Date: Monday 21 January 2019
Time: 3:30 p.m.
Place: Needles Hall, room 3407

OPEN SESSION

3:30
Consent Agenda
Motion: To approve or receive for information by consent items 1-5 below.
1. Minutes of the 19 November 2018 Meeting Decision
2. Reports from Committees and Councils
   a. Executive Committee Information
   b. Graduate & Research Council Information
   c. Undergraduate Council Decision/Information
3. Report of the President
   a. Recognition and Commendation Information
4. Reports from the Faculties Information
5. Committee Appointments Decision

Regular Agenda

3:35
6. Business Arising from the Minutes Information

3:40
7. Graduate Student Presentation – Phoebe Stephens, PhD Student, School of Environment, Resources and Sustainability Information

3:55
8. Reports from Committees and Councils
   a. Graduate & Research Council Decision
   b. Undergraduate Council Decision

4:05
9. Report of the President Information

4:15
10. Q&A Period with the President Information

4:25

4:35
12. Report of the Vice-President, University Research & International Information

4:45
13. Other Business Decision

CONFIDENTIAL SESSION

4:50
14. Minutes of the 19 November 2018 Meeting Decision

4:55
15. Business Arising from the Minutes

5:00
16. Other Business

21 December 2018
KJJ/ejg

Karen Jack
University Secretary
University of Waterloo  
SENATE  
Minutes of the 19 November 2018 Meeting  


Guests: Sarah Burch, Aldo Caputo, Ethan Candler, Jana Carson, Rick Culham, Erin Gillespie, Ross Johnston, Jennifer Kieffer, Andrew McAlorum, Brian McNamara, Norah McRae, Bruce Muirhead, Robert Park, Diana Parry Will Percival, Chris Read, Ian Rowlands, Emily Schroeder, Pamela Smyth, Allan Starr, Donna Strickland, Cristina Vanin


*regrets  
**joined by telephone

OPEN SESSION

The chair welcomed members to the meeting.

The chair acknowledged Professor Donna Strickland, recipient of the 2018 Nobel Prize in Physics. Dr. Strickland addressed Senate, briefly describing the research she undertook which won her the award. She expressed her pleasure in representing scientists, Canada, and the University of Waterloo, and closed with an expression of gratitude that she has already heard from many young women that the award has inspired them to pursue studies in science.

The chair made the following motion:

That the University of Waterloo’s Senate offers its highest praise to Dr. Strickland for her revolutionary work in laser physics, and commends and honours her extraordinary distinction as a winner of the Nobel Prize in Physics in 2018.

Driver and Samuel. Carried unanimously.

Consent Agenda

Senate heard a motion to approve or receive for information the items on the consent agenda.

Dea and Andrey. Carried unanimously.

1. MINUTES OF THE 15 OCTOBER 2018 MEETING
Senate approved the minutes of the meeting.

2. REPORTS FROM COMMITTEES AND COUNCILS

Graduate & Research Council. Senate received the report for information.

Undergraduate Council. Senate heard the following motions:

Faculty of Mathematics, Applied Mathematics
Motion: That Senate approve the inactivation of the Applied Mathematics/Earth Option plan, effective 1 September 2019.

Faculty of Applied Health Sciences, Numeric Grading Requirement
Motion: That Senate approve the addition of a 50% numeric grading requirement for Faculty of Applied Health Sciences’ undergraduate plans, effective 1 September 2019.

Faculty of Applied Health Sciences, Communication Requirement
Motion: That Senate approve revisions to the “Communication Requirement” section of the Faculty of Applied Health Sciences’ Undergraduate Studies Academic Calendar, effective 1 September 2019.

Faculty of Applied Health Sciences, Dean’s Honours List
Motion: That Senate approve revisions to the “Dean’s Honours List” section of the Faculty of Applied Health Sciences’ Undergraduate Studies Academic Calendar, effective 1 September 2019.

Faculty of Applied Health Sciences, Co-op Requirements
Motion: That Senate approve revisions to the “Co-op Requirements” section of the Faculty of Applied Health Sciences’ Undergraduate Studies Academic Calendar, effective 1 September 2019.

Faculty of Environment; Examinations, Petitions and Grievances, and Academic Standing
Motion: That Senate approve revisions to the “Examinations, Petitions and Grievances, and Academic Standing” section of the Faculty of Environment Undergraduate Studies Academic Calendar, effective 1 September 2019.

Faculty of Environment, Internal and External Transfer Credits
Motion: That Senate approve revisions to the “Internal and External Transfer Credits” section of the Faculty of Environment Undergraduate Studies Calendar, effective 1 September 2019.

Faculty of Environment; Overview of Plans, Sub-Plans, Course Enrollment, and Grading
Motion: That Senate approve revisions to the “Overview of Plans, Sub-Plans, Course Enrollment, and Grading” section of the Faculty of Environment Undergraduate Studies Academic Calendar, effective 1 September 2019.

Faculty of Environment, Notes for ENV Academic Plans
Motion: That Senate approve revisions to the notes for ENV academic plans in the Faculty of Environment Undergraduate Studies Academic Calendar, effective 1 September 2019.

Faculty of Mathematics, Degree Requirements – List 1
Motion: That Senate approve revisions to the List 1 requirements, effective 1 September 2019.

Faculty of Mathematics, Degree Requirements – List 2
Motion: That Senate approve revisions to the List 2 requirements, effective 1 September 2019.
Faculty of Mathematics, Bachelor of Computer Science and Bachelor of Mathematics Plan Combinations
Motion: That Senate approve revisions to the Bachelor of Computer Science and Bachelor of Mathematics Plan Combinations restrictions, effective 1 September 2019.

Senate received the remainder of the report for information.

3. REPORT OF THE PRESIDENT
Recognition and Commendation. Senate received the report for information.

4. REPORTS FROM THE FACULTIES
Senate received the reports for information.

5. COMMITTEE APPOINTMENTS
Senate approved the following appointments:
• Senate Graduate & Research Council: Lauren Meliss Holt (replacing Emily Cyr) as graduate student representative from the Faculty of Arts, term to 30 April 2019.
• Senate Nominating Committee for Honorary Degrees: Alysia Kolentsis (replacing Marlene Epp) as the affiliated and federated institutions of Waterloo member, term 1 January 2019 to 30 April 2019.
• Amit and Meena Chakma Awards for Exceptional Teaching by a Student Committee: Giuseppe Femia (arts and business), Navroop Kaur (biology), Nicholas Mok (biology) undergraduate student representatives, terms to 31 December 2019.
• Distinguished Teacher Awards Committee: Firas Mansour (physics and astronomy) as faculty representative, term ending 31 December 2019; Wei-Chau Xie (civil and environmental engineering) as faculty representative, term ending 31 December 2020; Wanis Nafo (civil and environmental engineering) as graduate student representative, term ending 31 December 2020; Giuseppe Femia (arts and business), Bilal Akhtar (software engineering), Magda Bentia (biology) as undergraduate student representatives, terms ending 31 December 2020.

The question was called, and the motion carried unanimously.

Regular Agenda

6. BUSINESS ARISING FROM THE MINUTES
There was no business arising

7. RESEARCH PRESENTATION
Jean Andrey introduced Sarah Burch, Associate Professor and Canadian Research Chair in Sustainability, Governance and Innovation, Faculty of Environment. Dr. Burch presented her research in the area of sustainability, governance and innovation. She spoke to: international temperature anomalies since 1900, and that climate change is not measured by one-time events, rather, averages over longer periods; new ways to consider “boundaries” and triggers re: the safe operating space for humanity, of which four of nine have been crossed as a result of human activity; transformational activities and advances; ways in which small and medium enterprises can make a difference; international efforts, including Dr. Burch’s project with scholarly networks, research hubs, government and the private sector to effect change.

Following the presentation, Senate discussed: possible sustainable business model structures; the role of factory farming in climate change; relationships between the boundary activities and sustainability.
8. **REPORTS FROM COMMITTEES AND COUNCILS**
   **Graduate & Research Council**
   **New Research Centre, Waterloo Centre for Astrophysics**
   Senate heard a motion to approve the establishment of the Waterloo Centre for Astrophysics.

   Casello and Lemieux. Carried unanimously.


   Senate heard the following motions:

   **Academic Calendar Dates 2019-2020**
   **Motion:** To approve the 2019-2020 calendar dates and calendar guidelines for establishing academic dates as presented in attachment 1 (clean copy) and attachment 2 (red-line copy).

   Newell Kelly and Coniglio. Carried unanimously.

   **Undergraduate Calendar Guidelines Re: Scheduled Pauses**
   **Motion:** To update the Study Days calendar text for undergraduate students.

   Newell Kelly and Coniglio. Carried unanimously.

   **Graduate Calendar Guidelines Re: Requirements During Scheduled Pauses**
   **Motion:** To include the following specific guidance in the Graduate Studies Academic Calendar that specifies the requirements for graduate students during scheduled academic pauses.

   Casello and Samuel. Carried unanimously.

   **Committee on Student Appeals**
   Coniglio spoke to this year’s report. In discussion: the difficulty identifying trends; recognition that there is heightened awareness in the community for academic integrity matters and reporting generally; ongoing efforts by the academic integrity office to educate both instructors and students; outcomes. Senate received the report for information.

9. **REPORT OF THE PRESIDENT**
   Hamdullahpur spoke to a variety of matters, including: an update on student mental health activities; the coming University’s free speech policy and next steps, including advice that Senate will have an opportunity to offer feedback on the draft; recent and coming activity on the strategic plan, including the pending culmination of the consultation sessions.

10. **Q&A PERIOD WITH THE PRESIDENT**
    In discussion: the current policy framework the University already has in place with respect to freedom of speech; the policy will be a “G” class policy; the University will respect individuals’ right to protest peacefully; the third strategic mandate agreement is still under consideration by the University, and we await further direction from the province; uncertainties with respect to provincial funding.

11. **REPORT OF THE VICE-PRESIDENT, ACADEMIC & PROVOST**
    The provost asked members to review his memo of 13 November re: university expenditures and keep it in mind with respect to 2019-2020 budget planning.
12. REPORT OF THE VICE-PRESIDENT, UNIVERSITY RESEARCH
   Senate received the report for information.

13. OTHER BUSINESS
   There was no other business.

Senate convened in confidential session.

20 December 2018
Karen Jack
University Secretary
FOR INFORMATION

At its 3 December 2018 meeting, in accordance with the powers granted to the Committee in Section 1.04.b. of Senate Bylaw 2, on behalf of Senate, the Committee approved definitions for graduate academic credentials as follows.

Motion: To approve text that defines academic credentials at the graduate level, as presented in Attachment 1. This text, once approved, will appear in the Graduate Studies Academic Calendar.

Rationale: In an effort to clarify and standardize the types of academic “products” (in addition to degrees) offered at the graduate level, the definitions are proposed. In each case, these guidelines indicate the academic requirements, the way in which the products are recorded (on transcripts or diplomas), and, finally, the role of the Quality Council. Please note that if these guidelines are accepted, the terms used – particularly fields and specializations – will become “reserved words” and their use at the University will be limited to these applications, effective Winter 2019.
Clarifying Diplomas, Fields and Specializations
McKenzie and Casello September 2018

Introduction:
In an effort to clarify and standardize the types of academic “products” (in addition to degrees) offered at the graduate level, the following definitions are proposed. In each case, these guidelines indicate the academic requirements, the way in which the products are recorded (on transcripts or diplomas), and, finally, the role of the Quality Council. Please note that if these guidelines are accepted, the terms used here – particularly fields and Specializations – will become “reserved words” and their use at the University will be limited to these applications.

Motion: To approve the following text that defines academic credentials at the graduate level. This text will appear in the Graduate Studies Academic Calendar.

Graduate Type 2 Diplomas:
A graduate Type 2 Diploma (GDip) is intended to demonstrate mastery of a topic area that is usually complementary to, but not embedded within, a graduate student’s primary area of study. The goal of the GDip is to encourage breadth at the graduate level, often through interdisciplinary studies. A student who completes a degree program and a GDip should have achieved different learning outcomes than a student who has completed only the normal degree requirements.

GDips at the University of Waterloo are achieved by successfully completing the academic requirements of the student’s program AND additional academic requirements – a combination of courses and/or academic milestones – specific to the GDip that total to the equivalent of 1.0 (academic) units. Normally, obtaining a GDip will require at least:
- Two 0.5 unit courses in addition to the program’s normal requirements; or
- one additional 0.5 unit course and one or more milestones the academic requirements of which are equivalent to a 0.5 unit course; or
- a set of milestones the academic equivalent of which are two 0.5 unit courses.
The Department offering the GDip may also require specific courses that replace electives in the student’s core program.
GDips:
- require Quality Council approval;
- should normally contain course or milestone options that promote interdisciplinarity; and
- are recognized on the student’s transcript and on the Diploma.

Graduate Research Fields:
Graduate programs and research areas are often defined by the administrative unit within which the graduate student or supervisor is appointed. Often fields define specific areas of research within the unit; in other cases, the research conducted is “at the edge” of the normal understanding of the administrative unit’s commonly understood focus. Graduate research fields are used to better define a student’s research concentration when the broader program definition is insufficient to appropriately represent (to academic and professional audiences) the student’s focus. Examples of existing research fields at Waterloo include several in the Master’s programs offered in Applied Math, Computer Science and Civil Engineering.
Research fields are specified at the time of application. Academic units who wish to employ research fields are encouraged to include specific course requirements that support the learning outcomes associated with that field. An assessment of whether or not the student’s completed research warrants the field designation should be completed by the Department or Faculty at the time of degree completion.

Graduate Research fields:
- are reported to Quality Council as part of the major modification report;
- may be specified by the student when applying to a program or unit;
- may have a corresponding unique set of required and elected courses;
- should not require additional academic accomplishments beyond the normal degree requirements;
- should be a recognized area of research;
- are recognized on the student’s transcript but not on the Diploma.

Graduate Specialization:
A graduate Specialization reflects expertise achieved by a graduate student in a sub-discipline of their primary area of study. Specializations are normally available in course-based graduate programs or research programs where there is sufficient required coursework to allow for the customization of the student’s program. For example, a Master’s research program with two required courses and two electives (four total courses), would not qualify for a Specialization because there is insufficient flexibility for the student to demonstrate mastery of a sub-discipline. In contrast, a research program with four required courses and four electives could easily be designed with multiple Specializations achieved by completing a specific set of courses as the electives.

A Specialization is achieved at the University of Waterloo by successfully completing a set of courses defined by the academic unit that collectively contain the necessary depth of material to ensure a student’s level of mastery.

Specializations:
- do not require Quality Council approval;
- do not require additional (to the host program) coursework or milestones;
- should include at least four 0.5 unit courses or 2.0 academic units in total specific to the Specialization;
- should reflect themes that are emerging or established in the discipline, such that the completion of the Specialization has meaning to an external audience;
- should only be offered in disciplines where sufficient breadth of scholarship or professional areas exists to warrant such a distinction;
- are recognized on a student’s official transcript, but not recognized on a student’s Diploma.
Senate Graduate & Research Council met on 12 November 2018 and 10 December 2018 and agreed to forward the following items to Senate for information as part of the consent agenda.

Further details are available at: https://uwaterloo.ca/secretariat/committees-and-councils/senate-graduate-research-council

FOR INFORMATION

CURRICULAR SUBMISSIONS
On behalf of Senate, council approved new courses, course revisions, course inactivation, and minor program revisions for the Faculties of Applied Health Sciences (kinesiology) and Arts (anthropology, french, economics, global governance, history).

FRAMEWORK FOR THE ASSESSMENT OF GRADUATE PLAGIARISM
Council was apprised of a new guideline pertaining to the assessment of graduate plagiarism (effective 1 January 2019) and which will work in conjunction with Policy 71 – Student Discipline.

ACADEMIC PROGRAM REVIEW REPORTS
On behalf of Senate, council approved:

- Two-year Progress Report – Computational Math, as presented in Attachment 2.

OFFICE OF RESEARCH
On behalf of Senate, council approved the following Human Research Ethics Committee continuing membership item: (1) renewal of a member for a third, 3-year term.

RENEWAL OF CENTRES AND INSTITUTES
On behalf of Senate, council approved the renewal, for a 5-year term, of the following four centres: Centre for Theoretical Neuroscience, Centre for Accounting Research & Education, Centre for Advanced Materials Joining, and Survey Research Centre. Support documentation may be found here: https://uwaterloo.ca/secretariat/sites/ca.secretariat/files/uploads/files/sgrc_2018-11-12_agenda_pacakge_reduced_version_2.pdf (item 8; pages 75-441).

GRADUATE AWARDS
On behalf of Senate, council approved the W.S. Rickert Graduate Student Fellowship in Science (endowment), Correlation One Data Science Graduate Scholarship (trust), Mathematics Graduate Enhancement Scholarship (operating), International Master’s Award of Excellence (operating), and Masternak Foundation Graduate Scholarship in English (trust).
Final Assessment Report
Environment and Business (BES, MEB),
Sustainability Management (MES), Economic
Development and Innovation (MEDI)
September 2018

Summary of the Program Review:
In accordance with the University Institutional Quality Assurance Process (IQAP), this final assessment report provides a synthesis of the external evaluation and the internal response and assessments of the programs (BES, MEB, MES and MEDI) delivered by the School of Environment, Enterprise and Development (SEED). A self-study (Volume I) was submitted to the Associate Vice-President, Academic and Associate Vice-President, Graduate Studies and Postdoctoral Affairs on August 17, 2016. The self-study presented the program descriptions and learning outcomes, an analytical assessment of these 5 programs (BES has a co-op and regular version), and program data including the data collected from a student survey along with the standard data package prepared by the Office of Institutional Analysis & Planning (IAP). Appended were the course outlines for all courses in the program and the CVs (Volume II) for each full-time faculty member in SEED.

Two arm’s-length external reviewers (Volume III), (Dr. Stephanie Bertels, Associate Professor, Simon Fraser University and Dr. Wesley Craig, Professor Emeritus, York University) were ranked and selected by Associate Vice-President, Academic and Associate Vice-President, Graduate Studies and Postdoctoral Affairs, in addition one internal reviewer (Dr. Gerry Boychuk, Professor of Political Science) was selected.

They reviewed the self-study documentation and then conducted a site visit to the University on February 9-10, 2017. The visit included interviews with the Vice-President, Academic & Provost; Associate-Vice President, Graduate Studies and Postdoctoral Affairs; Associate Vice-President, Academic; Dean of the Faculty; Directors of programs, Faculty members and staff, as well as meetings with a group of current graduate and undergraduate students. The external review team also had an opportunity to meet the team of librarians that support the programs.

This final assessment report is based on information extracted, in many cases verbatim, from the self-study, the external reviewers’ report and the program response.
Program characteristics:
The School of Environment, Enterprise and Development (SEED) was created in 2009 in order to consolidate undergraduate (UG) and graduate (G) programs in Environment and Business (UG), International Development (UG) and Local Economic Development (G) within a single academic unit. The constituent programs were previously offered at the faculty level without the benefit of a departmental structure.

The creation of SEED has also led to further program development, with the School adding graduate programs in Environment and Business (2010), Development Practice (2012), Social Innovation (2011-2014), and Sustainability Management (2013) in the last seven years. As a result of program growth within the existing programs and the addition of new programs, SEED has been one of the most rapidly growing Schools within the University of Waterloo.

The BES Environment and Business Honours Co-operative program and the BES Environment and Business Honours Regular program are two of several “X and Business” programs at UW which reflect the unique approach to business education UW adopts at the UG level. The Environment and Business (BES) program requires students to take base courses in both environmental studies and in business, as well as a series of courses that are intended to integrate environment and business. The key objective of the program is to produce knowledgeable and experienced graduates who can integrate and translate the tools of business and sustainability.

The Master of Environment and Business (MEB) is aimed at meeting the growing need for business sustainability professionals as a distinct group of knowledgeable, skilled, confident and motivated individuals with the information, tools and expertise to integrate environment with business in very practical ways. The program, which was first offered in Fall 2010, is specifically designed for working professionals and as such, it is offered on-line and on a part-time basis. Since 2015, the program has also been offered on a one year full-time basis.

The MAES in Local Economic Development (LED) program offers a balance of theory and practice, with a strong focus on experiential learning, a central goal of the Faculty of Environment and the University of Waterloo. During the period of time captured in the self-study, the MAES in Local Economic Development nomenclature was changed to a Master of Economic Development and Innovation (MEDI), which recognizes the professional nature of the program and the increased nexus between economic development and innovation studies in the field.

Sustainability Management (SUSM), which was first offered in 2013, is the research-based, standard Master’s program in SEED. SUSM enhances research skills and develops academic knowledge, methods and tools through course work and academic research in sustainability management. As a field of study and research concentration, sustainability management is the development and application of both technical (i.e., life cycle assessment, materials/energy flow analysis, reporting) and strategic (i.e., economic, financial, operational, regulatory) management tools and approach to enhance sustainable outcomes of businesses, organizations and communities.
Summary of strengths and challenges based on self-study:

Bachelor of Environmental Studies (BES) Environment and Business (Honours)

**Strengths:**
- Integrated nature of program makes it unique in Canada (and beyond) as it treats sustainability and business decisions as necessarily connected
- Interdisciplinary make up of SEED faculty creates learning opportunities that draw on expertise across a range of technical and theoretical perspectives
- The program has a rich diversity and significant depth of courses in sustainability management
- Experiential education opportunities are built into the program (i.e., co-op, capstone project)
- High quality students are attracted to the program
- SEED has established an educational partnership (2+3 collaboration) with Nanjing University of Finance and Economics (NUFE)

**Challenges:**
- Exposing upper year students to a range of business courses because Waterloo does not have a business school, which would typically offer a wide range of courses
- Some students have indicated that teaching quality is, in places, problematic (breadth and diversity of faculty and nature of curriculum means there is less overlap, administrative and sabbatical leaves require use of sessional lecturers)
- Integration of 2+2 students into overall fabric of program and their ability to find their first co-op job within Canada is an ongoing challenge as these international students have a limited local network, combined with language limitations
- Inability of the faculty members to react more flexibly to new opportunities in teaching as a result of limited capacity, which includes additional business-oriented courses and experiential learning opportunities

Master of Environment and Business

**Strengths:**
- The MEB is a highly integrated interdisciplinary program where environmental and social justice concerns are treated as core, not peripheral, considerations to business and organizational success
The program offers students a comprehensive understanding of the business challenges associated with sustainability and provides students with a suite of tools to address those challenges.

