

**Mathematics**  
**Final Assessment Report & Implementation Plan**  
**January 2025**

<b>Faculty / Affiliated University College</b>	Faculty of Science	
<b>Degrees Offered</b>	MSc, PhD	
<b>Date of Last Review</b>	2016-2017	
<b>Approved Fields</b>	Applied Mathematics	
<b>External Reviewers</b>	Dr. Hans Boden, Department of Mathematics and Statistics McMaster University	Dr. Julien Arino, Department of Mathematics University of Manitoba
<b>Internal Reviewers</b>	Dr. Nica Borradaile, Associate Vice Provost School of Graduate and Postdoctoral Studies	
<b>Date of Site Visit</b>	October 24 & 25, 2024	
<b>Date Review Report Received</b>	November 25, 2024	
<b>Date Program/Faculty Response Received</b>	Program – December 6, 2024 Faculty – December 16, 2024	
<b>Evaluation</b>	Good Quality	
<b>Approval Dates</b>	SUPR-G: February 24, 2025 ACA: March 4, 2025 Senate (for information): March 14, 2025	
<b>Year of Next Review</b>	Year of next cyclical review: 2032-2033	
<b>Progress Report</b>	June 2028	

### **Overview of Western’s Cyclical Review Assessment Reporting Process**

In accordance with Western’s Institutional Quality Assurance Process (IQAP), the Final Assessment Report (FAR) provides a summary of the cyclical review, internal responses, and assessment and evaluation of the Graduate Mathematics Program delivered by the Faculty of Science.

This FAR considers the following documents:

- the program’s self-study brief;
- the external reviewers’ report;
- the response from the Program; and
- the response from the Dean, Faculty of Science.

This FAR identifies the strengths of the program and opportunities for program enhancement and improvement, and details the recommendations of the external reviewers – noting those recommendations to be prioritized for implementation.

The Implementation Plan details the recommendations from the FAR that have been selected for implementation, identifies who is responsible for approving and acting on the recommendations, specifies any action or follow-up that is required, and defines the timeline for completion.

The FAR (including Implementation Plan) is sent for approval through the Senate Subcommittee on Program Review - Graduate (SUPR-G) and ACA, then for information to Senate and to the Ontario Universities’ Council on Quality Assurance. Subsequently, it is publicly accessible on Western’s IQAP website. The FAR is the only document from the cyclical review process that is made public; all other documents are confidential to the Graduate Mathematics Program, Faculty of Science, the School of Graduate & Postdoctoral Studies (SGPS), and SUPR-G.

## Executive Summary

The Department of Mathematics at Western University is a part of the Faculty of Science and, jointly with the Department of Statistical and Actuarial Sciences forms the School of Mathematical and Statistical Sciences. The graduate program has been in existence since the 1950's, initially offering an M.Sc. degree and subsequently, since the 1960's, a Ph.D. degree. Following the dissolution of the Department of Applied Mathematics in 2021, Applied Mathematics is now offered as an optional field within the Mathematics Program.

Students pursuing their M.Sc. degree have two options: a course-based and a thesis-based option. The course-based option is one-year long and requires completion of eight half-courses. The thesis-based option, in contrast, is two-years long and requires students to take four courses in addition to completing a thesis. The Ph.D. degree is obtained through a combination of coursework, milestones, and a thesis involving original research. Each student is required to complete: five half-courses, a comprehensive examination, a candidacy exam, and deliver two public lectures on their research. In 2022-2023 total enrolment in the MSc was 21 and 40 in the PhD.

The self-study was informed by data from annual student focus groups as well as recent departmental meetings and retreats. In addition, a dedicated committee on student surveys was formed to design and administer a dedicated self-study survey on a variety of topics – to both alumni and current students.

The external reviewers shared a positive assessment of the graduate Math Program. They offer five recommendations with considerations for further enhancement.

## Strengths and Innovative Features Identified by the Program

- Faculty members, renowned experts in their fields, provide a vibrant atmosphere by inviting visitors, hosting seminars, and providing research opportunities.
- Low student-to-faculty ratio results in a collegial atmosphere that supports individual student needs.
- Varied professional development opportunities, including seminars, colloquia, networking events with alumni, training from the CTL, and the Writing Support Centre, mentorship opportunities through the *Buddy program* and the *Directed Reading Program* offer excellent career preparedness.
- Strong partnerships include:
  - o 3+1+1 programs with select universities in China; Dual degree agreements with Makerere University, Uganda and the University of Osnabrück, Germany;
  - o Fields Institute for Research in Mathematical Sciences in Toronto offers additional advanced topics courses each term, labs and office space;

