 600, 692, and MATH 699. Additional requirements could be MATH 647, 661, 680, and one of MATH 630 or 631. Alternatively, additional requirements could be set up by area (e.g., student must complete at least X credits in courses with a modelling component, Y credits in courses with a computing component, etc.).

The MMT Graduate Committee has begun to discuss this recommendation and will continue to do so. Analysis of the courses taken by the first 160 graduates of the MMT shows that, in practice, an informal core already exists. MATH 600, MATH 692 and MATH 699 will be formally put forward as the "core" in the near future. Adding a new course (MATH 681, Problem Solving) to the core is also being discussed. Beyond that, it is likely that a set of "recommended courses" will be created. The Committee feels that it is important to give teachers in the program the flexibility to pursue the courses that are most relevant to their current practice.

Timeline: To be completed by the end of 2017

Summary

The Faculty of Mathematics and the CEMC are very pleased with the success of the MMT, both in terms of its growth and in terms of its quality. We are also very pleased that the reviewers recommended no substantial changes, and view this as a strong endorsement of the program's mission and of its quality. We look forward to the MMT continuing to be an excellent professional graduate program which is apparently both very attractive and very helpful to an important sector of society.

MMT Implementation Plan:

	Recommendations	Proposed Follow-up	Responsibility for Leading and Resourcing (if applicable) Follow-up	Timeline for addressing Recommendation
a)	Consideration should be made to separating the role of the program coordinator from the Director of CEMC. There are too many expectations in each of the roles for one person. It would also allow for greater cohesion if the tasks were divided.	The MMT sees advantages (workload) and disadvantages (removal of single-point of contact for relationship building with educational community) to this. The CEMC/MMT Director finishes his current term on 30 June 2017 and so the conversation about the Directorship of the MMT will occur while future governance of the CEMC is discussed.	Ian VanderBurgh No additional resourcing necessary	To be completed by mid-2018
b)	The regulations and guidelines within the Graduate Studies Office should be reviewed to better match the living experiences of part-time online students. It should be possible for MMT students to elect one, two or three term absences without penalty. The part-time online professionals (normally teachers) have different needs than full-time on campus students.	Since the review was completed in early 2017, practices in the Graduate Studies Office appear to have been relaxed somewhat. There still are some policies and procedures (eg. refund deadlines) which are not as friendly as they could be towards students in this type of program. The MMT will raise these concerns again in the near future.	Ian VanderBurgh No additional resourcing necessary	To be completed by the end of 2017

c)	<p>We suggest that the Faculty of Mathematics investigate the possibility that the part-time online model of the MMT be used for expanding to other markets for different fields within Mathematics. However, it should be recognized that the online model does not scale easily: interactions with students through email and discussion boards takes significant time. That is, the online model works well only with relatively small class sizes (unless there is significant additional instructional support).</p>	<p>The question about further programs is beyond the scope of the MMT. The MMT will continue to monitor class sizes and to seek out best practices for managing class sizes in an online environment.</p>	<p>Ian VanderBurgh No additional resourcing necessary</p>	<p>Ongoing</p>
d)	<p>The wording of the admission requirements posted on the MMT website (http://cemc.uwaterloo.ca/mmt/mmt-admissions.html) should be reviewed, with an eye to aligning the wording with current practice and encouraging any applicant who is actively teaching in mathematics, science, or computer science (not just those with a Bachelor's degree in a STEM field) to apply provided they have taken at least 3-4 post-secondary courses in mathematics.</p>	<p>The MMT will review its formal admissions criteria and propose changes through the proper channels.</p>	<p>Ian VanderBurgh No additional resourcing necessary</p>	<p>To be completed by the end of 2017</p>
e)	<p>The development of a curriculum map to visualize the co-/prerequisite structure of the courses in the MMT program would be helpful.</p>	<p>This will be done in conjunction with recommendation f).</p>	<p>Ian VanderBurgh No additional resourcing necessary</p>	<p>To be completed by the end of 2017</p>

f)	<p>Now that the program is mature and there is a good selection of courses available, it is worth considering whether the program would benefit from establishing a set of core requirements to ensure as complete a coverage of the GDLEs as possible. Core requirements should include at least MATH 600, 692, and MATH 699. Additional requirements could be MATH 647, 661, 680, and one of MATH 630 or 631. Alternatively, additional requirements could be set up by area (e.g., student must complete at least X credits in courses with a modelling component, Y credits in courses with a computing component, etc.).</p>	<p>The MMT Graduate Committee has begun to discuss this recommendation and will continue to do so. Analysis of the courses taken by the first 160 graduates of the MMT shows that, in practice, an informal core already exists. MATH 600, MATH 692 and MATH 699 will be formally put forward as the “core” in the near future. Adding a new course (MATH 681, Problem Solving) to the core is also being discussed. Beyond that, it is likely that a set of “recommended courses” will be created. The Committee feels that it is important to give teachers in the program the flexibility to pursue the courses that are most relevant to their current practice.</p>	<p>Ian VanderBurgh No additional resourcing necessary</p>	<p>To be completed by the end of 2017</p>
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