Two-Year Progress Report
Applied Mathematics, Combinatorics and Optimization, Computational Mathematics, and Pure Mathematics (BMath)
December 2019

Background

This particular combination of plans was reviewed for the first time in 2015-16, but each of these plans has been reviewed twice before, as part of a larger review of all undergraduate non-Computer Science plans in the Faculty of Mathematics, in 2008 and 2001 (Computational Mathematics did not exist in 2001, and so it was not reviewed at that time).

The 2015-16 review was carried out by Professor Michael Lamoureux, from the University of Calgary, and Professor Mary Pugh, from the University of Toronto. In addition, Professor Michael Dixon, from the Department of Psychology, served as an internal reviewer.

Progress on Implementation Plan

Recommendations

1) Significant effort must be made to improve the information and advice provided to potential and current undergraduate students in the programs in mathematics, whether that be through online resources and webpages, or in-person advising. The wide variety of math programs offered from these four units should be presented as a cohesive unit that students can enter with confidence. Currently, online information on what programs are available and their requirements is spread across many webpages, presenting a confusing matrix of data for the students to sort through. Some programs are described in various Department webpages, others in the Faculty's webpages, and many details are explained in University documents. In particular, Computational Mathematics being independent of Departments does not appear in any prominent way in the online documentation. Some information on possibilities and expectations (such as the option to take graduate courses while an undergrad, or to take a minor outside the Faculty) seems to be absent altogether.

   The Departments state that they do not have the resources to do one-on-one advising with all students. Even if such advising were available, it would have to be complemented by clear, easy-to-understand documentation on proper program information which would allow

students to explore their options and formulate their questions. It is strongly recommended program documentation for students be revised and clarified for student use. Such documentation could include student profiles of real (or hypothetical) students including the generic student who came in with top grades and went through the programs with the goal of going to graduate school in math, the ‘’good at everything” student who came in with top grades and either needed to discern a single focus or chose to focus on two subjects, the “Renaissance/Non-standard” student who came in with top grades and wants to study both computer science and psychology, the “challenged” student whose path through university has had bumps in the road and how they kept on track and so forth. One does see student profiles if one clicks on the “Future Undergraduates” link of the Faculty of Mathematics page but current undergraduates wouldn’t be looking there.

Status: Completed
Details: The Faculty of Mathematics is constantly updating its web presence, and seeking better tools with which to track and assist our students. The size of the faculty makes a distributed representation of its many plans and programs an unavoidable reality. Faculty web pages act as an aggregator, provide a broad overview of what programs are available in the various units, and include links to detail web pages that are owned by the respective units. Each unit constantly maintains the information on programs they own. Many of the units also present additional useful tools for their programs, like degree checklists, as well as profiles of students in their programs. The Undergraduate Calendar has all of the information described in the above recommendation, and departmental and Faculty-level advisors can and do dispense this information to students on a daily basis. More advisors have been hired to help students, and more communications personnel have been hired to assist departments in making opportunities more apparent to students.

2) We encourage the Departments and Faculty to reconsider the program entrance requirements. While the emphasis on contest exams scores (in conjunction with high school grades) has served the Departments well in selecting highly competitive, performance-focused students who will succeed in the program, it also may bias against creative, mathematically talented individuals who don't necessarily like competition. This does not serve the wider community of potential students who could have a full and productive career in mathematics. We understand that the math competitions and math education outreach are a vital service that the Faculty of Mathematics is providing to Canada and that, as a result, it’s part of its branding. We also understand that the mandate of the University is broader than simply trying to train undergraduates who might become world-class research academics. That said, it would likely be healthier if the math competition aspect be significantly downplayed the moment students arrive at Waterloo and start the next stage of their lives.

Status: Completed

Details: From the Final Assessment Report: “This recommendation is for something beyond the mandate of the reviewers, and outside of the mandate of the units being reviewed; admissions are handled by the Faculty of Mathematics, and math students enter into the programs under review after their first year of study. Despite that, it is worth mentioning that the faculty has made a number of changes recently to the way that undergraduate students are admitted. All students are now required to supply a “Admissions Information Form” with their applications. This allow the students to discuss things beyond their grades and competition scores. The Faculty of Math takes these forms quite seriously, and tries to admit students who are “well-rounded” as well as being very strong academically. It has been the faculty's experience that these are the students that are most successful in University.”