- Collaborative Specialization in Scientific Computing and Machine Learning in Health and Biomedical Sciences;
- Current consideration of a partnership with the Vector Institute in Toronto, which would provide additional financial support for M.Sc. students and enable a seamless transition to industry.
- Only one of two programs in Canada with a student chapter of the Association for Women in Mathematics (AWM). Founded in 2021, the chapter is very active, receiving an AWM award for its outreach activities in 2023.
  - The chapter's activities contribute to student recruitment and retention - the number of women in the program between 2019 and 2024 increased three-fold.
- Proactive recruitment strategies, including several summer research programs for undergrad students.
- Student and alumni are satisfied with: 1) selection of courses and Fields Academy courses; 2) regular meetings with supervisors, described by students as knowledgeable, caring supervisors with extensive research networks; 3) study space; 4) professional development opportunities, which they found to be relevant and useful; 5) the collegial and friendly atmosphere in the department.
- High levels of NSERC support among faculty members allow for financial support for student travel to conferences on a regular basis.
- Frequent program feedback opportunities: informal lunch focus groups with students and townhall meetings held 1-2 times per year.

### **Concerns and Areas of Improvement Identified and Discussed by the Program**

- Funding package has not kept up with inflation; the competitiveness of the program will be affected if funding at the University and Faculty levels are not increased.
  - Continue to explore new funding opportunities via partnerships with Canada's biggest banks, which will also enhance areas of cryptography and formal verification.
- Course topics offered has decreased since the pandemic and has not yet recovered to pre-pandemic levels. Students have expressed a desire for more topics.
- Continue to enhance interaction between members of previously separate programs; for instance, allowing students to 1) take comprehensive exams split between pure and applied mathematics; 2) study data science and formal verification, potentially providing graduates with additional funding as well as research and internship opportunities.
- Expand promotion of professional development events with a focus on networking with alumni working in academia, industry, or government.
- Implement changes to address concerns regarding the consistency and difficulty of comprehensive exams; departmental changes include assigning two members for a 2-year term to each of the exams.

- Student feedback noted that: 1) Comprehensive Exams are very stressful; 2) funding package is increasingly insufficient, especially for international M.Sc. students; and 3) TA workload is heavier compared to other departments in the Faculty of Science.
- There is a relatively small number of applicants from equity-deserving groups.

### **Review Process**

As part of the external review, the review committee, comprising two external reviewers and one internal reviewer, were provided with Volume I and II of the self-study brief in advance of the scheduled review and then met in-person over two days with the:

- Vice Provost, School of Graduate & Postdoctoral Studies
- Associate Vice-Provosts, School of Graduate & Postdoctoral Studies
- Acting Vice-Provost, Academic Planning, Policy and Faculty
- Director, Office of Academic Quality and Enhancement
- Associate Dean, Graduate and Post-Doctoral Studies, Faculty of Science
- Department Chair
- Graduate Chair
- Graduate Affairs Committee members
- Associate University Librarian
- Graduate Program and Department Staff
- Program Faculty Members
- Graduate Students

Following the site visit, the external reviewers submitted a comprehensive report of their findings which was sent to the Program and Dean for review and response. Formative documents, including Volumes I and II of the Self-Study, the External Report, and the Program and Decanal responses form the basis of this Final Assessment Report (FAR). The FAR is collated and submitted to the SGPS and to SUPR-G by the Internal Reviewer with the support of the Office of Academic Quality and Enhancement.

### **Summative Assessment – External Reviewers’ Report**

External reviewers shared that, *“the program aligns well with the university's mission and provides students with adequate information and guidance to pursue their intended course of studies. We found the faculty to be very competent and observed that students graduating from the program were quite productive.”*

### Strengths of the Program

- The program has a strong reputation for excellence in research and graduate training.
  - Internationally recognized faculty help foster: research excellence among a diverse group of graduate students; a high number of students published in top tier journals, and; success in scholarship competitions.
  - Grant funding for faculty members is well above the national average.
  - Seminars, colloquia, outreach activities, and Math Crochet meetings, along with EDI training for Graduate Affairs Committee members, promote inclusivity within the program.
  - World-renowned for its outstanding research groups in Mathematical Biology and Homotopy Theory.
- Combining applied and pure math departments was implemented carefully and resulted in a larger community with capacity for new training opportunities and cross-disciplinary research projects.
- Students have access to the High Performance Computing resources of Sharcnet – with PhD students each being provided with PCs.
- MSc has high completion rate; PhD completion rate is consistent with other institutions.
- Milestones in the research programs are well conceived and clearly must help students ensure their progression through the program.