The online learning environment is interactive and supportive.

Students have prior work experience and many are working in jobs that have some sustainability component, which helps to enhance the opportunities for peer sharing.

There is good retention in the program and strong student satisfaction.

**Challenges:**

- Enrollment numbers have not reached their potential
- Tuition fees are higher than standard graduate programs in the province
- Degree nomenclature is not sufficiently well known to compete with MBA programs in a market that places a considerable premium on the market recognition of the degree
- At the moment, there is a lack of support and funding for graduate recruitment; recruitment is left up to individual departments and faculties
- Attracting students from other programs to MEB electives remains challenging as they prefer in-person courses and tend not want to enroll in courses during the spring term

**Master of Economic Development and Innovation (MEDI)**

A number of changes were underway during preparation of the self-study including a change of the degree name to Master of Economic Development and Innovation (MEDI).

**Strengths:**

- The MEDI program is the only graduate program in its field at a major comprehensive university in Canada; consequently, the program occupies an important role in the professional training of economic development practitioners in Canada
- There are well established collaborations with industry associations, including the Economic Developers Association of Canada, which give MEDI students advanced access to their professional designation
- The strong program curriculum provides students with a theoretical and practical foundation in the field
- Well-developed experiential education opportunities are aligned with professional practice, and appear to result in positive employment outcomes for students

**Challenges:**

- Enrollment numbers are not as strong as they could be
As with the MEB, more focused recruitment activities could help increase numbers

Coordination of content delivery between the other SEED programs could assist in resource use

Time to completion has been a challenge as students often gain employment which interferes with their ability to complete their choice of either the Capstone Project, Internship, Applied Research Project, or Major Research Paper (MRP)

MRP requirement has strained the School’s supervisory capacity

**MES in Sustainability Management**

**Strengths:**

- Strong student demand has resulted in the program reaching a steady state of enrolment in its third year
- The program leverages the Faculty’s existing reputation as a leading centre for graduate education in the environment
- Curriculum and teaching within the program have been very well received by students and there is evidence of strong student progression to date
- Strong student uptake and the number of students pursuing doctoral work (5 within first three years of program’s existence) have encouraged the development of a PhD program – this will further strengthen research capacity, with consequent benefits for the SUSM program

**Challenges:**

- Distribution of supervisory workload is uneven
- Student funding is weak as there is no dedicated funding for SUSM students and many students are not prepared early enough to be competitive in SSHRC and OGS funding competitions

**Opportunities for SEED Programs:**

- The increased emphasis on the transitions to low carbon and green economy positions aforementioned programs as having great salience, particularly for business and government actors
- There is potential to grow the graduate Environment and Business, and Economic and Development Innovation programs
• Outside of classroom, there are important informal opportunities for cross-program interactions that could be taken advantage of that could enhance overall student experience

• The creation of a PhD in Sustainability Management will provide greater impetus for increased research funding, which would spill over to other programs and may provide more opportunities for research-based experiential education in research clusters or labs. However, delivering additional opportunities will be dependent on an increase in faculty capacity.

Summary of key findings from the external reviewers:
Reviewers found the SEED programs to be interesting, substantive, valuable and competently delivered. They also stated that what makes the SEED programs unique and attractive is that it is grounded on a moral vision. It is this vision that sets SEED apart and makes it an attractive educational option to potential and current students and many faculty.

Program response to external reviewer recommendations

Bachelor of Environmental Studies (BES) Environment and Business (Honours)

Recommendations:
1. Articulate a more coherent narrative about the key learning goals of the program including the perspective, knowledge, and skills that students will have gained by completing it.

Response
In order to address this issue, and based on the University guidelines, the School will initiate a common course outline for SEED courses that includes clear learning objectives, which will enable the School Director and the Program Director to better oversee the implementation of program objectives within individual courses. Appropriate consultation with faculty members on implementing a common course outline will take place before implementing any changes.

2. Review the content in the integrative courses with attention to overlap in content.

Response
The Program Director will hold a one-day curriculum retreat with faculty and instructors to coordinate the integrative course offerings to better avoid redundancy and to promote coverage of the program’s learning objectives.

3. Add a more deliberate reflection on students’ applied learning in the integrated courses in the program (those over which you have control).
Response

Reflection and integration of applied learning (chiefly, co-op work experience) is largely addressed through work term reports, which have been the subject of much discussion within the Faculty and the University at large. This discussion is ongoing and any new initiatives may help to address the need for more deliberate reflection on applied learning. These discussions are being led by the Assoc. Dean UG of the Faculty and are expected to result in new recommendations by the Winter of 2018.

Addressing this issue in course settings creates some challenges due to the diversity of co-op placements in which students tend to participate. The central avenue for consolidating applied learning within the program is through ENBUS 402, a final year capstone course that pairs student teams with outside clients to conduct an eight-month research-based consulting project. This opportunity is not tied directly to co-op, but leverages the professional skills and workplace knowledge gained on placements. In other courses, greater awareness of the particular placements may assist instructors in knowing how to draw on student workplace knowledge. Incorporating assessment opportunities that more explicitly draw on these skills and knowledge may also assist in reinforcing the link between program objectives and co-op placements. The School will explore ways to improve these links and will seek to identify opportunities within specific courses to introduce elements that draw on workplace-classroom connections.

4. Work with the co-op office to improve the availability of relevant co-op placements for ENVBUS students.

Response

The School has been active with the Centre for Cooperative Education and Career Action (CECA) in helping to facilitate the development of relevant co-ops for EB students. For example, past activities have included meetings with co-op job developers to discuss employment opportunities in the sustainability field, including bringing in employers to discuss their perspectives on the field and employer requirements. We have found CECA to be very receptive to these initiatives, which have been received positively by employers. We will continue to work with co-op on these types of initiatives, and to provide CECA with our understanding of the emerging and expanding set of opportunities in the sustainability area.

5. Better track student outcomes beyond graduation including more data on employment after six months and two years after graduation; post graduate study; and alumni reports on program quality.

Response

September 2018
Tracking student outcomes after graduation is extraordinarily important for the School, in that it greatly assists us in our ability to market programs to students and employers and to ensure strong links between student opportunities and outcomes and our program design. Typically, the task of tracking these outcomes is performed by the Faculty and University alumni relations staff. It must be borne in mind that due to the relatively short amount of time that SEED programs have been in existence that the number of alumni is much smaller than more established programs. The data we receive for our programs is improving yearly and we see no reason to seek changes to the way in which the University gathers and shares this information.

6. Contribute to the development of a common pool of core business courses such as courses in both macro and micro economics, financial and managerial accounting, operations management, data and decisions, marketing, business communication, and project management.

Response
This issue was addressed comprehensively in the report prepared by the UW Business Working Group entitled “Business at Waterloo Programs: Current State and Future Opportunities”, (delivered May 5, 2017 – after the completion of the Reviewers report). The School has identified areas, such as strategy and marketing, which it can contribute to the core business offerings of the University. Further progress on this issue will be taken-up by the implementation of the report’s recommendations, with the Associate Director Undergraduate Studies and the EB program’s academic leader being responsible for progress, which is ongoing.

7. Consider introducing a more ‘integrative’ course in second and third year.

Response
The suggestion of moving the current integrative course (ENBUS 112) to an upper year (second or third) will be evaluated by the School. At the time ENBUS 112 was created we were responding to student concerns that the first year curriculum did not have enough integrative content (there is one other integrative course – ENBUS 102 – in the first year). There are existing integrative courses in second and third years (ENBUS 202 and 302).

8. Consider developing streams within the program.

Response
The EB program has identified thematic areas in the past, but we moved away from this approach as it was a challenge to resource multiple areas of focus and student demand for specialization at this level was low. Students who are interested in particular sub-fields of sustainability management can take electives to gain the knowledge and skills they seek.
noted by the reviewers, sustainability management is a very new and dynamic field, and
identifying streams at the current time may reduce our ability to respond to developments in
the field.

Specialization is more expected at the graduate level. Our goal at the undergraduate level is
to ensure students have a comprehensive understanding of the field. Our preferred approach
is to identify key areas for new electives, including providing electives that have cross
program appeal. At this stage, the School does not feel that developing streams would be
desirable.

**Master of Environment and Business**

9. Revisit the curriculum map with attention to setting out a clearly sequenced set of
   learning objectives around knowledge development, knowledge mastery and knowledge
   application.

**Response**
The reviewers identified that there was some ambiguity and overlap in terms of mapping the
program objectives with the learning objectives in specific courses. We agree that it would be
beneficial to revisit this exercise, particularly as the program has developed new online
courses in the past twelve months. The MEB Program Director initiated this exercise in Fall
2017. To be clear, the reviewers note that the overall program objectives are sound, so the
exercise is not to engage in a full curriculum review, but rather a sequencing of learning
objectives and to course learning outcomes.

10. Tie key assessments to key learning objectives so that future self-assessment reports can
    comment on student performance in meeting key learning objectives.

**Response**
This comment is related to the above recommendation. It is current practice to complete an
incoming and an outgoing assessment of students based on the current learning objectives.
When the learning objectives are fully revised, the assessment surveys will also be revised.
The outgoing assessment results were not included in the last self-assessment report, but
they can be in the future.

11. Tighten up admission requirements with respect to prior work experience

**Response**
The School currently carefully considers work experience as part of its admission process. The
requirement is three years of prior work experience. At the time of the evaluation we were
September 2018
experimenting with allowing applicants with a highly relevant co-op degree (and the related co-op work experience) to be considered. We have since tightened this up as recommended by also expecting applicants to be working full-time in a sustainability related position, and we will only accept them into the part-time program.

12. Develop recommendations for how students can supplement the Learning Management System interface to enrich their interactions as a cohort.

Response
Recommendations 12, 14 and 15 address the management of the online learning environment. The recommendations suggest the need to improve the degree of interaction within courses and among students in the online environment. This is, of course, a key challenge in any online program, particular where the program is delivered asynchronously. Currently, as course are developed and revised, instructors work intensively with staff from the Centre for Extended Learning, and new elements are added on an ongoing basis. The Program Director has been especially vigilant in staying up-to-date with new developments and learning techniques in this area. What the reviewers recommend largely describes current practices. The key improvement we can make to address these issues is to ensure that instructors, the program director and CEL are sharing successful innovations and discussing strategies to best engage students in online learning environments. Outside the online environment, the MEB program promotes the June milestone and the Globe conference as valuable inter-cohort networking opportunities. Also, each cohort creates their own engagement mechanism. The last two cohorts have used WhatsApp, and the years before that used Slack and Facebook. This is not supported by the program as we think it is ideal that the students communicate without professors or staff present. We do let incoming cohorts know what past cohorts have done. We are told that these social media groups are very active.

In terms of leveraging content between programs, all of the MEB electives are open to non-MEB students, and we run parallel versions of the core courses for non-MEB students. For the most part, the take up of these courses has been by research students (SUSM), but certain courses are taken by MEDI and other students. We are experimenting with some more modular content that could be used across programs; for example INDEV 617 is a new field course in India that is popular with MEB students. With the addition of more online degrees at the University of Waterloo - including in climate risk management, green energy, and planning - our online courses are seeing increasing demand from other departments.

13. Incorporate a visit from the librarian into the introductory in-person module that is
linked to a deliverable (so that students have an opportunity to apply the knowledge provided).

**Response**
This recommendation is already largely implemented in current practice and hence was not pursued. The assessment of the in-person lessons occur a few weeks later in ENBUS 602.

14. Consider how the LMS could be enriched to provide a richer, more interactive experience.

**Response**
See 12 above.

15. Consider how this online content could be leveraged to enhance learning in your other programs.

**Response**
See 12 above.

16. Consider how some of the course content in other programs (for instance, MEDI) could be leveraged into this program.

**Response**
MEB students are free to take electives in other programs; the challenge is developing content that can be delivered across multiple platforms. To date, we have initiated meetings among Graduate Program Directors to assess the potential for sharing resources, including online deliveries, and we will continue to do. The current entrepreneurship course (ENBUS 612) does incorporate some aspects of economic development and innovation. These opportunities will be monitored for potential future incorporation.

**MES in Sustainability Management**

17. Provide more up-front support in planning for electives (consider creating guidance on electives streams in Life Cycle Assessment (LCA), responsible finance and community economic development)

**Response**
The School has developed a list of electives, but will revisit the list to clearly indicate the relevance of certain courses for various research interests.
18. Examine whether more ‘management’ content is needed in the curriculum

**Response**
Currently management content is available through MEB course offerings. We will review the need for more generalized content provided in an in-person delivery format. The feasibility of delivering a new course is resource dependent.

19. Consider adding a mandatory research statistics course

**Response**
The School does not agree with the recommendation for a mandatory research statistics course. The reasons are twofold: (1) students come to the program with a variety of backgrounds and those with statistical skills should not be required to take a further mandatory course; and (2) the program encourages students to use a wide range of research methods, some of which do not require statistics but do require other research methods and analytical skills. In this context, SUSM 603 Research Methods for Sustainable Management is intended as a broad survey course that reflects the diversity of research methods available to students who will undertake their thesis research on a variety of subjects. Students can therefore take elective courses in those research methods that suit their research ambitions and which are offered elsewhere in the Faculty and University.

**Master of Economic Development and Innovation (MEDI)**

The MEDI program underwent significant revision after the self-study was completed, but prior to the site visit. The Reviewers report accounted for the changes to the program.

20. Clarify who will provide administrative support for the capstone and internships.

**Response**
At the time of the site visit, the School’s Experiential Learning Coordinator (ELC) was on parental leave and some of her duties had been transferred to the Economic Development Program (EDP) Outreach Manager. It is expected that the ELC will be the primary administrative support person for MEDI capstone projects, with some support from the EDP Outreach Manager. The MEDI Program Director will work with the SEED Director and EDP Director to confirm arrangements and division of labour.

21. Work with graduate studies to seek out additional funding to replace the TA funding.
Response
Student funding allocations are determined at the Faculty level via the Associate Dean, Graduate Studies (AD-G). The MEDI Program Director worked with the AD-G to arrive at a funding model for this year that is consistent with other professional programs in the Faculty. MEDI also has a scholarship fund provided by the EDP to assist with recruitment. These funds are carried over annually if unused (for example, if highly qualified prospective students decline offers).

Several emerging initiatives, including international partnerships and changes to the University’s approach to graduate funding, may alter the funding landscape. The MEDI Program Director will continue to work with the SEED Director and AD-G to explore other funding opportunities and monitor the impacts of funding on application rates and enrolment outcomes.

22. Consider making the land planning course mandatory.

Response
Currently, MEDI students have 6 required courses and 2 electives. Thus, requiring an additional course may add too much rigidity to the students’ schedule, especially since the land planning course (ECDEV 612) is scheduled and resourced by the School of Planning, with a cross-list to an undergraduate class. MEDI will highly recommend the land planning course as an elective and work with the School of Planning to ensure that the course remains accessible and available to MEDI students.

23. Consider creating opportunities for more interaction between planners and the economic development program (for instance, working through case studies from both perspectives).

Response
There is a strong connection between planning and economic development in both theory and practice. Indeed, in the US and in other places, economic development courses are often embedded in planning programs. MEDI’s strongest students often have a planning background. MEDI will explore short-term and longer-term ways to create interactions with planning students. Given the relationship between these domains in theory and practice, the MEDI Program will explore ways to build and enhance partnerships with the School of Planning and ensure that MEDI students engage with planning ideas. MEDI students will be encouraged to take planning courses as electives. MEDI instructors will be asked to consider ways to include planning content in their courses and curriculum, including designing cross-disciplinary activities. The MEDI Program Director will discuss the availability of PLAN courses to MEDI
students with School of Planning, explore cooperation related to generating course-based and capstone projects, as well as ensure that MEDI students are invited to participate in Planning-related events.

Other Recommendations from External Reviewers

The reviewers identified some other more general recommendations, which applied to the programs under review as a whole. One set of recommendations was largely definitional and oriented towards the broader vision and approach within the school towards sustainability management. The reviewers framed these comments in terms of one of the areas that the School sought some advice from the reviewers; namely, whether there was benefit in considering a move to more recognized business degrees in our programs, such as MBAs or B.Comms. It ought to be noted that the advice sought was solicited prior to the Business at Waterloo Report referenced above, which has provided much greater clarity to the institutional approach to business at the University. SEED, in agreement with the reviewers, is of the view that the current approach, which strongly differentiates its approach from business schools, is the best pathway for the School and its programs.

As part of this discussion questions were raised about the need to further develop and define the concept of “business” and “sustainability” in the context of the School’s broader vision. The School has carefully developed a vision and mission statement through its strategic planning and believes that the level of specificity is appropriate.

The reviewers also generalized two of their recommendations to apply to all SEED programs:

24. It is recommended that SEED establish a common format for outlining learning objectives for programs, for curriculum mapping against these core learning objectives as well as a common format for course outlines. For instance, course outlines should consistently include course goals, course descriptions, and learning objectives linked to their associated learning assessments and ideally, rubrics of assessment.

As discussed above this is a valuable recommendation and the School will explore its implementation across the School.

25. While there is an emphasis on the application of knowledge in all of the programs, there appears to be a need to make more space to deliberately incorporate reflection on the application of that knowledge into all of these programs.

Similarly, the School agrees that reflection on applied learning, which is a constituent part of all our programs, is critical. There are activities, such as work term report changes, that are...
being considered at the Faculty and University levels. The School will seek incremental improvements to achieve this goal on an ongoing basis as part of these wider initiatives.

**Recommendations that were not selected for implementation:**

11. Tighten up admission requirements with respect to prior work experience.
12. Incorporate a visit from the librarian into the introductory in-person module that is linked to a deliverable (so that students have an opportunity to apply the knowledge provided).
18. Consider adding a mandatory research statistics course

**Response**
Recommendations 11 and 12 have been addressed; recommendation 18 is not being implemented for the reasons articulated.
### Implementation Plan:

<table>
<thead>
<tr>
<th>BES Environment &amp; Business Recommendations</th>
<th>Follow-up</th>
<th>Resp.</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1  Articulate a more coherent narrative about the key learning goals of the program including the perspective, knowledge, and skills that students will have gained by completing it</td>
<td>A common course outline that includes clear learning objectives will be implemented, with appropriate consultation with faculty.</td>
<td>SEED Director &amp; Program Directors</td>
<td>Winter 2018</td>
</tr>
<tr>
<td>2  Review the content in the integrative courses with attention to overlap in content</td>
<td>This will be discussed at our ENBUS faculty and staff retreat in June 2017.</td>
<td>BES Program Director</td>
<td>Summer 2017</td>
</tr>
<tr>
<td>3  Add a more deliberate reflection on students’ applied learning in the integrated courses in the program (those over which you have control)</td>
<td>There are plans to integrate reflective exercises about co-op placements into the new structure for co-op reports. These revisions are being implemented at the faculty level and are set to be in place by the beginning of 2018.</td>
<td>BES Program Director, in consultation with Assoc. Dean UG</td>
<td>Winter 2018</td>
</tr>
<tr>
<td>4  Work with the co-op office to improve the availability of relevant co-op placements for ENBUS students</td>
<td>Our experiential learning coordinator continues to have discussions with CECA about increasing the number and type of co-op positions that are related to the ENBUS program. We are also looking at opportunities for ENBUS related co-op positions through our alumni network (which is still young but rapidly growing).</td>
<td>Experiential Learning Coordinator</td>
<td>ongoing</td>
</tr>
<tr>
<td>5  Better track student outcomes beyond graduation including more data on employment after six months and two years after graduation; post graduate study; and alumni reports on program quality</td>
<td>Ongoing.</td>
<td></td>
<td>ongoing</td>
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<td></td>
<td>Recommendation</td>
<td>Follow-up</td>
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<td>6</td>
<td>Contribute to the development of a common pool of core business courses such as courses in both macro and micro</td>
<td>Address in Business at Waterloo Report (May 2017). Report Implementation in the hands of senior administration.</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Revisit the curriculum map with attention to setting out a clearly sequenced set of learning objectives around knowledge development, knowledge mastery and knowledge application</td>
<td>A limited mapping of program objectives to course learning outcomes to ensure clearly sequenced objectives.</td>
<td>MEB Program Director</td>
</tr>
<tr>
<td>10</td>
<td>Tie key assessments to key learning objectives so that future self-assessment reports can comment on student performance in meeting key learning objectives</td>
<td>Included in follow-up to above.</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Tighten up admission requirements with respect to prior work experience</td>
<td>No follow-up required.</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Develop recommendations for how students can supplement the LMS interface to enrich their interactions as a cohort</td>
<td>The MEB Program Director will survey existing MEB students on potential improvements for engagement and discuss strategies with CEL and MEB instructors.</td>
<td>MEB Program Director</td>
</tr>
<tr>
<td>13</td>
<td>Incorporate a visit from the librarian into the introductory in-person module that is linked to a deliverable (so that students have an opportunity to apply the knowledge provided)</td>
<td>Current practice meets recommendation. No follow-up required.</td>
<td></td>
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<td></td>
<td>Consider how the LMS could be enriched to provide a richer, more interactive experience</td>
<td>See recommendation #12 above</td>
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<tr>
<td>15</td>
<td>Consider how this online content could be leveraged to enhance learning in your other programs</td>
<td>See recommendation #12 above</td>
<td></td>
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<tr>
<td>16</td>
<td>Consider how some of the course content in other programs (for instance, MEDI) could be</td>
<td>The SEED Director and relevant program directors will continue to meet to assess opportunities to leverage</td>
<td>SEED Director</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>MES Recommendations</th>
<th>Follow up</th>
<th>Resp.</th>
<th>Timing</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>Provide more up-front support in planning for electives (consider creating guidance on electives streams in LCA, responsible finance and community economic development)</td>
<td>The existing list of electives will be revisited and placed on SUSM website.</td>
<td>MES Program Director</td>
<td>Fall 2017</td>
</tr>
<tr>
<td>18</td>
<td>Examine whether more ‘management’ content is needed in the curriculum</td>
<td>The adequacy of current offerings within MEB will be reviewed.</td>
<td>MES Program Director</td>
<td>Fall 2017</td>
</tr>
<tr>
<td>19</td>
<td>Consider adding a mandatory research statistics course.</td>
<td>No follow-up required.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LED (MEDI) Recommendations</td>
<td>Follow up</td>
<td>Resp.</td>
<td>Timing</td>
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<td>20 Clarify who will provide administrative support for the capstone and internships</td>
<td>The ELC will be the primary administrative support person for MEDI capstone projects, with some support from the EDP Outreach Manager.</td>
<td>MEDI Director to work with SEED Director and EDP Director to confirm arrangements and division of labour</td>
<td>Fall 2017</td>
<td></td>
</tr>
<tr>
<td>21 Work with graduate studies to seek out additional funding to replace the TA funding</td>
<td>MEDI Director to work with SEED Director and Dean’s Office to explore additional funding opportunities and monitor impact of funding on enrolment outcomes.</td>
<td>MEDI Director and SEED Director</td>
<td>ongoing</td>
<td></td>
</tr>
<tr>
<td>22 Consider making the land planning course mandatory</td>
<td>MEDI will highly recommend the land planning course as an elective, but adding a further required course will impose too much rigidity in program. MEDI Director to discuss scheduling of ECDEV 612 with School of Planning to ensure it is available to MEDI students.</td>
<td>MEDI Director</td>
<td>October 2017 (prior to scheduling of Winter 2018 courses)</td>
<td></td>
</tr>
<tr>
<td>23 Consider creating opportunities for more interaction between planners and the economic development program (for instance, working through case studies from both perspectives)</td>
<td>MEDI Director to discuss availability of PLAN courses to MEDI students with School of Planning, explore cooperation related to generating course-based and capstone projects, as well as ensure that students are invited to Planning-related speaking events. MEDI Faculty Instructors will also explore whether there are opportunities to include planning related issues in the required courses. In the longer term, MEDI faculty will give consideration for further partnerships and integration with the School of Planning.</td>
<td>MEDI Director</td>
<td>Summer 2018 and ongoing</td>
<td></td>
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<tr>
<td>SEED Recommendations</td>
<td>Follow-Up</td>
<td>Resp.</td>
<td>Time.</td>
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| 24  
It is recommended that SEED establish a common format for outlining learning objectives for programs, for curriculum mapping against these core learning objectives as well as a common format for course outlines. For instance, course outlines should consistently include includes course goals, course descriptions, and learning objectives linked to their associated learning assessments and ideally, rubrics of assessment | See recommendation #1 above. | SEED Director | Winter 2018 |
| 25  
While there is an emphasis on the application of knowledge in all of the programs, there appears to be a need to make more space to deliberately incorporate reflection on the application of that knowledge into all of these programs | See recommendation #3 above | SEED Director to follow up with Assoc Dean UG | Winter 2018 |

The Department Chair/Director, in consultation with the Dean of the Faculty shall be responsible for monitoring the Implementation Plan.
Date of next program review: 2024

Signatures of Approval:

Chair/Director

AFIW Administrative Dean/Head (For AFIW programs only)

Faculty Dean

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

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

August 9, 2018

Quality Assurance Office

The Faculty of Mathematics endorses the July 2018 two year progress report for the Computational Math (MMath) program.