3) A process should be put in place to continuously update and keep current the courses and curricula in the programs. It was somewhat surprising to these reviewers to see, for instance, that the Pure Math program is almost identical to similar programs from 35 years ago. There needs to be room in the programs for modern advances. Ideally, these course reviews would be done as a team by the three Departments (Applied Math, Combinatorics & Optimization, and Pure Math). In addition, it would be wonderful if there were some sort of teaching credit mechanism by which a faculty member from one department could teach a course that is affiliated with another department. One would want to have some sort of bookkeeping to ensure that over a five year windows, say, that these teaching exchanges are fair and balanced. Also, it would be helpful if there were faculty hires who were joint hires between two departments. While joint hires can be delicate when departments have markedly different cultures and professional expectations, because Applied Mathematics, Combinatorics & Optimization, and Pure Mathematics would normally be all in a single department and so the usual difficulties that joint hires would face should be quite minimal.

   Status: Completed
   Details: From the Final Assessment Report: “The recommendation was made based on incorrect information. All departments have processes in place to ensure that the programs are continuously updated and improved. In particular, all three departments have an Associate Chair for undergraduate studies, (Mohammad Kohandel for Applied Math, David McKinnon for Pure Math and Ricardo Fukasawa for Combinatorics & Optimization). Part of the mandate of these Associate Chairs is to oversee, update and improve the undergraduate curriculum. They would also identify any gaps within the curriculum and work to remove them. The position of Associate Chair rotates amount the faculty, and is supported by a Curriculum Committee. This ensures that the program is always being kept modern, and that multiple viewpoints are always involved. The structure for Computational Math is slightly different, in that the role of the Associate Chair is done by the Director, in consultation with the Undergraduate Advisor (Martin Pei), and the role of the Curriculum Committee is done by the Steering Committee. All four units have undergone changes, sometimes minor, sometimes significant, on a regular basis as part of this process. The reviewers were informed

that this was the case and given many examples of improvements to the programs. These processes currently work well, and there is no evidence to support the suggestion that the Pure Math curriculum has been unchanged for 35 years – or that it is 35 years behind the times. As the programs are already doing what the recommendation asked, it is believed that no further action is required to address this recommendation."

The mechanism for facilitating inter-departmental teaching has been implemented, and has resulted in several examples of faculty members teaching course offered by other units. There are also several examples of faculty members in one unit who have formal membership status in other units as well.

4) On a related matter, a process is needed to identify and cover any gaps in the curriculum. Perhaps because of the division of math into separate departments, there seem to be some holes that are not covered in the various mathematical programs. Geometric PDE's, theoretical PDE's, mathematical probability, some modern harmonic analysis (both pure and in applications), and industrial applications are some examples that highlight the issue. To present the students with a comprehensive mathematics education, it is important to monitor the breadth across all program and ensure important fields are covered.

   Status: Completed
   Details: From the Final Assessment Report: "Each department has an undergraduate committee whose purpose is to examine and renew the curriculum in each department. In addition, the Undergraduate Affairs Committee at the Faculty level is charged with the same task at a higher level. We will continue to work on providing the most excellent and broad-ranging courses that we can, given the resource constraints we must work with." There is no evidence to support the notion that the departments under review do not offer as broad and deep a program as they can.