### Prospective Improvements for the Program to Consider

- Professional development could be enhanced by offering opportunities for conducting tutorials, delivering lectures within a course, and/or being given positions as instructors-of-record for an undergraduate class. (*Associated with Recommendation #1*).
  - Development of an in-house training program specifically designed for the math graduate TAs. (*Associated with Recommendation #1*).
- Consider Introducing a major research project (MRP) as a required component of the one-year course-based MSc degree to ensure degree requirements are met. (*Associated with Recommendation #2*).
- Harmonize comprehensive exam and degree requirements for the MSc and PhD across the (Pure) Math and Applied Math options. (*Associated with Recommendation #3*).
- Increase in course offerings would enable important topics to be more consistently covered. (*Associated with Recommendation #5*).
  - Some students found it difficult to find advanced courses in their chosen domain of study because courses they had registered in were not run due to insufficient enrollment.
- Continue efforts to achieve greater gender balance within the faculty complement as this could support recruiting and retaining a more diverse student body.

**Summary of the Reviewers’ Recommendations and Program/Faculty Responses**

The following are the reviewers’ recommendations in the order listed by the external reviewers.

Reviewers’ Recommendation	Program/Faculty Response
<p><b>Recommendation 1:</b>                      Provide graduate students with more opportunities for teaching experience and training.</p>	<p><b>Program:</b> Agrees that classroom teaching is an essential component of the graduate program in mathematics. The program has started the <i>Teaching Training Program</i>, a mentoring program intended to help students develop inclusive teaching techniques and apply these techniques through guest lectures.</p> <p>Continue to work with the Faculty of Science and SGPS to find a way to give PhD students the necessary teaching experience before they graduate.</p> <p><b>Faculty:</b> The current budget landscape suggests that Limited Duties hires will be restricted in the future. Math already negotiates LD hires for post-docs with same purpose to provide necessary teaching experience. It is not feasible to expand this practice into a formal opportunity provided to every PhD student. The Dean’s office applauds the Teaching Training Program in Math; this is a great opportunity for graduate students to gain undergraduate lecturing experience under the careful guidance of a mentor. The Dean’s office will work with the program to investigate other ways that graduate students can gain teaching experience.</p>
<p><b>Recommendation 2:</b>                      Devise a mechanism to enhance PLO 2 in Research &amp; Scholarship for the course-based MSc students, possibly by introducing a Major Research Project as a requirement for the program.</p>	<p><b>Program:</b> Agrees with the assessment and will work with SGPS to submit a major modification to the program converting the course-based MSc degree into a project-based one. The project will replace two half-courses.</p> <p><b>Faculty:</b> The Faculty of Science supports the development of a project-based MSc. Similar programs are offered in Earth Sciences, Computer Science, Statistics, and Physics. In those programs, the project-based option is often more popular than the thesis-based MSc. The Dean’s office can provide guidance in the development of a Major Research Project component in the Math MSc and facilitate discussion among graduate chairs with similar programs.</p>

<p><b>Recommendation 3:</b> Harmonize the degree requirements for the MSc and PhD across the (Pure) Math and Applied Math options.</p>	<p><b>Program:</b> The Department held a series of meetings to reflect on the comprehensive exams, including their goals and format. As a result, a minor modification to change the scope of the applied math comprehensive exam was submitted. Plans are ongoing for modifying the math comprehensive exam along the lines of what the reviewers suggested: passing a selection of the program’s core courses with a grade of 80%.</p> <p>The course labels should be unified and there is no need to separate pure and applied mathematics. Once the major modification regarding the new format of the comprehensive exams is approved, a 3-person subcommittee will be formed within the Graduate Affairs Committee to unify course labels. Another major modification may be required.</p> <p><b>Faculty:</b> The Dean’s office supports the program’s initiatives to modify the degree requirements and course labels.</p>
<p><b>Recommendation 4:</b> Develop more team-building activities to promote cohesion and solidarity among the cohorts of graduate students in Math and Applied Math.</p>	<p><b>Program:</b> The Department’s leadership has been trying to bridge the gap between mathematics and applied mathematics since the merger of the departments in 2021 and welcomes all suggestions for how to do this effectively. The reviewers’ idea of starting a Grad Student Society seems to be another great step in the right direction.</p> <p><b>Faculty:</b> The formation of a graduate student society is a great idea for community building, as these groups often plan social events for their members. The Associate Dean can connect the student leaders in Math with organizers of similar student groups in other programs to facilitate building their society.</p> <p>The Dean’s office is optimistic that the introduction of the major research project in the course-based MSc (mostly populated by pure Math students) will encourage more interaction with thesis-based MSc (mostly applied Math). The program is encouraged to explore ways research training for both groups can be integrated, for example, a formal peer mentoring network, or research presentation days.</p>

**Recommendation 5:**  
Increase the number of math and applied math graduate courses offered.

**Program:** Taking into account the recent course enrolment thresholds, the program is currently working on consolidating undergraduate offerings into fewer more impactful courses. This change will filter the graduate offerings, affecting cross-listed courses. With fewer cross-listed courses being offered, it would be possible to schedule, e.g., Math 9144 Homological Algebra and other courses named in the report on the rotating basis (every 2-3 years). The program commits to working on designing a new model of grad-level course offerings.