Computational Mathematics has completed the first four recommendations (create a co-op & course based program, regularize the admin support, increase visibility, discuss more flexibility in the core). The fifth recommendation, add specialization to the program, will be explored this Fall by their graduate committee. The sixth recommendation, to become more involved in faculty and university-wide computational intensive initiatives, by its nature is never "complete". It is something that the Centre is always aware of, and becoming involved as opportunities present themselves. The last recommendation to recognize and incentivize the graduate officer will be a topic of discussion between myself and the Director of the Computational Mathematics program in the Fall term.

[Signature]

Stephen M. Watt
Dean, Faculty of Mathematics
Two-Year Progress Report
Computational Mathematics (MMath)
July 2018

**Background:**
The last review of the Computational Mathematics (MMath) program was completed in November 2016. The Final Assessment Report was approved by Senate Graduate and Research Council on April 10, 2017. The report pointed out many positive aspects of the program, including its uniqueness in Canada, breadth, and timeline. The report did, however, offer a number of recommendations.

**Progress on Implementation Plan:**

1. The reviewers support the ongoing initiatives to create course-based, and co-op Masters programs.

   **Status:** completed
   **Details:** Both the course-based and co-op programs were passed by the Senate Graduate and Research Council on October 17, 2016. The first cohort of co-op students are currently on their work term (as of Spring 2018). Eleven students were admitted into the co-op program, 10 of which secured jobs for Spring 2018.

   The course-based program also accepted its first cohort in Fall 2017. Four of the 14 Computational Mathematics (CM) MMath students were in the course-work program. The program continues to receive high-quality applicants; of the 20 students starting the CM MMath program in Fall 2018, 4 are course-based students.

2. We recommend that the half-time administrative position be made permanent in order to achieve stability and institutional memory. Staff is a critical point of contact for such a non-departmental based program.

   **Status:** completed
   **Details:** The position has been regularized and is now a permanent half-time position.

3. We recommend enhancement of the visibility of the program at the Faculty level, and increased efforts to highlight the program in promotional material and outreach activities.

   **Status:** completed
Details: In February 2018, a Graduate Alumni Career Panel was jointly held with the Math Graduate Student Association; the panel included two alumni of the CM MMath program. The event was well attended, with approximately 40 attendees. Many of the questions were geared toward CM, and related career paths.

The CM MMath program received more than 100 applications for the Fall 2018 admissions cycle. Many of those applications were of very high quality. Uptake by the faculty was healthy, with 16 students scheduled to start the research-based program in Fall 2018. This number was affected somewhat by the limited lab space allocated to the CM graduate program.

Despite this progress, we continue to discuss ways to promote the CM graduate program.

4. We recommend increasing flexibility within the curriculum by adding one or more course to the list of core courses, leading to a choice of 4 courses for 6 possibilities.

**Status: not selected for implementation**
Details: As stated in the Final Assessment Report, the Graduate Committee considered this recommendation and decided that adding more core courses would not benefit the program or its students.

5. We recommend exploring the possibility of adding specializations to the program to improve job placement in a competitive environment. The Director and Graduate Officer should follow up with the Associate Dean and take any necessary steps to approve changes in the program description in the calendar to allow for this.

**Status: in progress**
Details: Exploration of specializations will begin in Fall 2018.

6. We recommend involving Computational Mathematics in Faculty or University-wide computation-intensive initiatives.

**Status: in progress**
Details: Access to high-performance computing infrastructure (such as SHARCNet, or GPU machines) is made available through individual faculty members. In addition, email invitations to take part in various hack-a-thons are forwarded to the CM graduate students. As initiatives arise, the Director and Graduate Officer will consider how CM can be involved; as such, the status of this recommendation is “in progress”.
7. We recommend that the position of Graduate Officer be recognized and incentivized. This might involve a partial course release or stipend.

   Status: in progress
   Details: At the time of the report, the Graduate Officer indicated that the workload was not sufficient to justify further compensation, beyond the recognition already afforded in their annual evaluation.

   However, the size of the graduate program has increased considerably, and now also includes co-op and course-based options. Incentivizing the Graduate Officer position could also aid in creating a PhD program in CM. The possibility of incentivizing the position will be brought up with the Steering Committee in Spring 2018.

   Explain any circumstances that have altered the original implementation plan:

   Recruitment into the CM graduate program is being helped by enthusiasm for computing and machine-learning careers. Prospective students recognize the link, and a substantial number of our applicants are interested in machine-learning topics.

   Address any significant developments or initiatives that have arisen since the program review process, or that were not contemplated during the review:

   The number of applicants to both the graduate and undergraduate CM programs has increased recently. This puts more pressure on the administration of the programs, but also creates opportunity for growth. The CCMIC Steering Committee will be considering how best to take advantage of this new climate.

   Report on anything else you believe is appropriate to bring to Senate concerning this program:
Updated Implementation Plan:

<table>
<thead>
<tr>
<th>Recommendations</th>
<th>Proposed Actions</th>
<th>Responsibility for Leading and Resourcing (if applicable) the Actions</th>
<th>Timeline for addressing Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Course-based and Co-op Masters</td>
<td></td>
<td></td>
<td>Completed</td>
</tr>
<tr>
<td>2. Support Staff</td>
<td></td>
<td></td>
<td>Completed</td>
</tr>
<tr>
<td>3. Enhanced visibility of the program</td>
<td></td>
<td></td>
<td>Completed</td>
</tr>
<tr>
<td>4. Increased flexibility of the core</td>
<td></td>
<td></td>
<td>Not pursuing</td>
</tr>
<tr>
<td>5. Adding specialization to the CM program</td>
<td>Discussions of possible specializations</td>
<td>Graduate Committee of the CCMIC</td>
<td>Fall 2018</td>
</tr>
<tr>
<td>6. Involvement of CM in University wide computation-intensive initiatives</td>
<td>Investigation to be made by the Steering Committee on how to do this</td>
<td>Graduate Committee of CCMIC</td>
<td>Spring 2018</td>
</tr>
<tr>
<td>7. Incentivizing the Graduate Officer position</td>
<td>Investigation and discussion of the Steering Committee</td>
<td>Steering Committee of CCMIC</td>
<td>Spring 2018</td>
</tr>
</tbody>
</table>

The Department Chair/Director, in consultation with the Dean of the Faculty shall be responsible for monitoring the Implementation Plan.
Date of next program review: ______________ 2022

Signatures of Approval:

Jeff Orchard August 1, 2018
Chair/Director Date

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

Faculty Dean

Associate Vice-President, Academic
(For undergraduate and augmented programs) November 1, 2018

Associate Vice-President, Graduate Studies and Postdoctoral Affairs (For graduate and augmented programs) Date
Senate Undergraduate Council met on 13 November 2018 and 11 December 2018 agreed to forward the following items to Senate. Council recommends that these items be included for information or approval, as noted, in the consent agenda.

Further details are available at: uwaterloo.ca/secretariat/committees-and-councils/senate-undergraduate-council

FOR APPROVAL

FACULTY REGULATION CHANGES

Faculty of Arts

1. BA Breadth Requirements

Motion: That Senate approve the following revisions to the “BA Breadth Requirements” section of the Faculty of Arts Undergraduate Studies Academic Calendar, effective 1 September 2019.

Text with revisions inline (strikeout = deleted text; bold = new text):

Calendar location: under Arts Degree Requirements -> Bachelor of Arts (https://ugradcalendar.uwaterloo.ca/page/ARTS-BA-Breadth-Requirements)

All Bachelor of Arts (BA) students must meet the BA Breadth Requirements:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Units</th>
<th>Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine, Performing, and Communication Arts</td>
<td>0.5 unit</td>
<td>DAC, FINE, MUSIC, SPCOM, THPERF, VCULT</td>
</tr>
<tr>
<td>Humanities</td>
<td>1.0 unit</td>
<td>CLAS, ENGL, HIST, MEDVL, PHIL, RS</td>
</tr>
<tr>
<td>Languages and Cultures</td>
<td>1.0 unit</td>
<td>ASL, CHINA, CI, CROAT, DUTCH, EASIA, FR, GER, GRK, ITAL, ITALST, JAPAN, JS, KOREA, LAT, PORT, REES, RUSS, S I, SPAN. See Note 4 below.</td>
</tr>
<tr>
<td>Social Sciences</td>
<td>2.0 units</td>
<td>ANTH, ECON, PSCI, PSYCH, SDS, SOC. See Note 2 below.</td>
</tr>
<tr>
<td>Transdisciplinary Studies</td>
<td>0.5 unit</td>
<td>AFM, APPLS, ARBUS, ARTS, BUS, CMW, CNDST, GBDA, GSJ, HRM, HRTS, HUMSC, INDG, INTST, LS, MENN, MGMT, PACS, SMF, SOCWK. Also any course taken in another University of Waterloo faculty. See Notes 1 and 5 below.</td>
</tr>
</tbody>
</table>

Notes

1. Arts First courses (ARTS 102, ARTS 103, ARTS 130, and ARTS 140) do not fulfils any of the breadth requirements.

... Rationale: The intention is to allow BUS (Business) courses, offered at Wilfrid Laurier University or received as a transfer credit, to fulfil the transdisciplinary studies requirement. Currently, BUS courses do
not fulfill any of the breadth requirements because they are not an Arts course or offered by another faculty at Waterloo.

These changes also exclude ARTS 102 and 103, the recovery courses for ARTS 130 and 140, from fulfilling any of the breadth requirements. Since ARTS 130 and 140 are excluded from fulfilling any of the breadth requirements, ARTS 102 and 103 should also be excluded.

Faculty of Arts

2. BA Co-op Requirements

Motion: That Senate approve the following revisions to the “BA Co-op Requirements” section of the Faculty of Arts Undergraduate Studies Academic Calendar, effective 1 September 2019.

Text with revisions inline (strikeout = deleted text; bold = new text):

Calendar location: under Arts Degree Requirements -> Bachelor of Arts (https://ugradcalendar.uwaterloo.ca/page/ARTS-BA-Co-op-Requirements)

…

Professional Development (PD) Courses
PD courses are intended to enhance the professional development of the student and assist in integrating their academic and work-term experiences. With the exception of PD 1, students are expected to take the courses while on their co-op work terms. The required schedule for completing the PD courses is as follows:

- PD 1 must be taken in the an academic term prior to the first work term,
- PD 12 must be taken during the first work term,
- two additional PD courses of the student's choice should be taken in the second and third work terms.

…

Rationale: This change is of housekeeping nature to clarify that PD 1 must be taken in an academic term, not during an off term.

Faculty of Arts

3. Restrictions on Multiple-Plan Combinations

Motion: That Senate approve the following revisions to the “Multiple Plan Combinations” section of the Faculty of Arts Undergraduate Studies Academic Calendar, effective 1 September 2019.

Text with revisions inline (strikeout = deleted text; bold = new text):

Calendar location: under Arts Academic Regulations and Advice (https://ugradcalendar.uwaterloo.ca/page/ARTS-Restrictions-on-Multiple-Plan-Combinations)

…

Sample Invalid Multiple-Plan Combinations
The Faculty of Arts will amend the list of invalid plan combinations when new academic programs or plans (including minors/diplomas/certificates/specializations) are created. Students should confirm any plan combination with their academic advisor.

* Indicates an inactivated plan
### Table of invalid multiple-plan combinations

<table>
<thead>
<tr>
<th>Plan/Program</th>
<th>Cannot be Combined With</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arts and Business</td>
<td>Bachelor of Accounting and Financial Management, or Departmental Co-op, or</td>
</tr>
<tr>
<td></td>
<td>French Teaching Specialization (French majors), or</td>
</tr>
<tr>
<td></td>
<td>Bachelor of Global Business and Digital Arts, or</td>
</tr>
<tr>
<td></td>
<td>Management Studies Minor or Diploma, or</td>
</tr>
<tr>
<td></td>
<td>Mathematical Economics, or</td>
</tr>
<tr>
<td>Bachelor of Accounting and Financial Management</td>
<td>Sociology/Legal Studies - Criminology Specialization*</td>
</tr>
<tr>
<td>Bachelor of Arts (Honours major)</td>
<td>Bachelor of Arts (General major)</td>
</tr>
<tr>
<td>Bachelor of Global Business and Digital Arts</td>
<td>Arts and Business, or</td>
</tr>
<tr>
<td></td>
<td>Management Studies Minor or Diploma, or</td>
</tr>
<tr>
<td>Applied Mathematics – Economics Option</td>
<td>Any stand-alone major</td>
</tr>
<tr>
<td>Biotechnology/Economics</td>
<td>Economics plans</td>
</tr>
<tr>
<td>Church Music and Worship Minor or Diploma</td>
<td>Music majors</td>
</tr>
<tr>
<td>Classical Studies Minor</td>
<td>Classics major</td>
</tr>
<tr>
<td></td>
<td>Greek Minor</td>
</tr>
<tr>
<td></td>
<td>Latin Minor</td>
</tr>
<tr>
<td>Classics major</td>
<td>Classical Studies Minor</td>
</tr>
<tr>
<td>Crime and Deviance Specialization (Sociology majors)*</td>
<td>Legal Studies Minor</td>
</tr>
<tr>
<td>Digital Arts Communication Minor</td>
<td>Bachelor of Global Business and Digital Arts, or</td>
</tr>
<tr>
<td></td>
<td>Digital Arts Communication Specialization (Arts and Business)*, or</td>
</tr>
<tr>
<td></td>
<td>Digital Media Studies Specialization (English majors)</td>
</tr>
<tr>
<td>Digital Arts Communication Specialization (Arts and Business)*</td>
<td>Digital Arts Communication Minor</td>
</tr>
<tr>
<td>Digital Media Studies Specialization (English majors)</td>
<td>Digital Arts Communication Minor</td>
</tr>
<tr>
<td>Economics Minor</td>
<td>Applied Mathematics – Economics Option</td>
</tr>
<tr>
<td></td>
<td>Biotechnology/Economics</td>
</tr>
<tr>
<td></td>
<td>Mathematical Economics</td>
</tr>
<tr>
<td>Economics plans</td>
<td>Applied Mathematics – Economics Option</td>
</tr>
<tr>
<td></td>
<td>Biotechnology/Economics</td>
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<tr>
<td></td>
<td>Mathematical Economics</td>
</tr>
<tr>
<td></td>
<td>Environmental Economics Minor*, or</td>
</tr>
<tr>
<td></td>
<td>Economic Theory Minor</td>
</tr>
<tr>
<td>Plan/Program</td>
<td>Cannot be Combined With</td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Economic Theory Minor</td>
<td>Economics plans</td>
</tr>
<tr>
<td></td>
<td>Applied Mathematics – Economics Option</td>
</tr>
<tr>
<td></td>
<td>Biotechnology/Economics</td>
</tr>
<tr>
<td></td>
<td>Mathematical Economics</td>
</tr>
<tr>
<td>English majors</td>
<td>Technical Writing Minor</td>
</tr>
<tr>
<td>Environmental Economics Minor*</td>
<td>Economics plans</td>
</tr>
<tr>
<td>French Teaching Specialization (French majors)</td>
<td>Arts and Business, or</td>
</tr>
<tr>
<td></td>
<td>Any other stand-alone major</td>
</tr>
<tr>
<td>Greek Minor</td>
<td>Classical Studies Minor</td>
</tr>
<tr>
<td>Human Resources Management Minor or Diploma</td>
<td>Students who have completed a Diploma in HRM or the course requirements for the Certified Human Resources Professional (CHRP) designation, or who have graduated from a college or university HR or Business program</td>
</tr>
<tr>
<td>International Relations Specialization (History majors)</td>
<td>International Relations Specialization (Political Science majors)</td>
</tr>
<tr>
<td>International Relations Specialization (Political Science majors)</td>
<td>International Relations Specialization (History majors)</td>
</tr>
<tr>
<td>International Trade Minor</td>
<td>International Trade Specialization (Arts and Business)*</td>
</tr>
<tr>
<td>International Trade Specialization (Arts and Business)*</td>
<td>International Trade Minor</td>
</tr>
<tr>
<td>Latin Minor</td>
<td>Classical Studies Minor</td>
</tr>
<tr>
<td>Legal Studies Minor</td>
<td>Crime and Deviance Specialization (Sociology majors)*; or</td>
</tr>
<tr>
<td></td>
<td>Sociology/Legal Studies - Criminology Specialization*</td>
</tr>
<tr>
<td>Liberal Studies</td>
<td>Any other stand-alone major</td>
</tr>
<tr>
<td>Management Studies Minor</td>
<td>Any university business program, major, or sub-plans, including:</td>
</tr>
<tr>
<td></td>
<td>• Arts and Business</td>
</tr>
<tr>
<td></td>
<td>• Bachelor of Accounting and Financial Management</td>
</tr>
<tr>
<td></td>
<td>• Bachelor of Global Business and Digital Arts</td>
</tr>
<tr>
<td></td>
<td>• Business Administration and Mathematics Double Degree</td>
</tr>
<tr>
<td></td>
<td>• Environment and Business</td>
</tr>
<tr>
<td></td>
<td>• Mathematics/Business Administration</td>
</tr>
<tr>
<td></td>
<td>• Recreation and Sport Business</td>
</tr>
<tr>
<td></td>
<td>• Science and Business (any specialization)</td>
</tr>
<tr>
<td>Mathematical Economics</td>
<td>Arts and Business, or</td>
</tr>
<tr>
<td></td>
<td>Any other stand-alone major</td>
</tr>
<tr>
<td></td>
<td>Economics Minor</td>
</tr>
<tr>
<td></td>
<td>Economic Theory Minor</td>
</tr>
<tr>
<td>Music majors</td>
<td>Church Music and Worship Minor or Diploma</td>
</tr>
<tr>
<td>Music in a Global Context Specialization (Music majors)</td>
<td>Music and Peace Specialization (Music majors)</td>
</tr>
</tbody>
</table>
Table of invalid multiple-plan combinations

<table>
<thead>
<tr>
<th>Plan/Program</th>
<th>Cannot be Combined With</th>
</tr>
</thead>
<tbody>
<tr>
<td>Music and Peace Specialization (Music majors)</td>
<td>Music in a Global Context Specialization (Music majors)</td>
</tr>
<tr>
<td>Public Policy and Administration Minor</td>
<td>Public Policy Specialization (Economics majors)</td>
</tr>
<tr>
<td>Public Policy Specialization (Economics majors)</td>
<td>Public Policy and Administration Minor</td>
</tr>
<tr>
<td>Sociology/Legal Studies - Criminology Specialization*</td>
<td>Arts and Business, or Any other stand-alone major, or Legal Studies Minor</td>
</tr>
<tr>
<td>Spanish plans</td>
<td>Spanish/English Translation Minor*</td>
</tr>
<tr>
<td>Spanish/English Translation Minor*</td>
<td>Spanish plans</td>
</tr>
</tbody>
</table>

Rationale: These changes are of housekeeping nature. The Faculty is adding existing invalid plan combinations (e.g., Arts and Business with Accounting and Financial Management). It is also adding invalid plan combinations with Liberal Studies, as that will be a new Honours plan starting September 2019. This plan cannot be combined with any other stand-alone major, as previously approved, due to the structure of the plan and an absence of a limit to double counting.