5) The university needs to also consider the issue of renewal of faculty in Pure Math and Combinatorics & Optimization. Both departments appear to be "top heavy", especially the Pure Math department:

	Asst. Prof.	Assoc. Prof.	Full Prof.
Applied Math	4 (17%)	7 (30%)	12 (52%)
C & O	3 (11%)	6 (22%)	18 (67%)
Pure Math	2 (9%)	4 (17%)	17 (74%)

   Assuming that the time to tenure/promotion is 6 years and that the professorial career is 35 years, then one could expect 17% of the faculty to be assistant professors. In practice, one

would want higher numbers than this. Junior faculty are vital for bringing in new fields, new ideas, and for shaking up the status quo (however much senior faculty might resent such disruption). Not all assistant professors get tenure. Also, strong departments will have hired so well (and supported their hires so well) that some assistant and associate professors will move to even better departments. While such losses are unfortunate to the department, they are a sign of good taste in hiring and vigour - the departing faculty member will, no doubt, have invigorated the department while they were there and will, one hopes, have left with nothing but good things to say about the department they left.

Status: In progress
Details: As should be expected, all Departments are always willing and eager to hire strong candidates. In fact, all three Departments hired in 2017 and 2018, and all three are hiring again for 2020. The Departments will continue to hire excellent and energetic junior faculty members to all three Departments, as resources allow.

6) While we did not meet with any lecturers, the research faculty felt that lecturers need to be more fully integrated into departments so that they can be full participants in the delivery of the programs. For the lecturers to properly prepare the students for upper level courses, likely they need to do more than just teach first-year courses -- it might be appropriate for them to also teach the upper level courses. This would help address concerns raised about the mismatch between what is being delivered in first year courses, and what professors are needing their students to master before entering the upper years of the programs. Also, it would help if lecturers have a primary departmental affiliation. Having a departmental affiliation would, one hopes, allow them to be more fully aware of what students will need to know after their first year. Some of the research faculty expressed concerns that some of the first-year courses are not open to innovation. Running a large first-year course is a complicated, delicate job and it's easy to imagine that once the course coordinator has "figured things out" that he/she would prefer to let the machine run without change. This is the easiest thing to do but it doesn't allow for pedagogical innovation or for the introduction (or elimination) of topics or the redistribution of focus on topics. Further, because there seems to be a tradition of providing lecture notes for courses, rather than having students read a textbook, there's a risk that whoever writes the notes sets the tenor of the course. Experienced lecturers will lecture in an independent manner from the notes, providing their own vision and allowing the notes to serve as an additional resource, but inexperienced lecturers may not do so --- this makes having lecture notes instead of a book somewhat risky.

Status: Completed
Details: After much discussion, it was concluded that lecturers are best served by allowing a variety of different administrative structures. Some lecturers are at home in a department, and others are best used in the Centre for Education in Mathematics and Computing, or the

Dean of Mathematics Office, or the Mathematics Undergraduate Office, or indeed in the Mathematics and Business group.

Since the review, research active members of the Faculty have thoroughly reviewed the introductory algebra and calculus courses, resulting in a significant overhaul and improvement.

7) Some concrete decision needs to be taken on the Computational Math program. Specifically, either promote it, or close it down. There seems to be a great opportunity for an exciting math program that could lead to outstanding careers for students. This would be in computational math, modeling, data analytics, and related industrial careers that merge math skills with cutting edge computation. Yet we see little enthusiasm by current participants and little effort to advertise and promote the program. Without an effort by the Faculty of Mathematics to properly grow this endeavour, perhaps resources should be re-allocated elsewhere. We recognize that the program is probably not expensive to run and that the graduate portion of the program may be valuable --- it should at the very least be easy for current students to know about this program. For example, it is listed under "programs" on the "future undergraduates" page of the Faculty of Mathematics but is not listed under "majors, minors, and specializations" on the "current undergraduates" page.

Status: Completed

Details: Computational Mathematics (CM) is an important and vibrant part of the Faculty's undergraduate and graduate programs, and we are supporting it vigorously. Advertising for the program has significantly increased over the last two years, and in particular, it is advertised through the future undergraduates web page (https://uwaterloo.ca/math/future-undergraduates/programs). The undergraduate CM programs have been growing in recent years, increasing their enrolment by at least 30% each year since 2015 – from 32 students in Fall 2015, to 143 students in Fall 2019.