The program will also work with other universities on a course-sharing model, whereby specific courses can be offered via video conference to students from other institutions, while allowing Western students to take their courses. The program has done this in the past with York and UBC.

**Faculty:** The new course enrollment minimum set by the Provost's office is expected to be 15 for 4th year undergraduate courses that are cross listed with graduate courses. The Dean's office recognizes that for most graduate programs it is difficult to reach a course enrollment of 15.

The Dean's office encourages and supports any efforts to update and create more efficient courses. Building or expanding courses to meet breadth requirements of students in both applied and pure math will increase course size, enhance multi-disciplinary learning and encourage interactions among different groups of students resulting in a stronger community.

Offering graduate courses in a rotating schedule and offering blended (online and in person) courses to encourage enrolment from different universities (e.g. the OVGS program), is also a good strategy to increase enrollment in specialized courses.

**Implementation Plan**

The Implementation Plan provides a summary of the recommendations that require action and/or follow-up. In each case, the Graduate Program Chair, in consultation with the SGPS and the Dean of the Faculty is responsible for enacting and monitoring the actions noted in Implementation Plan.

Recommendation	Proposed Action and Follow-up	Responsibility	Timeline
<p><b>Recommendation 1:</b> Provide graduate students more opportunities for teaching experience and training.</p>	<ul style="list-style-type: none"> <li>• Maintain and assess the effectiveness of the Teaching Training mentorship Program.</li> <li>• Engage with the Dean’s Office and the SGPS to determine options to give PhD students the necessary teaching experience. For instance, workshops offered by their new graduate student society and/or programming through the CTL.</li> </ul>	<p>Department Chair</p> <p>Graduate Chair</p>	<p>By December 2025</p>
<p><b>Recommendation 2:</b> Devise a mechanism to enhance PLO 2 in Research &amp; Scholarship for the course-based MSc students, possibly by introducing a Major Research Project as a requirement for the program.</p>	<ul style="list-style-type: none"> <li>• In collaboration with the Dean’s Office and the SGPS, develop a major modification proposing converting the course-based MSc degree into a project-based one. The project will replace two half-courses.               <ul style="list-style-type: none"> <li>• The Dean’s office to support with guidance in the development of a Major Research Project component and facilitate discussion among graduate chairs with similar programs.</li> </ul> </li> </ul>	<p>Graduate Chair</p> <p>Dean’s Office</p>	<p>By May 2025</p>
<p><b>Recommendation 3:</b> Harmonize the degree requirements for the MSc and PhD across the (Pure) Math and Applied Math options.</p>	<ul style="list-style-type: none"> <li>• Clarify the purpose, requirements and format of the comprehensive exams.</li> <li>• Examine the option of modifying the comprehensive exam to include passing a selection of the program’s core courses with a grade of 80%.</li> <li>• Develop and submit a major modification.</li> <li>• Once the modification regarding the new format of the comprehensive exams is approved, form a 3-person subcommittee,</li> </ul>	<p>Graduate Chair</p>	<p>By January 2027</p>

	<p>within the Graduate Affairs Committee, to unify degree requirements and course labels as there is no need to separate pure and applied mathematics.</p>		
<p><b>Recommendation 4:</b>          Develop more team-building activities to promote cohesion and solidarity among the cohorts of graduate students in Math and Applied Math.</p>	<ul style="list-style-type: none"> <li>• Explore ways that research training for Math and Applied Math students can be integrated. For example, a formal peer mentoring network, or research presentation days.             <ul style="list-style-type: none"> <li>• Ensure that Graduate Student Seminar talks are accessible to all students in the program.</li> <li>• Establish a Graduate Student Society to build community. Connect the student leaders in Math with organizers of similar student groups in other programs.</li> </ul> </li> </ul>	<p>Graduate Chair</p>	<p>By          September          2025</p>
<p><b>Recommendation 5:</b>          Increase the number of math and applied math graduate courses offered.</p>	<ul style="list-style-type: none"> <li>• Continue working on consolidating undergraduate offerings into fewer more impactful courses. This change will filter to the graduate offerings, leading to fewer cross-listed courses.             <ul style="list-style-type: none"> <li>• Build or expand courses to meet breadth requirements of students in both applied and pure math with the aim of increasing course size, enhance multi-disciplinary learning and encourage interactions among different groups of students resulting in a stronger community.</li> </ul> </li> <li>• Revisit course-sharing with other institutions via video conferencing, thereby causing little disruption to students' schedule.</li> </ul>	<p>Graduate Chair           Graduate Program Committee           Dean's Office</p>	<p>By          September          2027</p>