Faculty of Arts

4. Communication Skills Requirement

Motion: That Senate approve the following revisions to the “Communication Skills Requirement” section of the Faculty of Arts Undergraduate Studies Academic Calendar, effective 1 September 2019.

Text with revisions inline (strikeout = deleted text; bold = new text):

Calendar location: under Arts Degree Requirements (https://ugradcalendar.uwaterloo.ca/page/ARTS-Communication-Skills-Requirement)

Undergraduate Communication Skills Requirement

Communication skills are essential to academic, professional, and personal success. The Arts First program fosters the development of foundational competencies in inquiry, communication, and analysis in students’ first year to support their success.

All Arts students must successfully complete the Undergraduate Communication Requirement; normally by successfully completing ARTS 130 and ARTS 140 (see Notes 1 and 2-3).

Notes

1. Successful completion of ARTS 130 and ARTS 140 requires a minimum grade of 50% in each course.
2. A completed English Language Proficiency milestone on a student’s academic record will indicate successful completion of this requirement.
3. In the event a student fails ARTS 130, they must successfully complete ARTS 102. In the event a student fails ARTS 140, they must successfully complete ARTS 103.
2. Students enrolled in Accounting and Financial Management (AFM) and Computer and Financial Management (CFM) satisfy the Undergraduate Communication Skills Requirement within their degree requirements.

3. The completion of a communication requirement, also known as an English Language Proficiency Requirement, while enrolled in another University of Waterloo faculty shall satisfy this requirement.

4. Students transferring to Arts at the University of Waterloo from other universities may request an exemption from one or both of ARTS 130 and ARTS 140 from the Arts First Director with proof of the appropriate equivalent.

5. Students are expected to complete ARTS 130 or ARTS 140 by the end of their 2A term. It is expected that one course be taken in fall term and the other in winter term. Both courses cannot be taken in the same term. Failure to complete these courses by the end of 3A term will result in a hold placed on the student’s account, preventing self-enrolment in courses for the following term.

6. ARTS 102, ARTS 103, ARTS 130, and ARTS 140 do not fulfil any of the Bachelor of Arts Breadth Requirements.

7. Students enrolled in a Faculty of Arts plan prior to the September 2018 Calendar should consult the English Language Proficiency Requirement as outlined in the calendar of their plan year.

**Rationale:** These changes are of housekeeping nature. The title of this requirement is being renamed to match the terminology determined by SCELCI (the Steering Committee, English Language Competency Initiative). The Faculty is removing reference to the 50% passing grade because this is the normal passing grade. It is also removing reference to the milestone because it is no longer being referred to as the English Language Proficiency Requirement. In addition, the Registrar's Office is discouraging references to milestones in the Calendar text, as this is a systems process used for tracking the completion of the requirement.

Note 1 is being added to explain that ARTS 102 and 103 are recovery courses for students who cannot successfully complete ARTS 130 or 140. These recovery courses are designed to help students develop fundamental communication skills in a more foundational manner.

Note 4 is being modified since a webform has been created to allow students to submit their exemption requests. A hyperlink to this form will be included in the note.

**FOR INFORMATION**

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**ACADEMIC PROGRAM REVIEW REPORT**

**Final Assessment Report – Biology**
Following discussion, Council approved the final assessment report for Biology on behalf of Senate. See Attachment #1.

**Final Assessment Report – Mathematics/Teaching**
Following discussion, Council approved the final assessment report for Mathematics/Teaching on behalf of Senate. See Attachment #2.

**Two-year Report – Computer Science**
Following discussion, Council approved the two-year report for Computer Science on behalf of Senate. See Attachment #3.
Two-year Report – Knowledge Integration
Following discussion, Council approved the two-year report for Knowledge Integration on behalf of Senate. See Attachment #4.

STUDENT SUCCESS OFFICE
Global Experience Certificate. After an assessment of the program, including an analysis of student feedback, a review of literature (competencies, pedagogy), and a comparative study of industry practices in similar certificates/programs, the Student Success Office proposed a number of changes to the program, including language requirements, the format for the reflection submission, and the experiences that qualify for the program. See Attachment #5.

PLAN & CURRICULAR MODIFICATIONS
Council approved the following on behalf of Senate:

- minor plan changes for: arts (arts and business, bachelor of accounting and financial management (co-op), four-year general economics, honours economics, honours mathematical economics, three-year general English language and literature, four-year general English – literature, four-year general English – literature and rhetoric, four-year general English – rhetoric, media and professional communication, honours English – literature, honours English – literature and rhetoric, honours English – rhetoric, media and professional communication, three-year general history, four-year general history, honours history, specializations in history); mathematics (joint mathematics for students outside the Faculty, mathematics minor for students outside the Faculty).
- new courses for: arts (School of Accounting and Finance, anthropology, dean of arts, classical studies, Mohawk).
- course changes for: arts (American Sign Language, anthropology, School of Accounting and Finance, dean of arts, German, music, economics, management, English language and literature, history, philosophy, religious studies, Russian and East European Studies); mathematics (mathematics, work report courses).

Mario Coniglio
Associate Vice-President, Academic

/rmw
Final Assessment Report
Biology (BSc/MSc/PhD)
September 2018

Summary of the Program Review
In accordance with the University Institutional Quality Assurance Process (IQAP), this final assessment report provides a synthesis of the external evaluation and the internal response and assessments of the programs (BSc, MSc, PhD) delivered by the Department of Biology. A self-study (Volume I) was submitted to the Associate Vice-President, Academic and Associate Vice-President, Graduate Studies and Postdoctoral Affairs on August 17, 2016. The self-study presented the program descriptions and learning outcomes, an analytical assessment of these three programs, and program data including the data collected from a student survey along with the standard data package prepared by the Office of Institutional Analysis & Planning (IAP). Appended were the course outlines for all courses in the program and the CVs (Volume II) for each full-time faculty member in the Department.

Two arm’s-length external reviewers (Volume III), (Dr. Jack Gray, Professor of Biology, University of Saskatchewan and Dr. Mark Bernards, Professor of Biology, University of Western Ontario) were ranked and selected by the Associate Provost, Graduate Studies and Postdoctoral Affairs, in addition one internal reviewer (Dr. Daniel Gorman, Associate Professor of History) was selected by the Associate Vice-President, Academic.

The external reviewers examined the self-study documentation and then conducted a site visit to the University on December 15-16, 2016. The visit included interviews with the: Associate Vice-President, Graduate Studies and Postdoctoral Affairs; Associate Vice-President, Academic; Dean of the Faculty; Chair of the Department; Associate Chairs of the Department; Faculty members; staff and laboratory technicians; as well as meetings with a group of current graduate and undergraduate students. The Review Team also had an opportunity to tour the Department facilities.

This final assessment report is based on information extracted, in many cases verbatim, from the self-study, the external reviewers’ report and the program response.

Program characteristics
The Department of Biology was established in 1964 as an independent academic department in the Faculty of Science. In addition to the core Biology undergraduate program (starting in 1964, co-op in 1979), the Department oversees programs in Biochemistry (1985, regular and co-op;
Biology and Chemistry before 1985), Biomedical Sciences (regular only, 2005, previously Pre-Optometry/Pre-Health) and Environmental Science (2013 regular and co-op, previously Biology and Environment and Resource Studies).

The graduate program features MSc and PhD degrees that prepare students for careers in various academic, industry or government sectors related to the subject of Biology. Through thesis research and course work, students acquire advanced scientific research and analytical skills.

Biology has been heavily involved (e.g., represented on the steering committees) in the Centre for Bioengineering and Biotechnology, the Water Institute, the Waterloo Institute for Nanotechnology, and the Centre for Chronic Disease Prevention. Along with the Department of Chemistry, the Department of Biology jointly leads the Institute for Biochemistry and Molecular Biology. Close research collaborations, including shared instrumentation, exist with each of the schools and departments in the Faculty of Science.

Summary of strengths, challenges and weaknesses based on self-study

Undergraduate Program

Strengths:
- The program continues to provide the breadth of basic Life Science education to the University at large, including pre-Professional preparation and elective courses for other Faculties
- Teaching quality is at a very high level, with numerous awards and recognitions
- Course instructors are highly engaged in developing and implementing new approaches such as active learning techniques
- Laboratory courses continue to be offered, some stand-alone and others embedded, and experiential opportunities are being welcomed as much as possible
- The co-op program continues to grow and is a major differentiating factor in undergraduate recruiting
- Strong collaborations have formed with other “bio-based” initiatives across campus

Challenges:
- While the Science Teaching Complex has helped, Biology is still handling huge numbers of students; more than half the students at Waterloo take at least one Biology course
- Enrolments continue to increase at higher levels proportionally to the University average with no accompanying increase in budget, stretching administrative and technical resources to their limits
- Enrolments in the co-op programs are increasing more quickly than the ability to identify relevant jobs, suggesting that either the number of required placements for the
co-op degree should be reduced and/or consideration should be given to unpaid placements if necessary

- Curriculum development is ongoing, reacting to changes in faculty complement and in the disciplines and techniques of Life Sciences

Weaknesses:
- The Biology programs have very few international students. There is interest in expanding joint programs (especially China 2+2), as, in addition to serving the University strategic area of internationalization, these students provide a mechanism for significant revenue generation

Graduate Program

Strengths:
- The graduate program has been enhanced over the review period by faculty renewal
- New research programs in Aquatic Biology, Computational Biology, Structural Biology, Cell Biology and Microbiology, in particular, have broadened the available training opportunities
- After two or three years of declining incoming enrolment, the numbers are starting to recover as these new programs grow
- Due to the breadth of research in the Department and the cohort that is built through a unified Graduate Student Association, seminar symposium and graduate course (“Scientific Communication”), students get exposed to more cross-disciplinary conversations and collaborations than in more specialized Departments

Challenges:
- Like many other departments, times-to-completion have been higher than desirable for MSc and PhD programs. The Associate Chair Graduate Studies has focused specifically on students beyond the expected time limits and, through personal coaching and mentoring, has succeeded in getting several long-term students to complete. There have also a more rigorous monitoring protocol put in place, for example through supervisory committee meetings
- Next steps will be a more structured curriculum with graduate courses offered more frequently, and a more active recruiting process to attract higher quality candidates
- While core facilities have been improved, the central support and instrumentation available to graduate students is a challenge compared to some of the competitor programs. The proposed Phase 2 building expansion will help to address this issue
- As in other institutions, research funding remains the primary long-term challenge in growing and maintaining a strong graduate program. Little internal support for graduate students is available
Weaknesses:

- As with the undergraduate program, there are few international students. There is a disincentive for accepting foreign graduate students because there is no provincial grant and tuition is higher.
- There are few studentships open to international students and each one takes a place that might otherwise be filled by a domestic student.
- The curriculum of graduate courses is limited, especially for courses offered on a regular basis. A thorough review of course offerings is planned.

Summary of key findings from the external reviewers:

Undergraduate Program Recommendations

The reviewers found the undergraduate program to be solid and firmly grounded in the discipline. However, since the Department of Biology is the only “Biological Sciences” department on campus, these programs are dependent on the maintenance of a broad-based faculty complement, with appropriate critical mass in each sub-disciplinary area. In addition, the Department faces very high enrolments, and does a lot of service teaching, which puts more pressure on faculty and instructors.

1. The external reviewers recommended that the Department review the criteria for continuance in their Honours programs. The minimum 60% average needed to continue seems low. Alternatives would be to increase the overall average required to continue in a program or require minimum grades (e.g., 70%) in key courses that define the program (e.g., plant course electives in the Plant Biology program, microbiology courses in the Microbiology program).

Response

Continuing averages in several programs have been the subject of consultation and discussion within the Department indicating strong support for higher continuing averages. However, the implementation of this plan faces some significant difficulties under the present program structure. The Department has looked at the impacts of raising the continuing average in the Biomedical Sciences program to 75%. This would result in the removal of 50% of the students enrolled in the program. Department data indicate that the students removed from the program would then likely shift to the Honours Science program, which has a lower continuing average. In the past, students who move to Honours Science then “mirror” the Biomedical Sciences program, continuing to take the same courses. This potential loss of students to Honours Science means the Department would no longer be advising students who are taking their courses.
The Department is considering several solutions that could be explored to facilitate increasing continuing averages in majors programs, contingent with our program renewal efforts. One option is to move towards a common first year for programs. This would reduce the number of specialized required-for-program courses, facilitating movement of students who do not meet the Honours Biomedical Sciences averages into Honours Biology. Another solution, as suggested by the reviewers, would be to require minimum grades (e.g., 70%) in key courses or combinations of courses that define the program. Another solution is to offer both Honours and non-Honours (general) degrees in Biology; an assessment of the resource requirements for this option would be required as would a recognition of the Faculty’s desire to streamline the number of BSc academic plans. All three scenarios would assist the Department in retaining students not maintaining an Honours program average. They will remain in the Departmental curriculum and will obtain advising and normal course progression. This is a strategy used by several Ontario universities and allows for a more streamlined and efficient academic curriculum.

In light of discussions on several items in relation to our curriculum, the department has initiated a comprehensive review for our curriculum. Currently, we have tasked an ad hoc curriculum review committee with a terms of reference to undertake a ‘broad strokes’ review of our curriculum and to propose direction for the departments consideration. A report from this committee and consultation with the department should be completed by early fall 2018. Following this process, the department will task another group (perhaps the standing committee on curriculum) to propose specific changes to meet the goals of the proposal from the ad hoc committee and a means by which these can be implemented to minimize disruptions. Therefore, the department expects that the structure and direction of its offerings could change as a result of this process, and once decisions have been made changes may very well require several years to implement. As a result, we are currently in a ‘hold’ mode and do not expect to have any significant alterations in our offerings until this process is complete.

2. The external reviewers recommended that the Department consider including undergraduate representation on their Curriculum Committee (if it doesn’t already exist), and to include student bodies such as the Biology Undergraduate Society in their curriculum decision making.

Response
The Departmental Curriculum Committee has already initiated contact with Biology Undergraduate Society (BUGS) in terms of decision-making. We have rejected having a full time undergraduate member on the Curriculum Committee due to the high turnover of students in BUGS and the changing focus of the society on an annual basis. However, there is broad
support for a consultative role. The Department also consulted with biomed students via a town hall to seek their input on our programs.

3. The external reviewers recommended that the degree credit level remain unchanged, and that the program not be forced to reduce the credit load to 20. The current number of lecture content courses is appropriate, and the “artificial” inflation of degree credits created by splitting some labs away from the lecture courses they were traditionally associated with does not represent additional work that students must complete to meet degree requirements. Removal of lecture content courses to accommodate lab credits would represent a reduction in program content, relative to similar programs at other Canadian universities.

Response
The Department has made progress on workload associated with our programs by making some changes (e.g., eliminating tutorial sessions, reduced lecture contact hours for courses with integrated lecture and lab) and will continue to be mindful. Regardless, we are confident that the workload required to complete our programs are in line with the expectations of similar programs offered at peer institutions. As indicated by the reviewers the number of credits required for our program is “artificially” high due to the non-traditional assignment of credit units (e.g., separation of lab and lecture component of a course).

The department has ongoing discussion with this issue with the Associate Dean Undergraduate Studies and the Dean of Science. We seem to be in agreement that our ongoing curriculum review, as described above, will address issues regarding credit number of our programming, including examining ways to limit programs to 22.0 credits, without compromising the integrity of programs.

4. The external reviewers recommended that the Department find a way to incorporate a requirement for university level mathematics (e.g., calculus) into their degree programs, rather than leaving this as an option.

Response
Several of the Department’s programs do have calculus as a requirement (e.g., Honours Biochemistry, Honours Environmental Science (Ecology specialization), Honours Life Physics (Biophysics specialization)). Most students (>75%) in the Biomedical Sciences program take calculus as an elective to meet admission requirements of various professional schools. The Department has recently modified math offerings in consultation with the Faculty of Mathematics and is now offering sections of its first year calculus course (Math 127) that are
framed in biological measurement and design for students in life sciences programs. This will make the courses more relevant and attractive to students enrolled in Biology programs. The Department’s approach has been to ensure Biology students have mathematical numeracy/literacy that can be satisfied through diverse courses. All of the Biology programs require students to take math and/or statistics or physics courses that require numeracy as a primary measurement of success. The ongoing ad hoc curriculum review committee will be addressing this more thoroughly with their recommendations expected in September 2018.

5. The external reviewers recommended that program requirements be reviewed with an eye to requiring a minimum number of 400-level courses.

Response
The Honours Biology program requires a minimum five 400-level courses and Honours Environmental Science (Ecology specialization) requires a minimum of three 400-level courses. The Honours Biomedical Sciences program currently has no requirement for 400-level courses. As part of the restructuring of the undergraduate curriculum the inclusion of a minimum number of 400-level courses is expected for all programs. We have already completed this for the Biomedical Sciences program.

6. The external reviewers recommended that the Department, in conjunction with the Faculty of Science, explore mechanisms to increase the number and quality of Co-op placements for Biology students.

Response
The Department has consulted with Co-op Education and Career Action (CECA) on this issue. The lack of employment in Co-op does not always reflect a lack of employment opportunity. CECA feels that the quality of jobs available to Biology students is good and Biology has become a focus program in CECA receiving increased attention from Account Managers and Business Developers. The Faculty of Science has recently formed a Co-op committee under the guidance of the Associate Dean, Computing and Co-operative Education—that will address issues that surround Co-op employment in the Faculty of Science. The Department of Biology will work closely with this group to help improve workplace placement opportunities.

7. The external reviewers recommended that the Department make a concerted effort to more overtly expose undergraduate students to the breadth and extent of on-going research amongst Biology faculty. This could be achieved through an active “in-reach” program that includes promotional posters and the involvement of the Biology Undergraduate Society.
Response
About 15% of students enrolled in department-based programs engage in research opportunities. It is challenging to increase this percentage because of the very high student:faculty ratio that exists in our department relative to peer units. The department is hoping to receive support to increase our research faculty complement and funding to support our programming in the coming years to address this important issue.

Despite the limitations, we do have in-reach programs inviting undergraduates to participate in research activities in the department through Biol 499 Senior Honours projects, summer NSERC USRAs, volunteer opportunities as well co-op employment. Further, Departmental seminars are advertised through posters that are routinely posted around the department. There is an active twitter feed and substantial Facebook presence. Professors announce seminars in lectures that are pertinent to the material being covered in that course. The Faculty and Department work with various science societies to promote events. There is a recently mounted digital display screen in the Biology department that is now utilized for advertising research-focused events.

8. At risk of interfering with internal university personnel structure, we strongly recommend that consideration be given to converting “Instructor” roles in the Department into “Lecturer” (i.e., faculty) positions. The current instructors are carrying out a lot of what are traditionally faculty roles.

Response
The job description for our instructors were reviewed and updated in January 2015 and the instructors have expressed satisfaction with their current role in the department.

9. We recommend that the Department put in place a clear communication strategy to ensure lab equipment needs are coordinated between course instructors/lecturers and the technical staff in place to support them.

Response
The composition of the curriculum committee has been altered recently to include substantial representation of technical staff. The current curriculum committee consists of research and teaching faculty representing major programs. The instructors are well represented and there are two technicians who participate. The committee meets monthly and all members of the department are welcome to submit items to the agenda. Input is requested from all members of the committee and any changes to labs are cleared through both instructor and technicians. The associate Chair Undergraduate Studies now meets with technicians once a semester. Our impression is that system works well and that lines of communication are open.

September 2018
Graduate Program Recommendations

The Department delivers a robust graduate program with a strong national and international reputation. Many of the reviewers' observations showed a general satisfaction amongst graduate students and faculty and the collegiality of all departmental members was clear. All members were attuned to the strengths and weaknesses of the graduate program and there are positive efforts being made to maintain the strengths and address the weaknesses.

10. The external reviewers recommended that clarity on prioritizing domestic or international graduate student recruitment would be beneficial to articulate a common goal understood by the Department and administration.

Response
The Department agrees with the recommendation and looks forward to clarity coming from upper administration and the faculty dean on the balance between the desire for internationalization and the need for domestic financial return.

11. The external reviewers recommended that supervisory committees have authority to recommend waiver of one or more PhD course requirements, for approval by the Graduate Chair, following assessment of courses completed in a previously completed MSc program, including programs completed at another institution.

Response
There is currently a mechanism in place to waive PhD course requirements, which requires approval at the departmental level through the Associate Chair (Graduate Studies) and approval at the faculty level through the Associate Dean (Graduate Studies). While this option is available to students it has not been widely used or promoted within the Department.

12. The external reviewers recommended that supervisors and students draft an agreement of mutual expectations and timelines soon after the student enters the program and that timelines be updated in each progress report presented to the supervisory committee and that these timelines be approved by the committee.

Response

September 2018
This has already been enacted in the Department. Students present a proposal within two (MSc) to three (PhD) terms of starting their program that outlines their research, course work, as well as timelines to completion. This is approved by the supervisory committee and reported to the departmental graduate office in writing. Student progress is then assessed on an annual basis in a supervisory committee meeting and a report on progress is submitted to the departmental graduate office. The Associate Chair (Graduate Studies) reviews all student reports (proposal, committee meeting, comprehensive). The Department is working hard to bring increased responsibility and engagement from graduate students enrolled in the Biology program by providing students with letters that note the milestone that is overdue. The student must then determine a date that the milestone will be completed and this letter is returned to the Associate Chair (Graduate Studies). If that date is not met, there is a follow up meeting with the Associate Chair (Graduate Studies).

13. The external reviewers recommended that the comprehensive exam procedure be reviewed, and consideration given to alternative models such as inclusion of a literature review or a mock grant proposal (such as a NSERC Discovery Grant) that is evaluated by the examination committee (written and oral components).

**Response**
The Biology Graduate Studies Committee (BGSC), which also includes graduate student representative, has examined this issue and has proposed to retain the present comprehensive exam procedure, as it is a useful exercise that had positive academic benefits. This has been discussed at a recent departmental meeting (April 2017). To assist students with their comprehensive exams graduate student orientation will now include discussion on the expectations and the process for the comprehensive exam. A fall workshop is being planned for incoming PhD candidates that includes student experiences for this particular milestone. The Graduate Studies and Post Doctoral Affairs Office (GSPA) is also currently examining the comprehensive exam milestone.

14. The external reviewers recommended that a committee meeting in the later stages of the student’s program be designated to determine if the student has completed data collection and be given formal permission to begin writing a thesis. At this meeting, the student could submit a table of contents of the proposed thesis.