8) In our discussions with the research faculty, there was great concern about the New Resource Allocation Model (NRAM) that is being implemented. For example, the Applied Mathematics department is in a precarious position vis a vis engineering. Engineering programs at other universities have created their own courses, with their own course codes, in which they present mathematical material. They then changed their program requirements so that they no longer require a particular course that is taught by the mathematicians and, instead, required their own course. It is our understanding that the Applied Math department has made great efforts to staff first year math courses for engineering students and so they are, naturally concerned, about whether the NRAM will encourage engineering departments to try and play the types of games that have been played at other universities. And, of course, because of the three-department structure any such behaviours would disproportionately

affect the Applied Math department which has been acting for the common good by sending its faculty members to teach courses that are focussed on students from an outside faculty.

Status: N/A
Details: This is not a recommendation.

9) As a final note, the innovation goals of the university need to be better addressed in the programs. While the co-op programs, and online course development are a notable and worthy contribution to innovation, it would be outstanding to see the introduction of professional skills training for the students. This could include courses that work on presentation skills, project management, team management, use of technology in mathematical work, a math modelling course in AMATH for use in industry, and so on. Experiments in novel teaching methods, experiential learning, and entrepreneurial activities should be actively promoted by the Faculty for delivery in its programs.

   Status: Complete
   Details: From the Final Assessment Report: "The co-op program includes substantial professional skills training for students, and our departments' courses already include presentations, project and team management, technology, and mathematical modelling. All units under review are constantly examining their teaching methods, and we will continue to teach our students in the best way possible, using both novel and tried-and-true techniques." In particular, we require all of our students to take communications courses which are designed to enhance the students' communications skills, in part to enable them to be more successful in the workplace.

Updated Implementation Plan

	Recommendations	Proposed Actions	Responsibility for Leading and Resourcing (if applicable) the Actions	Timeline for addressing Recommendations
5.	Faculty Renewal	Hire more junior faculty	Department Chairs and Faculty Dean	2020 and ongoing

The Department Chair/Director, in consultation with the Dean of the Faculty shall be responsible for monitoring the Implementation Plan.

UNIVERSITY OF WATERLOO

Date of next program review: _____

Date

_____

Signatures of Approval:

_____ Oct 22, 2019

Chair/Director Date

_____

AFIW Administrative Dean/Head (For AFIW programs only) Date

_____ 2019-10-23.

Faculty Dean Date

Note: AFIW programs fall under the Faculty of ARTS; however, the Dean does not have fiscal control nor authority over staffing and administration of the program.

_____

Associate Vice-President, Academic Date
(For undergraduate and augmented programs)

_____

Associate Vice-President, Graduate Studies and Postdoctoral Affairs Date
(For graduate and augmented programs)

Date of next program review: **2022-2023**

Date

Signatures of Approval:

Chair/Director Date

AFIW Administrative Dean/Head (For AFIW programs only) Date

Mark Giesbrecht
Dean, Faculty of Mathematics
Aug 27, 2020

Faculty Dean Date

Note: AFIW programs fall under the Faculty of ARTS; however, the Dean does not have fiscal control nor authority over staffing and administration of the program.

May 26, 2020

Associate Vice-President, Academic Date
(For undergraduate and augmented programs)

Associate Vice-President, Graduate Studies and Postdoctoral Affairs Date
(For graduate and augmented programs)

Checklist for SUC/SGRC Reviewer Feedback
Quality Assurance Office

Two-Year Progress Report: Applied Mathematics, Combinatorics and Optimization, Computational Mathematics, and Pure Mathematics (BMath)

Name of Reviewer: Kathy Acheson

Date: 8/20/2020

Does the Two-Year Progress Report:

1.	Clearly describe progress achieved on the various action items in the implementation plan?	☒ **Yes**	☐ **No**
2.	Explain convincingly any circumstances that would have altered the original implementation plan?	☒ **Yes**	☐ **No**
3.	For items that are behind schedule, propose an amended implementation schedule that is reasonable and credible?	☒ **Yes**	☐ **No**
4.	Address significant developments or initiatives that have arisen since the program review process, or that were not contemplated by the program review process?	☒ **Yes**	☐ **No**

General Comments

N/A