**Response**
The present system has a “permission to defend” committee meeting at the end of the students’ programs. This recommendation has been made in the revised regulations for PhD.
defences from the Graduate Studies and Postdoctoral Affairs (GSPA) office. The Associate Chair (Graduate Studies) has been recommending to all students that they have a committee meeting a term (MSc) or two (PhD) prior to defence and this has been occurring more frequently. In April 2017, a Pre-Defence Advisory Committee Report form has been developed by the Biology Graduate Studies Committee to be implemented immediately. This form has a check box for whether or not the student can proceed towards completion of their thesis. The form also has a required comments box to provide students with feedback from their committee. Currently, the Department is recommending that this meeting take place to be in line with the recommendations for the PhD defence from the GSPA.

15. The external reviewers recommended that the graduate course curriculum more accurately map to the research fields and that courses be modified to provide a balance between specific training with their programs and broad training within the field (possibly through common graduate courses in the subfields) and for professional development.

**Response**

The Department is currently undergoing program renewal and will be examining courses and the program to ensure they map to the new research fields. There are currently professional development courses on academic teaching offered through the Centre for Teaching Excellence (CTE) and the GSPA offers resources in professional development through GRADventure. The BGSC and the Department will be examining options for Biology-specific professional training and development through our program renewal.

16. The external reviewers recommended that a human resource appointment within the Faculty of Science be attached to the Department to provide support related to graduate student TA appointments, files for postdoctoral positions, etc.

**Response**

In the Department there is a full-time graduate administrative assistant and a part-time position in support of the administrative assistant. These positions provide direct liaison with faculty level management. There is a Graduate Management System that is currently being developed at the faculty level. This will help to automate some of the administrative work around teaching assistant appointments in terms of generating letters and payment information. However, there is likely going to be significant change in TA administration across the entire Faculty of Science due to the impact of the new budget model. Postdoctoral appointments are now being managed through the Chairs Office Department of Biology as well as through the GSPA.

September 2018
17. The external reviewers recommended that the Vice President Research commit to a subsidy to support a renovated aquatic facility, which could be included in a potential CFI application.

Response
The Dean of Science and the Office of Research have both committed $750,000 each to renovate the aquatic facility. An animal care technician that is presently working part time in the aquatic facility will be dedicated to the management and running of the facility.

18. The external reviewers recommended that the Department work with the Faculty of Science to provide matching funds to support a CFI proposal to improve the aquatics facility.

Response
The Faculty of Science now has a group of research fellows that receives and assesses such proposals and makes recommendations to the Dean of Science. For CFI grants the funding formula is 40% CFI, 40% Ontario Research Fund, and 20% vendor in-kind discounts. In cases where the vendor in-kind does not reach the 20% level, the Faculty of Science will consider making up the shortfall following assessment by the Research Fellows. The Department of Biology will help facilitate these discussions and recommend proposals for support from the Dean of Science.

19. The external reviewers recommended that the Committee of Research Fellows create clear and transparent guidelines for provision of equipment maintenance funds.

Response
The Department has requested further clarification on this point from the Associate Dean Research and is encouraged by the response. The Faculty of Science is presently working to address researcher access to equipment maintenance funds. For common equipment Chairs/Directors will ask for maintenance funding in their yearly budget requests to the Dean. For equipment located in individual labs once a term calls for proposals for maintenance funding will be made, with the Research Fellows adjudicating the requests and recommending which ones to fund to the Dean. There is a mechanism in place already for the repair and maintenance of eligible CFI equipment. Annual proposals are submitted to the research fellows for evaluation and funding is awarded based upon decisions recommended to The Office of Research.
20. The external reviewers recommended that the Department work with the Faculty of Science to firmly establish a risk-funding program for faculty facing grant renewal. If this funding was guaranteed, it would allow researchers to develop longer term plans for their programs.

Response
The University has instituted an Internal UW NSERC Discovery Grant Research Incentive Fund (RIF) that provides $15,000 to researchers that have lost NSERC Discovery funding. The Faculty of Science has instituted discussions on providing backstop funding for graduate students that have not completed their degrees and are in a lab that has lost funding. Both programs offer support for both researchers and graduate students to develop long term research plans.

21. The external reviewers recommended that the Department work with the Graduate Studies Office to determine campus-wide quota system for scholarships that doesn’t disadvantage strong departments, such as Biology.

Response
Previously when students competed directly through funding agencies, Biology was receiving the benefit of 15-20 post-graduate scholarships a year. Under the present University of Waterloo quota system based upon Tri-council funding, Biology has limited access to MSc level scholarships. In the past few years there has been a steady decline in availability to scholarships such that we presently have a maximum number that is 40% of previous awards. This decrease in scholarship funds has been concurrent with a decline in graduate enrollment as research labs find themselves pressed for funds to support students. The lack of access to scholarships makes the Department less competitive when recruiting students, it limits the number of students in the Department as a whole and as such has a direct impact on our research activities and consequently ability to attract and hold tri-council funding. At this time this outside of departmental governance.

22. The external reviewers recommended that the number of Special Topics (i.e., targeted) courses could be reduced.

Response
Currently there are two special topics courses, MSc (BIOL 680) and PhD (BIOL 681). The reason for the apparent large number of special topics (targeted) courses is that the GSPA requires departments to provide a title for each course. As these are target courses for a low number of
students and are often specific to the field of study, it results in a large number of titled courses. The BGSC has examined this and is considering that for each of the Department’s identified research fields that there be a special topics course for MSc and PhD programs but that there will be no titles associated with these. While this will result in 12 new courses, this will dramatically reduce the visual impact of the number of special topics courses while retaining the course flexibility that a diverse department needs.

23. The external reviewers recommended that common courses could be offered in the Department’s newly identified research fields.

Response
Graduate curriculum is presently under reform with an aim to increase enrollment in research-field specific courses. The aim is to build cohorts of students, increase interaction between students and reduce the number of graduate courses offered. The Department has currently examined our course offerings and inactivated eight courses that have not been taught recently. In addition, the course descriptions for three courses have been updated. Going forward in the graduate curriculum reform, the Department will be examining the number of courses taught in our fields of study as well as the special topics courses noted in the previous recommendation. This is currently being addressed and should be complete within two years followed by approvals for calendar changes.

24. The external reviewers recommended creation of a modular-based graduate course that could be tailored across research fields and allow for breadth and flexibility for each student. As an example, this course could contain six modules, of which the student would be required to complete three for credit. Incorporation of the existing BIOL 690 – Scientific Communication into this model could better insure that students attain important communication skills without making it a full course requirement.

Response
The BGSC has discussed the potential for a modular graduate course and this proposal will be continued further.

25. The external reviewers recommended that the Department could regularize when new faculty are expected to begin to teach grad courses, and how they will fit their courses into the program.

Response

September 2018
The Department is enforcing the teaching of courses at the graduate level through activities of the Associate Chair Graduate Studies and through the departmental merit committee. At this time most faculty are consistently offering graduate courses in their area of specialization. The Department has worked on consolidating course offerings and has removed many defunct courses from the calendar. Due to the diverse nature of our department, consolidation of our courses is challenging due the diverse needs of our students. Regardless, this is being addressed through targeted hiring and long range plans addressing faculty recruitment to build strength in core research areas.

Recommendations that were not selected for implementation:

Recommendation 7. The external reviewers recommended that the Department make a concerted effort to more overtly expose undergraduate students to the breadth and extent of ongoing research amongst Biology faculty. This could be achieved through an active “in-reach” program that includes promotional posters and the involvement of the Biology Undergraduate Society.

Response
The Department already has substantial in-reach programs inviting undergraduates to participate in research activities in the Department through Biol 499 Senior Honours projects, summer NSERC USRA’s, volunteer opportunities as well co-op employment. Departmental seminars are advertised through posters that are routinely posted around the Department. There is an active Twitter feed and substantial Facebook presence. Professors announce seminars in lectures that are pertinent to the material being covered in that course. The Faculty and Department work with various science societies to promote events. There is a recently mounted digital display screen in the hallway outside the Biology General Office that is used for advertising research-focused events.

Recommendation 8. At risk of interfering with internal university personnel structure, the external reviewers strongly recommended that consideration be given to converting “Instructor” roles in the Department into “Lecturer” (i.e., faculty) positions. The current instructors are carrying out a lot of what are traditionally faculty roles.

Response:
The job description for instructors were recently reviewed (January 2015) and updated and the instructors have expressed satisfaction with their current role in the Department. Regardless, as the department considers its curriculum in the coming years we will be mindful of the appointment details of hires in this area.
Recommendation 9. The external reviewers recommended that the Department put in place a clear communication strategy to ensure lab equipment needs are coordinated between course instructors/lecturers and the technical staff in place to support them.

Response:
The composition of the Curriculum Committee has been altered recently to include substantial representation of technical staff. The current curriculum committee consists of research and teaching faculty representing major programs. The instructors are well represented and there are two technicians who participate. The committee meets monthly and all members of the Department are welcome to submit items to the agenda. Input is requested from all members of the committee and any changes to labs are cleared through both instructor and technicians. The Associate Chair Undergraduate Studies now meets with technicians once a semester. Our impression is that system works well and that lines of communication are open.
## Implementation Plan

<table>
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<tr>
<th>External Reviewer Recommendations</th>
<th>Proposed Actions</th>
<th>Responsibility for Leading and Resourcing (if applicable) the Actions</th>
<th>Timeline for addressing Recommendations</th>
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<tr>
<td>1. The Department review the criteria for continuance in their Honours programs. The minimum 60% average needed to continue seems low. Alternatives would be to increase the overall average required to continue in a program or require minimum grades (e.g., 70%) in key courses that define the program (e.g., plant course electives in the Plant Biology program, microbiology courses in the Microbiology program, etc.).</td>
<td>The Department is undergoing a comprehensive review and renewal of our undergraduate curriculum. The Department is considering several solutions that could be explored to facilitate increasing continuing averages in majors programs.</td>
<td>Department Chair and Associate Chair Undergraduate Studies</td>
<td>Our approach has multiple steps with a first ‘broad strokes’ report to be finalized in early fall 2018. Detailed proposals with implementation plan to follow in 2019. Implementation may take multiple years.</td>
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<td>2. The Department consider including undergraduate representation on their Curriculum Committee (if it doesn’t already exist), and to include student bodies such as the Biology Undergraduate Society in their curriculum decision making.</td>
<td>The Department has engaged BUGS in decision making through the Curriculum Committee.</td>
<td>Associate Chair Undergraduate Studies</td>
<td>Enacted and ongoing</td>
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<td>3. The degree credit level remain unchanged, and that the program not be forced to reduce the credit load to 20. The current number of lecture content courses is appropriate, and the “artificial”</td>
<td>This issue has been resolved, for the time being at least. This point will be more</td>
<td>Department Chair and Associate Chair Undergraduate Studies</td>
<td>Our approach has multiple steps with a first ‘broad strokes’ report to be finalized in</td>
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September 2018

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<td>4.</td>
<td>The Department find a way to incorporate a requirement for university level mathematics (e.g., calculus) into their degree programs, rather than leaving this as an option.</td>
<td>The curriculum renewal process will consider making calculus a requirement in most programs.</td>
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<td>5.</td>
<td>Program requirements be reviewed with an eye to requiring a minimum number of 400-level courses.</td>
<td>Our curriculum renewal will include required 400 level courses in all programs.</td>
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<td>6.</td>
<td>The Department, in conjunction with the Faculty of Science, explore mechanisms to increase the number and quality of Co-op placements for Biology students.</td>
<td>Faculty of Science has formed a Co-op Committee and Biology will work closely to assist in developing work placements.</td>
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inflation of degree credits created by splitting some labs away from the lecture courses they were traditionally associated with does not represent additional work that students must complete to meet degree requirements. Removal of lecture content courses to accommodate lab credits would represent a reduction in program content, relative to similar programs at other Canadian universities.

The Department find a way to incorporate a requirement for university level mathematics (e.g., calculus} into their degree programs, rather than leaving this as an option.

Thoroughly addressed as we review and revise our curriculum.

September 2018

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7. The Department make a concerted effort to more overtly expose undergraduate students to the breadth and extent of ongoing research amongst Biology faculty. This could be achieved through an active “in-reach” program that includes promotional posters and the involvement of the Biology Undergraduate Society.  

8. Consideration be given to converting “Instructor” roles in the Department into “Lecturer” (i.e., faculty) positions. The current instructors are carrying out a lot of what are traditionally faculty roles.

9. The Department put in place a clear communication strategy to ensure lab equipment needs are coordinated between course instructors/lecturers and the technical staff in place to support them.

| 7. | The Department make a concerted effort to more overtly expose undergraduate students to the breadth and extent of ongoing research amongst Biology faculty. This could be achieved through an active “in-reach” program that includes promotional posters and the involvement of the Biology Undergraduate Society. | The Department has substantial channels of engagement and feels these are adequate at this time. | Broad departmental responsibility | Ongoing |
| 8. | Consideration be given to converting “Instructor” roles in the Department into “Lecturer” (i.e., faculty) positions. The current instructors are carrying out a lot of what are traditionally faculty roles. | The Department rejects the reviewers’ interpretation of the instructors roles. Following thorough consultation with our instructors their job descriptions were reviewed and updated in 2015. They have expressed satisfaction with their roles and job descriptions. | Chair of Department | Rejected the recommendation |
| 9. | The Department put in place a clear communication strategy to ensure lab equipment needs are coordinated between course instructors/lecturers and the technical staff in place to support them. | We have altered the composition of our curriculum committee and management structure such that | Associate Chair Undergraduate Studies | Enacted |

September 2018
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<td>10.</td>
<td>Clarity on prioritizing domestic or international graduate student recruitment would be beneficial to articulate a common goal understood by the Department and administration.</td>
<td>The Department seeks clarity from upper administration on this issue.</td>
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<td>11.</td>
<td>Supervisory committees have authority to recommend waiver of one or more PhD course requirements, for approval by the Graduate Chair, following assessment of courses completed in a previously completed MSc program, including programs completed at another institution.</td>
<td>Mechanism already exists. No action needed.</td>
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<td>12.</td>
<td>Supervisors and students draft an agreement of mutual expectations and timelines soon after the student enters the program and that timelines be updated in each progress report presented to the supervisory committee and that these timelines be approved by the committee.</td>
<td>This has already been enacted in the Department</td>
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<td>13.</td>
<td>The comprehensive exam procedure be reviewed, and consideration given to alternative models such as inclusion of a literature review or a mock grant proposal (such as a NSERC Discovery Grant) that is evaluated by the Examination Committee (written and oral components).</td>
<td>BGSC has met and rejected the recommendation. Students and Faculty are happy with present system.</td>
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<td>14.</td>
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<td>This is now part of our supervisory</td>
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<td>given formal permission to begin writing a thesis. At this meeting, the student could submit a table of contents of the proposed thesis.</td>
<td>committee meeting report</td>
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<td>15. The graduate course curriculum more accurately map to the research fields and that courses be modified to provide a balance between specific training with their programs and broad training within the field (possibly through common graduate courses in the subfields) and for professional development.</td>
<td>Our curriculum is under review and renewal and will be mapped to research fields. Professional development is widely available across campus</td>
<td>Associate Chair Graduate Studies</td>
<td>Ongoing with up to a 4-5 year timeline for completion</td>
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<td>16. We recommend that a human resource appointment within the Faculty of Science be attached to the Department to provide support related to graduate student TA appointments, files for postdoctoral positions, etc.</td>
<td>Outside of Department governance</td>
<td>Dean of Science and Department</td>
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<td>17. The Vice President Research commit to a subsidy to support a renovated aquatic facility, which could be included in a potential CFI application.</td>
<td>Completed</td>
<td>Dean of Science and Office of Research</td>
<td>2017</td>
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<td>18. The Department work with the Faculty of Science to provide matching funds to support a CFI proposal to improve the aquatics facility.</td>
<td>Ongoing</td>
<td>Aquatic Facility Users Group, Department Chair</td>
<td>Ongoing 2017- 18</td>
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<td>19. The Committee of Research fellows create clear and transparent guidelines for provision of equipment maintenance funds.</td>
<td>Outside of Department Governance</td>
<td>Department Chair, Associate Dean Research</td>
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<td>20. The Department work with the Faculty of Science to firmly establish a risk-funding program for faculty facing grant renewal. If this funding was</td>
<td>Existing</td>
<td>Associate Dean Research</td>
<td>Ongoing</td>
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guaranteed, it would allow researchers to develop longer term plans for their programs.

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<td>21.</td>
<td>We recommend that the Department work with the Graduate Studies Office to determine campus-wide quota system for scholarships that doesn’t disadvantage strong departments, such as Biology.</td>
<td>Associate Chair, Graduate Studies</td>
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<td>We recommend creation of a modular-based graduate course that could be tailored across research fields and allow for breadth and flexibility for each student. As an example, this course could contain six modules, of which the student would be required to complete three for credit. Incorporation of the existing BIOL 690 – Scientific Communication, into this model could better insure that students attain important communication skills without making it a full course requirement.</td>
<td>Associate Chair, Graduate Studies</td>
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| 25. | We recommend that the Department could regularize when new faculty are expected to begin to teach grad courses, and how they will fit their courses into the program. | Department Chair Associate Chair, Graduate Studies | We now have clarified direction on this. |

The Department Chair/Director, in consultation with the Dean of the Faculty shall be responsible for monitoring the Implementation Plan.
Date of next program review: 2023

Signatures of Approval:

Chair/Director

AFIW Administrative Dean/Head (For AFIW programs only)

Faculty Dean

September 28, 2018

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

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

September 27, 2018

Quality Assurance,

The Faculty of Mathematics endorses the Final Assessment Report of the Mathematics/Teaching (BMath) September 2018 report.

The proposed actions and timelines are reasonable, and address the recommendations of the original report.

Regards,

Stephen M. Watt
Dean, Faculty of Mathematics
Final Assessment Report
Mathematics/Teaching (BMath)
September 2018

Summary of the Program Review:
In accordance with the University’s Institutional Quality Assurance Process (IQAP), this final assessment report provides a synthesis of the external evaluation and the internal response and assessments of the Bachelor of Mathematics in Mathematics/Teaching delivered by the Faculty of Mathematics. A self-study (Volume I) was submitted to the Associate Vice-President, Academic on October 6, 2017. The self-study presented the program descriptions and learning outcomes, an analytical assessment of the program, including the data collected from student surveys along with the standard data package prepared by the Office of Institutional Analysis & Planning (IAP). The CVs for each full-time faculty member in the Department were included in Volume II of the self-study.

Two arm’s-length external reviewers were selected from Volume III of the self-study. Dr. Timothy Sibbald, Associate Professor in the Schulich School of Education, Nipissing University, and Dr. Gerda de Vries, Professor in the Department of Mathematical and Statistical Sciences, University of Alberta were ranked and selected by the selected by the Associate Vice-President, Academic as well as one internal reviewer (Dr. Eric Helleiner, Professor of Political Science).

Reviewers appraised the self-study documentation and conducted a site visit to the University on November 16 and 17, 2017. The visit included interviews with the Vice-President Academic and Provost; Associate Vice-President, Academic; Dean of Mathematics; Associate Dean, Undergraduate of Mathematics; Director of Mathematics/Teaching, Faculty members, staff and current undergraduate students. The review team also had an opportunity to meet with representatives from the library and Co-operative Education.

This final assessment report is based on information in many cases copied from the self-study, the external reviewers’ report and the program response.

Program characteristics:
The co-operative Mathematics/Teaching plan combines academic studies in mathematics, teaching experience in secondary schools, professional training, and other work experience. A graduate of this program will have demonstrated significant quantitative abilities in algebra, calculus, geometry, probability, statistics, computer science and mathematical education, as well as an aptitude for teaching.
The Mathematics/Teaching program exists in three different forms. First, Mathematics/Teaching exists as a stand-alone plan within the Faculty of Mathematics. Students can enrol in and graduate from the Mathematics/Teaching plan. Second, there is a stand-alone Pure Mathematics Teaching plan. Third, Mathematics/Teaching exists as an optional addition to most other undergraduate plans within the Faculty of Mathematics. Each of these programs is available as co-op only and are second-entry, requiring admission usually at the second-year level.

Summary of strengths, challenges and weaknesses based on self-study:
Strengths:
- Students get direct, relevant experience in their intended profession.
- Students earn Honours degrees in Mathematics, which includes a minimum of 26 mathematics courses. This extensive mathematics background is good for mathematics education in the secondary schools.
- Non-teaching work terms give experiences that inform the students’ teaching.

Challenges:
- Changes in teacher education programs in Ontario, and the resulting loss of Queen’s University as a partner institution for the Bachelor of Education, takes away the attraction of doing two degrees at one time.

Weaknesses:
- The number of schools who hire co-op work term students needs to be expanded. Public/Separate school boards no longer hire students on co-op terms and so we rely on private schools for work term opportunities. While this is not intrinsically a bad thing, a wider variety of opportunities (locations) would be beneficial.

Program response to external reviewer recommendations:

Recommendations

1. The Teaching option [now known as Mathematics/Teaching] should be continued and succession planning should begin in a manner that allows for an overlap with existing faculty. This will allow existing practices to be understood and relationships with existing schools to be continued.

Response
A Director for Mathematics/Teaching was appointed in Summer 2018. Discussions will be scheduled with current personnel about their interest and availability in supporting the program going forward. The CEMC Director and Dean of Mathematics will then discuss a succession plan.

2. Modification of the existing MTHEL course should be considered, such as changing the orientation from teacher/textbook-centered approaches to student-centered approaches.

Response
First reconfirm the goals, objectives and key priorities of Mathematics/Teaching. Then review the content and delivery of MTHEL 206A. Consider soliciting external expertise.

3. Addition of a second MTHEL course should be considered. For example, bringing the students back together to debrief their placements would be beneficial. In effect, the first MTHEL course is taken, the placements are done, but there is no opportunity for students to reflect on their teaching experience within their cohort. Having a mechanism whereby students could share, and reflect on how their co-op placements connected to the concepts taught in the first MTHEL course would be worthwhile and enrich the educational experience.

Response
Consider creation of a second MTHEL course or creative alternative (seminar, facilitated online discussions, etc.) after establishing goals, objectives and key priorities of Mathematics/Teaching. Give strong consideration to incorporating student reflection and sharing of experiences.

4. The Teaching Option should be advertised as such in the Calendar (on first glance, it currently appears to be available only through the stand-alone Mathematics/Teaching program), so that more students recognize the opportunity to individualize or add extra value to their degree.

Response
Revise text in Calendar to make it clear that Mathematics/Teaching can be done on its own or in conjunction with almost any other Faculty of Mathematics undergraduate plan.

5. Further increase in enrolment may be achieved through the use of statistics to show that there is a need for mathematics teachers. In conjunction with this, broadening the placements to clearly include grades 7-10 and/or placements in community colleges may help address a need for more placement options. Lastly, having an arrangement for direct
admission into a Faculty of Education would also provide additional motivation for students to consider adding the teaching option to their degree.

Response
Discuss these issues and ideas after reconfirming goals, objectives and key priorities of Mathematics/Teaching.
Implementation Plan:

<table>
<thead>
<tr>
<th>Recommendations</th>
<th>Proposed Actions</th>
<th>Responsibility for Leading and Resourcing (if applicable) the Actions</th>
<th>Timeline for addressing Recommendations</th>
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<tr>
<td>Reconfirm goals, objectives and key priorities for the program.</td>
<td>Through consultation with CEMC Director, Dean of Mathematics, and current program personnel, the Director of Mathematics/Teaching will reconfirm goals, objectives and key priorities for the program.</td>
<td>Director of Mathematics/Teaching</td>
<td>June 2019</td>
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<td>1. The Teaching option should be continued and succession planning should begin in a manner that allows for an overlap with existing faculty. This will allow existing practices to be understood and relationships with existing schools to be continued.</td>
<td>A new Director for Mathematics/Teaching will be found for a fixed-term appointment. Discussions will be scheduled with current personnel about their interest and availability in supporting the program going forward. The CEMC Director and Dean of Mathematics will then discuss a succession plan.</td>
<td>CEMC Director and Dean of Mathematics</td>
<td>A new Director was appointed summer 2018.</td>
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<td>2. Modification of the existing MTHEL course should be considered, such as changing the orientation from teacher/textbook-centered approaches to student-centered approaches.</td>
<td>First establish the goals, objectives and key priorities of Mathematics/Teaching. Then review the content and delivery of MTHEL 206A. Consider soliciting external expertise.</td>
<td>Director of Mathematics/Teaching, recent/future MTHEL 206A instructors and CEMC leadership</td>
<td>Spring 2020, with partial process by Spring 2019</td>
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<td>3. Addition of a second MTHEL course should be considered. For example, bringing the students back together to debrief their placements would be</td>
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beneficial. In effect, the first MTHEL course is taken, the placements are done, but there is no opportunity for students to reflect on their teaching experience within their cohort. Having a mechanism whereby students could share, and reflect on how their co-op placements connected to the concepts taught in the first MTHEL course would be worthwhile and enrich the educational experience.

| 4. | The Teaching option [now known as Mathematics/Teaching] should be advertised as such in the Calendar (on first glance, it currently appears to be available only through the stand-alone Mathematics/Teaching program), so that more students recognize the opportunity to individualize or add extra value to their degree. | Revise text in Calendar to make it clear that Mathematics/Teaching can be done on its own or in conjunction with almost any other Faculty of Mathematics undergraduate plan. | Director of Mathematics/Teaching | End of 2018 |

| 5. | Further increase in enrolment may be achieved through the use of statistics to show that there is a need for mathematics teachers. In conjunction with this, broadening the placements to clearly include grades 7-10 and/or placements in community colleges may help address a need for more placement options. Lastly, having an arrangement for direct admission into a Faculty of Education would also provide additional motivation for students to consider adding the teaching option to their degree. | Discuss these issues and ideas after establishing goals, objectives and key priorities of Mathematics/Teaching. | Director of Mathematics/Teaching, Mathematics/Teaching personnel and CEMC leadership | Ongoing, beginning in Fall 2018 |

The Department Chair/Director, in consultation with the Dean of the Faculty shall be responsible for monitoring the Implementation Plan.
Date of next program review: 2022-23

Signatures of Approval:

Chair/Director

AFIW Administrative Dean/Head (For AFIW programs only)

Faculty Dean

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

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

October 25, 2018

The Faculty of Mathematics endorses this two year progress report for the BCS, BMath (CS), MMath and PhD programs, as revised August 2018. Two of the five recommendations are now complete. The nature of the other three recommendations (develop a hiring plan, promote the CS graduate program and increase the number of lecturers) are very long term projects, and have now commenced. They will be ongoing projects well into the future, as is appropriate given the recommendations.

Regards,

Stephen M. Watt
Dean, Faculty of Mathematics
Two Year Progress Report
BCS, BMath(CS), MMath, and PhD
June 2016 (revised August 2018)

Background:
The last cyclical review was completed in January 2014. The School undertook a major self-study of all its programs (266 pages), and invited Dr. Anne Condon (University of British Columbia), and Dr. Ken Jackson (University of Toronto) to be the external reviewers. As noted in the report, the Cheriton School of Computer Science is one of the strongest in the world, currently ranked #31 in the QS world rankings. It is also very large, with over 3600 undergraduate students, over 400 graduate students, and more than 80 faculty members. The self-study and external review were very effective in identifying the strengths and challenges for the School in the coming years. The reviewers made a number of very appropriate recommendations. In response the School made a number of action steps in a two-year progress report that was originally submitted in June 2016. However delays in both in the School and in the Quality Assurance Office warranted revisions to the 2016 draft and the current document was resubmitted in August 2018.

Progress on Implementation Plan:

Recommendations

1. Develop a hiring plan that takes into account what research areas are priorities for the School as well as how hiring more women faculty members might improve the learning environment for women students and how hiring more lecturers might reduce the need to hire as many sessional instructors and might also reduce class sizes.

Status: In progress, and ongoing
Details: In 2013-2014 and 2014-2015 the School conducted open hires in all areas of Computer Science. This was determined to be the most adaptable approach to hiring a large number of faculty members (4 positions in each year), as well as potentially be proactive in hiring women. The plan was successful in hiring 8 new faculty members (2 of them women) and one Cheriton Chair. In May 2015 we surveyed the School regarding the recent hiring approach, priority areas for research, and the appropriate balance of professorial and lecturer faculty. As a result, for 2015-2016 we identified three target research areas (Systems & Networking, Software Engineering, and Machine Learning) as well as advertising one position for strategic hires in any area of computer science. This was necessary to address the research and teaching imbalance due to some retiring and departing faculty. While this round of hiring was successful, and 4 faculty members were hired, all of them were male. The top candidates in both Systems & Networking and Software Engineering were both female, and were made competitive offers, but both of them ultimately decided to go elsewhere. In both cases we were very proactive in

August 2018
reaching out to the candidates to encourage them to apply. This pattern has continued for the past two years, though indeed we have had notable successes: in addition to generally hiring quite successfully, the School also has hired a female assistant professor, Dr. Xi He, who will arrive soon. Still, our new hires barely keep up with retirements and faculty leaving for chairs and other positions outside Waterloo, and our number of students has skyrocketed.

The issue of the balance of lecturers and professors is an on-going discussion, and has been addressed in each year’s post-hiring-round survey. While no firm resolutions have been made in this regard, seven new lecturers have been hired over the past four years (two female), and there is an expectation to hire more in coming years. The quality of applicants varies year over year. A very competitive industrial market, as well as strong hiring of faculty at good second-tier CS departments with some research component are posited as reasons.

At this point, we plan annually our faculty hiring, partly because there is so much unpredictability in the success of each year’s hiring: in particular, in 2017-2018, we hired seven new professors (including two senior hires from Western University) and two new lecturers; the previous year’s hiring was much less successful. A long-term hiring plan seems unlikely at this time; additionally, faculty retirements have proven very difficult to plan for. A particular challenge with long-term faculty planning for our School is the dramatic changes in our field: just since the 2014 review, the rise of artificial intelligence as a key area in CS has hastened to a level that could not have been predicted then. As such, we expect that a longer-term prioritization project to identify areas for growth is unlikely to work as well as the more organic model we have been following. We may have a CS retreat organized around other long-term School structural issues in 2019, and we would include this topic.

Since the 2014 program review, our undergraduate enrolment dramatically increased, and as such, the issue of balancing lecturers and professors has been less of a worry than the issue of balancing lecturers and sessionals. Consistently we have not been able to fill all existing lecturer openings, and the ones we have been producing have consistently kept the number of lecturers at approximately 17% of the School faculty complement.

2. Appoint a senior faculty member to work closely with the Directors in developing bold new strategies to attract women at the undergraduate, graduate, postdoctoral and faculty levels.

**Status:** Completed

**Details:** In July 2015 we created the position of Director of Women in Computer Science with the mandate to provide a strong and active voice on the CS Executive Committee (and hence providing input into all School operations, including admissions), and to lead all manner of activities regarding women in CS, from K-12 to undergraduate and graduate education through development and recruitment of research faculty. The position has teaching relief and a significantly increased budget for a number of new activities aimed at outreach, recruitment, retention, and post-graduate success of students. This has been extremely successful and Prof. Jo Atlee, Director of Women in CS has been active in leading a number of new initiatives at the...
School and Faculty levels. She has also worked closely with fundraising staff in the Math Faculty to bring in support for initiatives that she has begun.

Current outreach initiatives are two programs. Technovation Challenge is a world-wide competition for girls 10-18, for which our Women in CS program is the Waterloo Region ambassador. Girlsmarts4tech is an annual one-day event for girls in grades 6 and 7.

On campus, we offer a half-day orientation event for new students, a peer mentorship program (Big CSters), Lean-In circles, technical interview preparation workshops, career panels, and workshops on responding to sexism for students; we also send students to conferences focused on women in technology, such as the Grace Hopper Celebration of Women in Computing.

Future programs include more technical programs for senior university students, an expansion in the Technovation Challenge project, and a focus on environmental sustainability for WiCS events.

The number of women accepted into Computer Science programs rose from 16% to 25% from 2014 to 2015, and sustained these levels in 2016 through 2018. While we cannot claim a direct connection, it is felt that new programs and publicity are having a very positive effect.

While we mark this item as “completed”, in that the position of Director of Women in CS has been successfully created, the project itself, and the problem it addresses, is far from gone and we expect to be dealing actively with this for the indefinite future.

3. Step up efforts to promote the CS graduate program at Waterloo, and to ensure timely and smooth communication with prospective and accepted graduate students. Consider introducing an alternative pathway for excellent students from other disciplines to transition into the graduate program.

**Status:** In progress

**Details:** The School introduced a number of new measures for graduate student recruitment over the past 4 years.

First and foremost is the very successful Undergraduate Research Opportunities Conference (UROC) which brings in senior undergraduate students from all over Canada for 3 days of intensive research projects led by a research faculty. Since beginning UROC in 2015, we have had 128 students attend in four years, of whom 18 have joined us as graduate students in the first three years. We reduced the size of UROC in September 2018, to 26, to focus on students whom we expect are bound for graduate school.

We are also developing a new Master’s degree in Data Science and Artificial Intelligence (MDSAI) with the Department of Statistics and Actuarial Science. This will provide a path for students with a strong computer science or statistics background to obtain a Master’s in this exciting area of computing. A Data Science option for the CS and Statistics Master’s programs...
was rolled out to the first students in Fall 2017, and the full MDSAI program is going through the approval processes, with an expected start date of Fall 2019.

The School (and University) could still improve with respect to timely and smooth communication with prospective and incoming graduate students. In particular, there are still lags at a number of levels (between faculty members indicating that they have accepted students and the formal offers going out), and the finances in offer letters are somewhat complicated, especially for international students (high tuition fees are usually compensated for by large scholarships and TAs, but the net income may be difficult to discern). A recent initiative has been an e-newsletter for applicants, students who have been accepted, and those who have decided to attend Waterloo.

As well, the offers themselves are often at a lower financial level than competing schools, especially those in the US. UW support packages, as of 2018, are approximately $3000 less than comparable funding packages in CS at the University of Toronto, though obviously the cost of living in different places (e.g. Toronto) plays a significant role. Top US School regularly offer up to $10,000 more than this in take-home pay (though this information is somewhat anecdotal, and difficult to verify).

Our Grad Visit Day in the winter, where we bring in accepted students from near and far, and also strong domestic applicants who have not yet been accepted, has grown in the past few years: approximately 25 students attend per year, of whom half subsequently enroll (13 in each of 2017 and 2018). Many new students cite it as a big factor in their decision to come here.

4. Increase the number of lecturers, as a means of reducing the number of sessionals. Ensure that lecturers and faculty in the professorial ranks strengthen their partnership in advancing and delivering the curriculum, are supported in adopting and assessing new practices pertaining to curriculum or pedagogy and extracurricular enrichment, and avail of professional development opportunities, e.g., through participation in the Association for Computing Machinery’s Special Interest Group in Computer Science Education.

**Status:** In progress

**Details:** The School has hired seven new definite term lecturers over the past four years. It is expected that we will hire at least one more lecturer in the coming year. As well, the School has been proactive in encouraging strong lecturers to apply for Continuing status. Finally, Lecturers (especially Continuing Lecturers) are becoming more involved in the leadership of the School, with two of them serving sometimes as chair of School committees: the Outreach Committee (which has done computer science outreach to K-12 students through open courseware, on campus events and School visits) and the Commons Committee, (whose goal is to encourage the social and scientific commons of the School).

Senior lecturers have taken a leading role in the Undergraduate Curriculum Committee. A 2014 subcommittee report led by one senior lecturer on CS minor programs has led to substantial changes in this aspect of our curriculum (see recommendation 5 below). The Undergraduate
Academic Plans Committee (UAPC – the undergraduate curriculum committee), has a long tradition of being an exciting and dynamic body for curriculum development and has always had strong participation from lecturers.

There has been little recent engagement in SIGCSE by the lecturer group, though there has been in the past. This has more to do with their other current non-teaching engagements, including completing their PhDs and other research endeavours, involvement in Centre for Education in Mathematics and Computing and the International Olympiad in Informatics, the Canadian Computing Competition, other conferences, and deep contributions into the advising and data collection infrastructure through the development of the Online Advisor Tool (OAT). One interesting change has been the increase in the number of lecturers in CS who have a non-zero research appointment; one of our lecturers currently holds an NSERC discovery grant, and another will apply in the 2018-2019 competition.

As noted above, the market for hiring lecturers is very tight, and we were unsatisfied with the quality and depth of the applicant pool in recent hiring rounds, though we have made good hires. We will continue to try and recruit top-quality lecturers, in particular by developing lecturers from those already teaching sessionals and from our graduate students who prefer a teaching-oriented career. Nonetheless, we expect these difficulties with overall lecturer hiring to continue.

With respect to new models of curriculum and pedagogy, two recent developments are relevant. First, following on the successful introduction of enriched sections in first year courses, in the past four years the School has successfully introduced enriched sections of four of its second-year core courses. The intent of these courses is to deliver an enriched (as opposed to accelerated) version of the material which can be taught to 10% of the students, or approximately 50 per year, per course. These courses go deeper into particular topics to provide challenges to strong students and to encourage them towards research and exploring their own new ideas. The second curriculum innovation is in the development of online graduate courses for CS non-major students. Three such courses have been developed and now delivered, in Networking, Databases and Security. These were originally developed as Computer Science courses in the Masters of Health Informatics (now hosted by Applied Health Sciences), but the plan is to use them in other programs, as well as for the senior non-major undergraduate program (see 5 below). We will be developing some other undergraduate non-major courses in the next few years as part of the Math Online project.

5. Review the non-majors undergraduate program in CS in light of increasing enrollments in the School and changes in CS curriculum at peer institutions.

**Status:** Completed
**Details:** In March 2014 the CS Minor subcommittee reported back with a proposal for a complete revision of the minor programs in Computer Science. This involved the creation of a greatly strengthened Computer Science minor, which is a proper subset of a full CS degree, and also a Computing Option (briefly named Computing Technology), available broadly throughout
the University to provide a less intense, but still valuable exposure to computing. This minor and option were formally introduced in late 2015, and should provide more possibilities for involvement in Computer Science for non-major students both inside and outside the Faculty of Mathematics.

Address any significant developments or initiatives that have arisen since the program review process, or that were not contemplated during the review:

The School of Computer Science has seen enormous growth in both undergraduate applications and in the program size itself. The number of students in CS has grown from around 2000 students in 2011 to over 3600 students in 2018 with essentially the same faculty complement of 80 faculty members. A considerable amount of this growth has been through transfers into the program after first year, largely from within the Faculty of Math. This has led to significant stresses on the teaching environment, where we now have over 80 sessionals per year and regular faculty have “taught ahead” more than 100 courses. There is an expectation that this “teaching debt” owed to the regular faculty members will be slowly payed back (by these faculty members teaching less in some future years), introducing an even greater need for sessionals. This has also significantly stressed resources, especially with respect to developing new courses. It is forcing the choice of hiring more lecturers, even in a tough market, and sapping resources for graduate growth. New policies have been put into place (in fall 2017) to limit transfers into CS, but some of these late transfers are women who are not drawn to CS in high school, but discover it after first year university. The new transfer policy into CS is being monitored very closely to ensure it does not introduce any new biases, or entrench undesirable old biases, in our student population.
### Updated Implementation Plan:

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<tr>
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<th>Responsibility for Leading and Resourcing (if applicable) the Actions</th>
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<tr>
<td>1. Develop a hiring plan that takes into account what research areas are priorities for the School as well as how hiring more women faculty members might improve the learning environment for women students and how hiring more lecturers might reduce the need to hire as many sessional instructors and might also reduce class sizes.</td>
<td>1. Develop a 5-year hiring plan to accommodate predicted faculty losses due to retirement and attrition, and to accommodate the current number of students. In practice, this has been done <em>ad hoc</em> each year, with an emphasis on each year’s appropriate hiring priorities. We have hired two new female assistant professors since 2014.</td>
<td>Director of SCS, with Chair of School Advisory Committee on Appointments</td>
<td>Ongoing</td>
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</table>
| 2. Appoint a senior faculty member to work closely with the Directors in developing bold new strategies to attract women at the undergraduate, graduate, postdoctoral and faculty levels. | 2a. Continue to develop the office of Women in CS.  
2b. Establish external funding for Women in CS to allow for larger-scale projects | Director of Women in CS Director of SCS | Completed Fall 2017  |
| 3. Step up efforts to promote the CS graduate program at Waterloo, and to ensure timely and smooth communication with prospective and accepted graduate students. Consider introducing an alternative pathway for excellent students from other disciplines to transition into the graduate program. | 3a. Complete implementation of Masters of Data Science Approval process still in progress.  
3b. Work to reduce lags in offering times, and improve clarity of communications with prospective students  
We have worked both within CS and outside to improve this process. | Director of Graduate Studies | For recommendation 3a, Fall 2018. Other recommendations are ongoing |
3c. Improve financial packages to be competitive with peer institutions. Largely outside our control: other universities (particularly those in the US) consistently have deeper pockets than we do.

4. Increase the number of lecturers, as a means of reducing the number of sessionals. Ensure that lecturers and faculty in the professorial ranks strengthen their partnership in advancing and delivering the curriculum, are supported in adopting and assessing new practices pertaining to curriculum or pedagogy and extracurricular enrichment, and avail of professional development opportunities, e.g., through participation in SIGCSE.

4a. Establish realistic balance of lecturers and professorial faculty to accommodate current student numbers.

4b. Continue to recruit and develop high quality lecturers. We are specifically hiring only PhD holders as new lecturers, and many of them are choosing to have a research component, though mostly this is not in educational research.

Director of SCS
Chair of Lecturer hiring committee
Ongoing

4a. Establish realistic balance of lecturers and professorial faculty to accommodate current student numbers.

4b. Continue to recruit and develop high quality lecturers. We are specifically hiring only PhD holders as new lecturers, and many of them are choosing to have a research component, though mostly this is not in educational research.

Director of SCS
Chair of Lecturer hiring committee
Ongoing

5. Review the non-majors undergraduate program in CS in light of increasing enrollments in the School and changes in CS curriculum at peer institutions.

5. Develop Computing Option for non-majors in collaboration with external units.

Director of Undergraduate Studies
Completed Fall 2015

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

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Signatures of Approval:

Chair/Director  

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Faculty or Administrative Dean  

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

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Associate Provost, Graduate Studies  
(For Graduate and augment programs)  

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<td>August 29, 2018</td>
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Two-Year Progress Report
Knowledge Integration (BKI)
June 2018

Background:
The Knowledge Integration (KI) program, housed in the Faculty of Environment (ENV), admitted its first students in Fall 2008. The first and most recent seven-year program review of the Knowledge Integration program was completed in November of 2015, with the on-campus visit taking place November 12 and 13. The associated Final Assessment Report was accepted by Senate at its September 2016 meeting.

Overall the external reviewers were impressed with the KI program and considered it to be well conceived, executed and supported by a very dedicated, supportive faculty. Reviewers found that students and alumni were complimentary about the program, the faculty and the University, and the current resources available support the current program needs. The reviewers viewed the KI program as an innovative approach to the concept of a more traditional ‘liberal arts undergraduate degree program’ and saw it as being entirely consistent with the external perception of the innovative solutions and programs provided at the University of Waterloo.

The reviewers identified a number of issues, which were analysed and articulated in the implementation plan included in the Final Assessment Report. The purpose of this two-year progress report is to provide an update on activities with respect to the implementation plan.

Recommendations:

1. Consider a rebranding exercise for the program.
2. Consider adjustments to the marketing and advertising strategies for the KI program.

Status: in progress
Details:

The Department considered several options for brand renewal of the program, including the possibility of changing the name of the program and/or degree. Other universities’ “arts and science” programs provide one possible model, but KI is both broader and more design-focused than most of these programs. Going forward, we are committed to being vigilant about the KI name and brand. Our recruitment numbers are up slightly
since the program review, and so our path forward at this point is to test different marketing language and platforms for the KI program.

For example, one of our senior thesis students carried out a review in 2017-18 of our communication language and brand promise under co-supervision of the Chair, Rob Gorbet, and Tina Roberts, Director of MUR. The student surveyed key stakeholders on campus to identify KI’s distinctive program attributes, then tested these with applicants to determine which program attributes were most attractive, as well as testing language to effectively convey these attributes to our target audience. The report was delivered in May 2018 and follow up is being organized with representatives from MUR, ENV, and KI. We anticipate, as a first stage, preparing scripts for use by staff and student volunteers at open-house events where they are in contact with prospective students and their parents. In a second stage, the results will be reviewed to inform possible changes to our print and online material.

In Fall 2017 we piloted a program in which we hired one of our undergraduate students to act as a social media strategist for the Department. The student, supervised by Kim Boucher, KI Outreach and Administrative Manager, managed the departmental Twitter and Instagram accounts. In addition to regular posts, she created and led several social media interventions (e.g., Instagram takeovers and a “#myKI” video marketing campaign showcasing both current students and alumni), and also produced reports showing followership and engagement. Thanks to her work, our social media followership saw a steady increase in both numbers and engagement over the Fall and Winter terms. We consider this to be an effective investment and will continue the practice going forward.

In Fall 2017, we also did a KI promotional mailing to almost 1,000 outstanding high school students from across Canada who participated in the SHAD enrichment program in 2017 at 13 university campuses, and this resulted in an increase in applicants to KI from SHAD alumni as well as awareness raising of KI in this segment of our target population.

3. Consider revisions to the curriculum to: reconsider the name, aim and scope of the Museum Course; increase opportunities for KI students to engage in more effective academic career mapping; create clearer links with ENV without making the connection too explicit.

Status: in progress
Details:

KI has been moving forward with significant curriculum changes, which help us move in this general direction. We do believe the Museum Course is a key component of the
program, that it is working well, is a significant part of the program’s identity. We therefore are unlikely to change the scope of it in the near future. We have, however, been revising the course to more clearly emphasize the professional skills development present in the course and to align the exhibit topics with the UN Sustainable Development Goals, helping to create clearer links with ENV. In addition, we have created an elective course (INTEG375: Hands-on Sustainability, F2018) which approaches observation, analysis, design, and applied problem-solving, from a sustainability perspective. For more on curriculum changes, please see the Implementation Plan below.

4. Find ways to broaden campus-wide understanding of KI and its aspirations, thereby increasing the resources available to support the program.

Status: ongoing
Details:

The reviewers recommended exploring adjunct and joint positions for faculty from other units, into KI, as well as broad advertising of the Friday KI Seminar and events showcasing student work (e.g., the annual KIX museum exhibition and the fourth-year thesis symposium).

We continue to advertise all of the events mentioned, as we have always done, through email, social media, the Daily Bulletin, campus TV monitors, and the other channels that we’re aware of. We regularly review this strategy, as well as the potential for new opportunities or communication channels.

The creation of adjunct positions at Waterloo does not bring increased resources to a program, though it might be a way of recognizing those faculty from other units who consistently supervise KI senior thesis projects. This is something we will explore further. The negotiation of joint appointments would depend on the availability of resources, appropriate candidates, and the strategic direction of the Faculty and institution. This will be considered moving forward, should the enrolment continue to improve.

While not directly responding to this reviewer recommendation, the Fall 2018 launch of INTEG210 Making Collaboration Work as a campus-wide course on effective interdisciplinary collaboration will contribute to increased exposure to KI across campus.

5. Encourage increased Scholarship of Teaching and Learning (SoTL) scholarship on the KI program itself and cognitive development among KI students. Encourage the University
to codify the ‘cross-appointment letter’ [Memoranda of Understanding] which is made available to KI faculty.

Status: N/A
Details:

While these are not really program-level recommendations, KI faculty do have an interest in SoTL research and in particular Dr. Kathryn Plaisance is currently engaged in such research in her classrooms. For example, in Fall 2018 she will be running a study on the impact of her new course INTEG210: Making Collaboration Work. This course is intended to host students from across campus and teach them some of the fundamentals of group work and interdisciplinary collaboration from several of the KI core courses.

As we wrote in our response in the Final Assessment Report with respect to the KI faculty MOUs, we have encouraged the University to create policy and language clarifying the processes of annual merit assessment and tenure and promotion for faculty with interdisciplinary appointments, and have offered to consult on such efforts.

6. In the category of Other: increase money available for large entrance scholarships; develop more partnerships to help place students’ museum exhibits in the community post-exhibition; expand design thinking and problem solving courses to other constituents.

Status: ongoing
Details:

We continue to monitor student input on program choice and don’t believe that the lack of large scholarships plays a significant role in attracting students. Of course, we continue to work with ENV advancement staff to steward current donors and seek future donors.

In 2018 we announced a three-year partnership with the City of Waterloo museum to host up to three of the student-designed exhibits each year from March to June. In addition, the museum will make available its archives and staff to contribute to student learning and engagement. We continue to work with staff at other local museums, THEMUSEUM and the Waterloo Regional Museum, and beyond (Design Exchange, Ontario Science Centre) with whom we have strong relationships. They act as expert critics for the students’ museum exhibit, and have hired our students as interns.
We continue to expand our involvement in design on campus. In Winter 2019 we will be offering an additional section of *INTEG121: Collaboration, Design Thinking and Problem-Solving* as a core course in the International Development program. More informally, we continue to work with Tania Del Matto and Brendan Wylie-Toal of GreenHouse at St. Paul’s, to coordinate efforts and support each other in the design thinking space. The Department Chair is also involved in ongoing discussions with cross-campus constituents about a more formal design movement on campus. We would welcome the opportunity to work with other constituencies on campus as well.
The table below includes the 18 original items that were either recommended by reviewers or cited by program staff/faculty as being important. Status has been updated.

<table>
<thead>
<tr>
<th>Recommendations</th>
<th>Proposed Actions</th>
<th>Responsibility for Leading and Resourcing (if applicable) the Actions</th>
<th>Timeline for addressing Recommendations</th>
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<tbody>
<tr>
<td>1. Complete a branding exercise for the program.</td>
<td>After a review of available resources and expertise, this was launched as a senior thesis project with co-supervision by Tina Roberts, Director of Marketing and Undergraduate Recruitment (MUR). The report was completed in April and is currently being reviewed by MUR/ENV/KI for action.</td>
<td>ENV/MUR</td>
<td>In progress. Staged actions include: development of recruitment scripts for volunteers interacting with potential students &amp; parents (Fall 2018), review of print and online material (Fall 2019).</td>
</tr>
<tr>
<td>2. Review and revise marketing and communication strategy and materials.</td>
<td>A social media strategist position has been created, for which we interview and hire an undergraduate student each term (starting Fall 2017). This has proven to be quite successful, increasing both social media followership, engagement, and quality of engagement, and providing a platform to showcase the KI program, students, staff, faculty and alumni. Beyond social media, this work overlaps with the branding work identified in #1 above, which is more closely being managed by ENV/MUR staff with support from KI staff and Chair.</td>
<td>Chair (social media strategist) ENV/MUR (print, online, communication materials)</td>
<td>In progress/ongoing.</td>
</tr>
<tr>
<td>3. Complete review of the Waterloo Unlimited structure and implementation</td>
<td>The Waterloo Unlimited program was shut down in 2017.</td>
<td>Director of Waterloo Unlimited</td>
<td>N/A.</td>
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<td>4. <strong>Implement work-integrated learning more formally (but still optionally) in the program.</strong></td>
<td>The work-integrated learning internship, KI Works, ran a successful pilot in Spring 2016 with 3 students and had 5 students complete internships in 2017. We have had very positive feedback from employers on the quality of our students, who consistently rate Outstanding or Excellent. As we continue to operate KI Works, we are also closely monitoring the changing co-op/WIL/internship ecosystem (e.g., Coop 2.0, EDGE, CAFCE’s switch to CEWIL, the GBDA program’s internships) and are in discussions with CECA about how they might support a model of optional internships for KI students going forward.</td>
<td>Chair</td>
<td>Completed: creation of a work-integrated learning program</td>
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<tr>
<td>5. <strong>Increase the presence of entrepreneurship and social entrepreneurship within the curriculum. Review opportunities to better connect curriculum and student projects indirectly with Environment.</strong></td>
<td>This work is ongoing, as individual instructors integrate themes of entrepreneurship, social entrepreneurship, environment and sustainability into their courses as appropriate. For example, KI students tackled the theme of the UN SDGs in their museum exhibit design projects for 2018. We received positive feedback on this from all stakeholders, and we will continue this thematic association for the near future.</td>
<td>KI faculty</td>
<td>Ongoing.</td>
</tr>
<tr>
<td>6. <strong>Implement pending curriculum changes.</strong></td>
<td>The past two years have seen significant curricular change in the program, in part as a result of the program review and in part</td>
<td>Associate Chair Undergrad</td>
<td>Complete. These changes have been initiated. Several have passed Senate, while others will come to Senate in Fall</td>
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<tr>
<td>7. Increase the structure of the curriculum.</td>
<td>Some of the changes already made contribute to more appropriate program structure (e.g., introducing a conflict management course into the breadth requirements). Now that these changes have been completed, attention will turn to further structural changes such as providing opportunities for course planning, and encouraging students to declare a specialization (traditional or self-designed) by the end of 2B.</td>
<td>Associate Chair Undergrad</td>
<td>In progress: these will be undertaken in an upcoming calendar cycle.</td>
</tr>
<tr>
<td>8. Develop new course offerings designed for a campus-wide audience.</td>
<td>While the majority of KI’s courses are open to students from across campus, INTEG210 Making Collaboration Work (first offering Fall 2018) is specifically designed for students outside of KI.</td>
<td>Associate Chair Undergrad</td>
<td>Complete. Course to be offered in Fall 2018.</td>
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<tr>
<td>9. Review the aims, title, and scope of the Museum Course. Consider placing the product of the Museum Course beyond the University.</td>
<td>A review of the four-course sequence suggests that the Museum Course is a key component of the program, is working well, and is a significant part of the program’s identity; we are unlikely to change the scope of it in the near future. We have, however, made several changes as a result of this review: removal of INTEG231 from the core and integration of salient parts into INTEG320; an increasing of 0.25 credit weight for museum sequence of courses; greater emphasis on the professional skills development present in the course; alignment of the exhibit topics with the UN Sustainable Development Goals, helping to create clearer links with ENV. We have developed and nurtured informal relationships with several museum design/science communication professionals (from, e.g., The Ontario Science Centre, the Design Exchange, THEMUSEUM, the Waterloo Regional Museum), who contribute their expertise to the course and provide feedback to students. We have also formalized a partnership with the City of Waterloo Museum, to showcase student work for the months of March-Jun each year, after the campus exhibition is done.</td>
<td>Museum Course instructor (who is also the current Department Chair)</td>
<td>Complete. The majority of the organizational changes will be effective Fall 2019.</td>
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| **10.** Enhance connections between KI and faculty across campus, as a way of increasing course offerings and understanding of the KI program. | Reviewers raise some interesting and novel suggestions for building community and connecting with faculty outside of KI. Some suggestions include “special designations,” and possible adjunct/cross-appointed status. We have also been considering some initiatives aimed at building community and connections both on campus as well as with the broader community, including a KI Teaching Fellow residency and creating a KI advisory board of UW faculty and other community partners. | Schweizer | Fall 2019 strike a working group to consider benefits and models  
Spring 2020 produce a recommendation report |
<p>| <strong>11.</strong> Consider offering Collaborative Design courses to new audiences, e.g., transition courses for students entering Waterloo, incoming graduate students. | The reviewers’ recommendation raises the possibility of repackaging many of the transferrable, professional skills education from the KI core into block courses or workshops for various audiences. If opportunities are identified and additional teaching resources can be secured, this is something KI could build. | Associate Chair Undergrad and KI ENV Graduate Studies Council representative | Fall 2019 Produce a report outlining opportunities, benefits, and costs |
| <strong>12.</strong> Encourage greater scholarship on the pedagogical impacts of “KI-thinking” and cognitive development among students. | There is great opportunity to study the impact of the KI education on the cognitive skills of our students, especially relative to their peers in the same courses that they take as electives. Gorbet and Plaisance are interested in taking this on as a SOTL research project. Plaisance is also studying the impact of INTEG210 on her students, which will provide a model for carrying | Various KI Faculty | Ongoing. |</p>
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<td>13. Investigate appropriate external metrics of program performance. Develop internal metrics of program performance and assess how these compare with institutional metrics.</td>
<td>A department committee will be struck to consider what is important to measure internally, and how best to capture those measures in the KI context. In addition, they will also survey external interdisciplinary rankings we should consider targeting (e.g., whether there are appropriate QS rankings).</td>
<td>Chair</td>
<td>2018/2019: This has been delayed but will be appropriate given the upcoming strategic planning being undertaken at the Faculty and University level.</td>
</tr>
<tr>
<td>14. Ensure that all cross-appointed faculty members are listed as such on the web pages of their departments of cross-appointment.</td>
<td>We will investigate this and, to the extent possible, arrange for appropriate representation on departments’ web sites.</td>
<td>Individual faculty members. Program Coordinator to follow up.</td>
<td>Complete.</td>
</tr>
<tr>
<td>15. Activity-based budgeting as a decision-making model should be limited to the Faculty level.</td>
<td>None. This recommendation is not ours to lead. We have conveyed the recommendation to the Dean.</td>
<td>Chair</td>
<td>Complete.</td>
</tr>
<tr>
<td>16. Consider developing a more effective and transparent financial modelling system for the MAD facilities. Extend the capabilities of</td>
<td>The Chair will communicate this support, along with the reviewers’ recommendations, to the Director of MAD.</td>
<td>Chair</td>
<td>Complete.</td>
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<tr>
<td><strong>17.</strong> The University should codify KI’s model of expectations and support frameworks for interdisciplinary cross-appointments.</td>
<td>The Chair will share this recommendation at the University level.</td>
<td>Chair</td>
<td>Complete.</td>
</tr>
<tr>
<td><strong>18.</strong> Consider ways to provide very high level scholarships for KI students as a competitive recruitment tool.</td>
<td>We continue to seek more scholarships, and steward relationships with our donors.</td>
<td>Environment Director of Advancement</td>
<td>ongoing</td>
</tr>
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</table>

The Department Chair/Director, in consultation with the Dean of the Faculty shall be responsible for monitoring the Implementation Plan.
Date of next program review: 2022-2023

Signatures of Approval:

Chair/Director

AFIW Administrative Dean/Head (For AFIW programs only)

N/A.

Faculty Dean

August 22, 2018

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

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

To: Rebecca Wickens, Associate University Secretary  
CC: Chris Read, Associate Provost, Students  
     Ian Rowlands, Associate Vice-President, International  
From: Pam Charbonneau, Director, Student Success  
       Sacha Geer, Manager, International Mobility and Intercultural Learning, Student Success  
Date: November 26 2018  

Re: Amendments to the Global Experience Certificate Program

After an assessment of the program, including an analysis of student feedback, a review of literature (competencies, pedagogy), and a comparative study of industry practices in similar certificates/programs, the following recommendations are being presented:

1) The GEC currently requires all International Experiences and Cross-Cultural Volunteer Experiences to be approved by program staff at the time of or after enrollment in the GEC and before they have been undertaken by the student. This is done so that the opportunities are vetted in advance to ensure acceptability of the opportunity.

   We propose that the academic calendar be amended so that some International Experiences and Cross-Cultural Volunteer Experiences (listed on the GEC website) can be completed prior to enrollment in the GEC. For example, a student who goes on international exchange or on an international co-op term and subsequently applies for the GEC may have these experiences counted as an International Experience requirement. Similarly, we propose that a list of Cross-Cultural Volunteer Experiences, such as participation in the SSO’s International Peer Community or Renison’s Conversation Partner’s program, can be completed in advance of applying. Allowing retroactive credit for these particular types of opportunities will increase the ability for a greater number of UW students to obtain a Global Experience Certificate. To ensure suitability for the program all International Experiences and Cross Cultural Volunteer experiences not listed on the GEC website must be approved in writing by GEC program staff in writing in advance in order to be considered.

2. The Academic Calendar currently notes: “Academic discipline is handled by the associate vice-president international or designate in consultation with the associate dean for the student’s home faculty. A discipline decision is appealable under Policy 72- Student Appeals provided that grounds for appeal can be established.” After consultation with the Associate Vice President, International, we propose that this section be struck and
that Academic discipline will remain the purview of the relevant Associate Dean within the student’s faculty.

3. The academic calendar currently states that students are required to submit a one page reflection summary upon completion of their Cross Cultural Volunteer Experience. We propose to amend this to require that students complete a more broadly defined and academically rigorous guided reflection assignment based on either the Cross Cultural Volunteer Experience or their International Experience. A range of pedagogically sound submission types (e.g. written piece, photo journal, short video) of roughly equal effort will be outlined on the program’s web page with guidelines for each.

4. The current course language requirement stipulates that students must take “two first-year sequential language courses (other than the applicant's native language or a language in which they are fluent).” We propose removing the requirement that these courses be first year to allow for students who have some facility in multiple languages to take more advanced courses that can count towards their certificate. The language should be amended to “two sequential language courses (other than applicant's native language or a language in which they are fluent).”

Summary of Recommendations to be approved by Senate Undergraduate Council:
1) a list of pre-vetted International Experiences and Cross-Cultural Volunteer Experiences may be considered retroactively as milestones for the GEC;
2) that reference to the Associate Vice President International as the individual responsible for academic discipline related to the Global Experience Certificate be removed from the academic calendar and other materials;
3) that students be required to complete a short guided reflective assignment on their International Experience or Cross-Cultural Volunteer Experience;
4) that the language requirement for the Global Experience Certificate be amended to remove the condition that the two sequential language courses be at first-year level.
**Recognition and Commendation**

The University of Waterloo has been recognized as Canada’s most innovative university by Maclean’s magazine for the 27th consecutive year. It also named Waterloo 2nd place in the ‘best overall’ and ‘leaders of tomorrow’ reputation categories and 3rd place among comprehensive universities in Canada. (adapted from the *Daily Bulletin* 12 October 2018)

St. Paul's GreenHouse, in partnership with the Murray Alzheimer Research and Education Program and the Faculty of Applied Health Sciences, hosted Hack4Health 4.0, alongside the MS Society and the Alzheimer Society. Winners for the Best Potential for Impact category were **HotStop**, a team focused on empowering and supporting individuals living with mild to moderate dementia to cook both independently and safely in their homes. Winners for the Best Problem-Solution Fit category were **BakeDem**, a team who focused on using a baking social media app to tackle social isolation and withdrawal from social activities for those living with mild to moderate dementia. (adapted from the *Daily Bulletin* 18 October 2018)

Peter Huck, a civil and environmental engineering professor and Industrial Research Chair in Water Treatment, was recently awarded more than $3 million to continue his research program at the University of Waterloo. As part of the Natural Sciences and Engineering Research Council of Canada (NSERC) Industrial Research Chair (IRC) program, Huck leads a group of researchers, graduate students and postdoctoral fellows addressing challenges in water treatment and supply. (adapted from the *Daily Bulletin* 22 October 2018)

For the third year in a row, the University of Waterloo was named one of Canada’s Top 100 Employers through a survey conducted by MediaCorp Canada. The official announcement was published in the national edition of the Globe and Mail on November 9, 2018. (adapted from the *Daily Bulletin* 9 November 2018)

Waterloo’s international co-op team has won two Excellence Awards from the Canadian Bureau for International Education (CBIE). The North Star Award was presented to Shabnam Ivkovic, Team Manager, International Mobility. This is awarded to a new professional who has shown extraordinary promise in the field of international education. The Panorama Award was given to Waterloo’s international co-op team in recognition for their innovation and excellence in design, planning, implementation and management of high-quality endeavours in international education, with programming that focuses on academic, extracurricular, capacity building and/or learning abroad.

The ten Panorama Award recipients from the University of Waterloo are:

- **Bettina Wahl**, International Employment Specialist
- **Cathy Stein**, International Employment Specialist
- **Celeste Horne**, Student Advisor
- **Gail Tymchuk**, Account Manager
Cheriton School of Computer Science Professor Srinivasan Keshav has been named by the Institute of Electrical and Electronics Engineers as an IEEE Fellow for his contributions to fair queueing techniques and flow-control algorithms in computer networks. (adapted from the Daily Bulletin 23 November 2018)

The Velocity Fund Finals were held on November 27, 2018 in the Student Life Centre. The four companies awarded the top $25,000 prizes were: Brink Bionics, which is developing bionic arms for amputees that use machine learning to seamlessly integrate with the human body; CataLight, which is making safe drinking water accessible for all with a new water treatment solution; Pulse Industrial, which is developing a smart monitoring system for steam traps to improve safety and reduce CO2 emissions and Membio, which is developing a scalable biological manufacturing platform. The $10K prize was awarded to startup Intelline, to help with the additional hardware costs associated with the development of their scalable cryocoolers. These startups will also receive $5,000 in IP legal services from PCK, mentorship, coaching, and workspace in the Velocity Garage, Canada’s most productive startup incubator.

The teams awarded $5K in seed money were: Material Futures Lab, which uses bacteria to create natural eco-friendly pigments for textile dyeing; Oleotech, which uses oleophilic properties of fiber from waste tires to remove hydrocarbons in stormwater runoff; FEM in STEM, which is empowering young women to develop careers in underrepresented industries through programming and resources; and PriveHealth, which is developing a gamified cybersecurity training platform for healthcare professionals. Each of the $5K winners also receives an offer to live in a residence at a discounted rate, offered in partnership with Waterloo Residences. (adapted from a Velocity news story 27 November 2018)

The President’s Community Impact Awards were presented on December 13, 2018 at the President’s annual Holiday Dinner. Awards were given to:

Community Leaders
Michael Beazely, Professor, School of Pharmacy
Mike has contributed to the Waterloo Region Crime Prevention Council and has been involved with the Waterloo Region Integrated Drug Strategy (WRIDS) since its inception. As chair of the WRIDS since 2017, Mike’s leadership has contributed to prevention resources, partnerships with school boards and the Waterloo Region Local Health Integration Network, and promotion of student volunteer engagement in this critical community issue.

Robin Mazumber, PhD candidate, cognitive neuroscience
Robin has served on the City of Kitchener Cycling & Trails Advisory Committee and as Guest Librarian to the Kitchener Public Library in 2016. He partnered with the Waterloo Region Local Health Integration Network and the Kitchener Downtown Community Health Centre to make light therapy lamps available at all KPL locations and to the Waterloo campus.

University Leaders

Sustainable Waterloo Region
Sustainable Waterloo Region (SWR) programs such as TravelWise and the Regional Sustainability Initiative have helped shape the University of Waterloo’s sustainability strategy, which was recognized with a SWR Breakthrough award in spring 2018. A unique partnership between SWR, the Cora Group, EY Canada and the University’s David Johnston Research & Technology Park (R&T Park) led to the opening of Canada’s first net-positive multi-tenant building in the R&T Park this fall. Many UWaterloo students and faculty are SWR volunteers.

Volunteer Action Centre Waterloo Region
In 2014, the Volunteer Action Centre Waterloo Region (VACWR) began a formal partnership with the University’s Federation of Students (FEDS), leading to the launch of the FEDS Volunteer Centre one year later. To date, the online volunteer database has made more than 2,000 meaningful community connections for Waterloo students, as well as staff and faculty. VACWR is a regular participant at our biannual campus Volunteer Fairs, and have also partnered with the University’s Centre for Career Action, St. Paul’s Greenhouse, and the First Year Engineering Leadership conference.

(adapted from the Daily Bulletin 14 December 2018)

The Association for the Advancement of Sustainability in Higher Education (AASHE) has given the University of Waterloo a Silver rating on the Sustainability Tracking, Assessment, and Rating System (STARS). The rating recognizes Waterloo’s progress and actions across academics, campus operations, community engagement and campus planning and governance as it relates to sustainability efforts.

(adapted from the Daily Bulletin 17 December 2018)
A. APPOINTMENTS

**Definite Term Research Appointment**
Van OOTEGHEM, Karen, Research Assistant Professor, Department of Kinesiology, September 1, 2018 – August 31, 2022. [BSC, 1999, University of Waterloo, PhD, 2009, University of Waterloo, Postdoctoral fellow, 2013, University of Waterloo, Postdoctoral fellow, 2010 to present, University of Waterloo]. Dr. Van Ooteghem will conduct research associated with ONDRI@Home project under the supervision of Professor McIlroy.

**Visiting Appointments**
XIAO, Honggen, Visiting Researcher, Department of Recreation and Leisure Studies, January 1, 2019 – April 30, 2019.

WANG, Baoheng, Visiting Scholar, Department of Recreation and Leisure Studies, April 10, 2019 – April 9, 2020.

**Adjunct Appointments**
**Graduate Supervision**
KAAI, Susan, Assistant Professor, School of Public Health and Health Systems, January 1, 2019 – December 31, 2021.

**Adjunct Reappointments**
**Graduate Supervision and Research**
COSTELLO, Mary Jean, Assistant Professor, School of Public Health and Health Systems, February 1, 2019 – January 31, 2021.

PREMJI, Stephanie, Associate Professor, School of Public Health and Health Systems, March 1, 2019 – April 30, 2020.

**Graduate Supervision**
GARNER, Rochelle, Assistant Professor, School of Public Health and Health Systems, January 1, 2019 – December 31, 2019.

**Special Appointments**
**Undergraduate Instruction**
GRiffin, Janet, Instructor, Department of Recreation and Leisure Studies, January 1, 2019 – April 30, 2019.

**Graduate Instruction**
CUERDEN KNIGHT, Meaghan, Lecturer, School of Public Health and Health Systems, January 1, 2019 – April 30, 2019.

MOSTAFAPOUR, Mehrnaz, Lecturer, School of Public Health and Health Systems, January 1, 2019 – April 30, 2019.
Postdoctoral Appointments
ALENABI, Seyedeh Talia, Department of Kinesiology, September 1, 2018 – August 31, 2019.

KING, Emily, Department of Kinesiology, December 1, 2018 – November 30, 2021.

MARRIOTT, Kendal, Department of Kinesiology, January 1, 2019 – December 31, 2019.

B. RETIREMENT
HAVITZ, Mark, Professor, Department of Recreation and Leisure Studies, March 1, 2019.

C. SABBATICAL
For approval by the Board of Governors
QUADRILATERO, Joseph, Associate Professor, Department of Kinesiology, July 1, 2019 – December 31, 2019, six months at full salary.

Paul Stolee, Interim Dean
Faculty of Applied Health Sciences
UNIVERSITY OF WATERLOO
REPORT OF THE DEAN OF THE FACULTY OF ARTS TO SENATE
January 21, 2019

FOR INFORMATION

A. APPOINTMENTS
Adjunct Reappointments – Instruction
HUTCHISON, Jesse, Lecturer, Department of English Language and Literature, January 1, 2019 to April 30, 2019.

LOCK-O’CONNOR, Kaylee, Lecturer, Department of Communication Arts, January 1, 2019 to April 30, 2019.

MELNYKEVYCH, Viktoria, Lecturer, Department of Germanic and Slavic Studies, January 1, 2019 to April 30, 2019.

NICKERSON-WHITE, Sara Jane, Lecturer, Department of Sociology and Legal Studies, January 1, 2019 to April 30, 2019.

PLOWMAN, Robert, Lecturer, Department of Communication Arts, January 1, 2019 to April 30, 2019.

REDDOCK, Jennifer, Lecturer, Department of Communication Arts, January 1, 2019 to April 30, 2019.

ROSSITER, Simon, Lecturer, Department of Communication Arts, January 1, 2019 to April 30, 2019.

SCHWEITZER, David, Lecturer, Department of History, January 1, 2019 to April 30, 2019.

SILK, Matthew, Lecturer, Department of Philosophy, January 1, 2019 to April 30, 2019.

Staff Appointments to Faculty
RAINVILLE, Janelle, Lecturer, Department of Communication Arts, January 1, 2019 to April 30, 2019.

Douglas M. Peers
Dean, Faculty of Arts
FOR INFORMATION

A. APPOINTMENTS

Probationary Term

PAN, Zhao, Assistant Professor, Department of Mechanical and Mechatronics Engineering, August 1, 2019 – June 30, 2022. PhD Brigham Young University, Provo, UT, 2016; MS University of Louisiana, Lafayette, LA, 2012, BA, Jilin University, Changchun, China, 2009. Dr. Zhao Pan’s research is in the area of error propagation dynamics of PIV-based pressure calculations in experimental flow diagnostics. He is currently a postdoctoral fellow with Prof. Tadd Truscott and Prof. Barton Smith at Utah State University. He joins the Fluid Mechanics research group in support of the undergraduate Mechatronics program expansion.

WU, Yimin, Assistant Professor, Department of Mechanical and Mechatronics Engineering, July 1, 2019 – June 30, 2022. PhD University of Oxford, Oxford, UK, 2013; BASc Wuhan University of Technology, Wuhan, P.R. China, 2008. Dr. Yimin Wu’s research interests are in energy materials, functional electronics and optical materials from synthesis to device fabrication, and advanced structural characterization using aberration corrected transmission electron microscopy, in situ environmental transmission electron microscopy and scanning X-ray microscopy. He was a postdoctoral fellow at the University of California, Berkeley and Lawrence Berkeley National Laboratory. He is currently a postdoctoral fellow at the Center for Nanoscale Materials at Argonne National Laboratory. He joins the Materials research group following the retirement of Prof. Robert Varin last year.

New Definite Term- full-time

IBRAHIM, Nadine, Lecturer, Department of Civil & Environmental Engineering, January 1, 2019 – December 31, 2021. PhD University of Toronto 2015; MASc University of Toronto 2003; BASc University of Toronto 2000. Nadine will be leading a thrust in urban engineering in the department as holder of the Turkstra Chair that will motivate and educate our students to engage directly in the key urban challenges facing us today, including mobility, sustainability, and equity of access to services and facilities

New Definite Term Reappointment- full-time

NEZHAVAD-AHMADI, Mohammad-Reza, Research Assistant Professor, Department of Electrical & Computer Engineering, October 1, 2018 – April 30, 2019.

Visiting Appointments

ALLEN, Evelyn, Scholar, Department of Chemical Engineering, November 1, 2018 – May 31, 2021.


DATTANI, Nike, Researcher, Department of Electrical & Computer Engineering, October 9, 2018 – October 15, 2019.


HAIDO, James, Researcher, Department of Civil & Environmental Engineering, June 1, 2019 – May 31, 2020.

LI, Xu, Researcher, Department of Chemical Engineering, December 3, 2018 – April 23, 2019.

LIU, Haitao, Researcher, Department of Chemical Engineering, December 2, 2018 – April 23, 2019.

LIU, Youlin, Scholar, Department of Chemical Engineering, November 7, 2018 – November 1, 2019.


MOUSAVI, Seyyed Jamshid, Professor, Department of Electrical & Computer Engineering, November 1, 2018 – October 31, 2019.

SHARIF, Farhad, Associate Professor, Department of Chemical Engineering, November 14, 2018 – July 30, 2019.


Visiting Reappointments
SHAKIR, Ammar Mahmood, Researcher, Department of Civil & Environmental Engineering, November 1, 2018 – October 31, 2019.

Special Appointments
Undergraduate Instruction
AMELARD, Robert, Lecturer, Department of Systems Design Engineering, January 1, 2019 – April 30, 2019.
ARIAS, Juan F., Lecturer, Department of Civil & Environmental Engineering, January 1, 2019 – April 30, 2019.

BARRAGE, Ryan, Lecturer, Department of Civil & Environmental Engineering, January 1, 2019 – April 30, 2019.

BOOTH, Kyle, Lecturer, Department of Management Sciences, January 1, 2019 – April 30, 2019.

BYSKAL, Daniel, Lecturer, Department of Civil & Environmental Engineering, January 1, 2019 – April 30, 2019.

DE CARVALHO, Paulo, Lecturer, Department of Management Sciences, January 1, 2019 – April 30, 2019.

HE, Jiayuan, Lecturer, Department of Systems Design Engineering, January 1, 2019 – April 30, 2019.

JOHNSON, Erin, Lecturer, Department of Chemical Engineering, January 1, 2019 – April 30, 2019.

REID, Robertson, Lecturer, Department of Civil & Environmental Engineering, January 1, 2019 – April 30, 2019.

ROH, Patrick, Lecturer, Department of Management Sciences, January 1, 2019 – April 30, 2019.

TERRY, Jacob, Lecturer, Department of Civil & Environmental Engineering, January 1, 2019 – April 30, 2019.

Special Appointments
Graduation Instruction

AMAR, Haitham, Lecturer, Department of Electrical & Computer Engineering, January 1, 2019 – April 30, 2019.

ELKADRI, Chadi, Lecturer, Department of Management Sciences, January 1, 2019 – April 20, 2019.

IZADPANAH, Pedram, Lecturer, Department of Civil & Environmental Engineering, January 1, 2019 – April 30, 2019.

Special Reappointments
Undergraduate Instruction

ALZAYAT, Ayman, Lecturer, Department of Management Sciences, January 1, 2019 – April 30, 2019.

Special Reappointments
Graduate Instruction

ALLARAKHIA, Minna, Lecturer, Department of Management Sciences, January 1, 2019 – April 30, 2019.
Adjunct Appointments
Graduate Supervision and Research
ALARAKHIA, Mohamed, Assistant Professor, Department of Systems Design Engineering, November 15, 2017 – November 14, 2020.

BANISTER, Carsen, Assistant Professor, Department of Mechanical & Mechatronics Engineering, October 10, 2017 – October 9, 2020.

IZADPANAH, Pedram, Assistant Professor, Department of Civil & Environmental Engineering, January 1, 2019 – December 21, 2021.

NANTEL, Julie, Associate Professor, Department of Systems Design Engineering, November 1, 2018 – October 31, 2021.

Adjunct Appointments
Graduate Supervision
DICKSON, Sarah, Associate Professor, Department of Civil & Environmental Engineering, May 1, 2019 – August 31, 2021.

Adjunct Appointments
Graduate Supervision and Research
FAHMI, Mohamed, Assistant Professor, Department of Electrical & Computer Engineering, November 1, 2018 – October 31, 2021.

KARBASI, Hamidreza, Assistant Professor, Department of Mechanical & Mechatronics Engineering, November 1, 2018 – October 31, 2021.

LEVESQUE, Julie, Assistant Professor, Department of Mechanical & Mechatronics Engineering, October 1, 2018 – September 30, 2021.

NARAYAN, Apurva, Assistant Professor, Department of System Design Engineering, October 1, 2018 – September 30, 2021.

SOLTANI, Madjid, Assistant Professor, Department of Electrical & Computer Engineering, November 1, 2018 – October 31, 2021.

WELLS, Mary, Professor, Department of Mechanical & Mechatronics Engineering, November 1, 2018 – October 31, 2021.

Adjunct Appointments
Research
KHANIYEV, Taghi, Assistant Professor, Department of Management Sciences, November 1, 2018 – October 31, 2021.

Adjunct Reappointments
Research and Graduate Supervision
ROTHENBURG, Leo, Professor, Department of Civil & Environmental Engineering, November 1, 2019 – October 31, 2021.

RYDER, Noah, Assistant Professor, Department of Mechanical & Mechatronics Engineering, October 15, 2018 – October 14, 2021.
SHARMA, Jitendrapal, Professor, Department of Civil & Environmental Engineering, April 1, 2017 – March 31, 2020.

TAO, Ye, Assistant Professor, Department of Chemical Engineering, January 1, 2019 – December 31, 2020.

WASYLYSHYN, Dwayne, Assistant Professor, Department of Chemical Engineering, November 1, 2018 – October 31, 2021.

Cross Appointments
BAUGH, Jonathan, Associate Professor, Department of Chemistry, Faculty of Science to Department of Electrical & Computer Engineering, December 1, 2018 – November 30, 2021.

Changes in Appointments
CASCANTE, Giovanni, Administrative Appointment, Associate Chair, Graduate Studies, Department of Civil & Environmental Engineering was July 1, 2016 – June 30, 2019 changed to July 1, 2016 – April 30, 2019.

B. ADMINISTRATIVE APPOINTMENTS
GRACIE, Robert, Associate Chair Graduate Studies, Department of Civil & Environmental Engineering, May 1, 2019 – April 30, 2020.

ADMINISTRATIVE REAPPOINTMENTS
EL-SHATSHAT, Ramadan, Director, Electrical Power Engineering Program, Department of Electrical & Computer Engineering, September 1, 2018 – August 31, 2021.

C. RESIGNATIONS
WELLS, Mary, Professor, Department of Mechanical & Mechatronics Engineering, October 31, 2018.

D. DEATHS
REMPLE, Garry, Professor, Department of Chemical Engineering, November 2, 2018.

FOR APPROVAL BY THE BOARD OF GOVERNORS

E. SABBATICAL
ALUMUR ALEV, Sibel, Assistant Professor, Department of Management Sciences, May 1, 2019 – October 31, 2019, six months at 100% salary.

Pearl Sullivan
Dean, Faculty of Engineering
FOR INFORMATION

A. APPOINTMENTS

Adjunct Appointments

Graduate Supervision

DICKINSON, Brock, Entrepreneur-in-Residence, Faculty of Environment, October 1, 2018 to September 30, 2019.

LETOURNEAU, Marcus, Assistant Professor, School of Planning, September 1, 2018 to August 31, 2019.

ORDONEZ-PONCE, Eduardo, Assistant Professor, School of Environment, Enterprise and Development, November 1, 2018 to December 31, 2019.

XU, Bin, Assistant Professor, Department of Geography and Environmental Management, December 1, 2018 to December 31, 2022.

Graduate Supervision and Research

AMARAL, Valter, Assistant Professor, School of Environment, Resources and Sustainability, January 1, 2019 to December 31, 2020.

COWAN, Don, Professor, School of Environment, Resources and Sustainability, January 1, 2019 to December 31, 2021.

Research

YATES, Colin, Assistant Professor, School of Environment, Resources and Sustainability, January 1, 2019 to December 31, 2021.

Special Appointments

Instruction

CERVENAN, Amy, Lecturer, School of Environment, Enterprise and Development, January 1, 2019 to April 30, 2019.

CORDONIER SEGGER, Marie-Claire, Lecturer, School of Environment, Enterprise and Development, November 1, 2018 to December 31, 2018.

DICKINSON, Brock, Lecturer, School of Environment, Enterprise and Development, January 1, 2019 to April 30, 2019.

JACKSON, John, Lecturer, School of Environment, Resources and Sustainability, January 1, 2019 to April 30, 2019.

NG, Garrick, Lecturer, School of Environment, Enterprise and Development, January 1, 2019 to April 30, 2019.

SARKANY, Laszlo, Lecturer, School of Environment, Enterprise and Development, January 1, 2019 to April 30, 2019.

STIRBET, Hari, Lecturer, School of Environment, Enterprise and Development, January 1, 2019 to April 30, 2019.
SWERDFAGER, Trevor, Lecturer, Department of Geography and Environmental Management, January 1, 2019 to April 30, 2019.

Cross Appointments
GRIMWOOD, Bryan, Associate Professor, Recreation and Leisure Studies, Faculty of Applied Health Sciences to the School of Environment, Resources and Sustainability, January 1, 2019 to December 31, 2021.

HOMER-DIXON, Thomas, Professor, Faculty of Environment to the School of Environment, Resources and Sustainability, January 1, 2019 to December 31, 2020.

McLEVEY, John, Assistant Professor, Department of Knowledge Integration to the School of Environment, Resources and Sustainability, January 1, 2019 to June 30, 2019.

SCHWEIZER, Vanessa, Assistant Professor, Department of Knowledge Integration to the School of Environment, Resources and Sustainability, January 1, 2019 to June 30, 2020.

Graduate Students Appointed as Part-Time Lecturer
COOK, Julie, School of Environment, Enterprise and Development, January 1, 2019 to April 30, 2019.

CRAY, Heather, Faculty of Environment, January 1, 2019 to April 30, 2019.

RISHWORTH, Andrea, Department of Geography and Environmental Management, January 1, 2019 to April 30, 2019.

B. SABBATICAL LEAVES
For Approval by the Board of Governors
CLAPP, Jennifer, Professor, School of Environment, Resources and Sustainability, July 1, 2019 to June 30, 2020, at 100% salary.

WORTH, Nancy, Assistant Professor, Department of Geography and Environmental Management, July 1, 2019 to December 31, 2019, at 100% salary.
FOR INFORMATION

A. APPOINTMENTS (for approval by the Board of Governors)

Probationary-Term Reappointments

NAGAPPAN, Meiyappan, Assistant Professor, David R. Cheriton School of Computer Science, July 1, 2019 – June 30, 2022.

SALIHOGLU, Semih, Assistant Professor, David R. Cheriton School of Computer Science, July 1, 2019 – June 30, 2022.

Definite Term - Appointments

LANCTOT, Kevin (BSc, 1984; MSc, 1990, Carleton University; PhD, 2000, University of Waterloo), Lecturer, David R. Cheriton School of Computer Science, September 1, 2018 – August 31, 2019. Dr. Lanctot will teach six courses per year, as assigned by the Director of Undergraduate Studies and be assigned service tasks as required.

SHARMA, Puneet (BSc, 1998, Guru Nanak Dev University; MSc, 2001, Panjab University; PhD, 2015, University of Waterloo), Lecturer, Dept. of Applied Mathematics, September 1, 2018 – August 31, 2019. Dr. Sharma’s duties will be to teach six undergraduate courses and conduct service duties as required.

Definite Term - Reappointments

NEKRITCH, Iakov, Research Assistant Professor, David R. Cheriton School of Computer Science, March 1, 2019 – February 28, 2022.

PEI, Martin, Lecturer, Dept. of Combinatorics and Optimization, December 31, 2018 – August 31, 2020.

Visiting Appointments


THOMASSEN, Carsten (Aarhus University), Dept. of Combinatorics and Optimization, September 1, 2019 – December 31, 2019.

XU, Ning (National University of Defense Technology), Scholar, November 1, 2018 – April 30, 2020.
Adjunct Appointments
Research
DiCICCIO, Vic, Adjunct Professor, David R. Cheriton School of Computer Science, January 1, 2019 – June 30, 2022.

SCOTT, Stacey (University of Guelph), Associate Professor, David R. Cheriton School of Computer Science, November 1, 2018 – June 30, 2022.

Adjunct Reappointments
Instructor
ALI, Javid, Lecturer, Dept. of Statistics and Actuarial Science, January 1, 2019 – April 30, 2019.

BAER, Jeffrey, Lecturer, Dept. of Statistics and Actuarial Science, January 1, 2019 – April 30, 2019.

BROWN, Janice, Lecturer, David R. Cheriton School of Computer Science, January 1, 2019 – April 30, 2019.

GHORBANI, Mohboobeh, Lecturer, David R. Cheriton School of Computer Science, January 1, 2019 – April 30, 2019.


HARRIS, Samuel, Lecturer, Dept. of Pure Mathematics, January 1, 2019 – April 30, 2019.

ISTEAD, Joe, Lecturer, David R. Cheriton School of Computer Science, January 1, 2019 – April 30, 2019.


McLEISH, Don, Lecturer, Dept. of Statistics and Actuarial Science, January 1, 2019 – April 30, 2019.

ROEGIEST, Adam, Lecturer, David R. Cheriton School of Computer Science, January 1, 2019 – April 30, 2019.


WEHBE, Rina, Lecturer, David R. Cheriton School of Computer Science, January 1, 2019 – April 30, 2019.

Research
BRZOZOWSKI, Janusz, Professor Emeritus, David R. Cheriton School of Computer Science, July 1, 2018 – June 30, 2021.

Graduate Students appointed as Part-time Lecturers

Graduate Students reappointed as Part-time Lecturers


TONDELLO, Gustavo Fortes, David R. Cheriton School of Computer Science, January 1, 2019 – April 30, 2019.

Postdoctoral Fellow reappointed as part-time Lecturers

ROY, Quentin, David R. Cheriton School of Computer Science, March 19, 2019 – August 13, 2020.

A.1 Change
BELTAOS, Andrew, Lecturer, Office of the Dean, (ref. Dean’s Report to Senate, May 2018)
From: August 29, 2018 – August 27, 2020
To: September 1, 2018 – August 31, 2021

DAWOUD, Dina, Lecturer, Dept. of Statistics and Actuarial Science (ref. Dean’s Report to Senate, March, 2017)
From: April 28, 2017 – April 26, 2019
To: September 1, 2018 – August 31, 2021

NAGAPPAN, Meiyappan, Assistant Professor, David R. Cheriton School of Computer Science (ref. Dean’s Report to Senate, September, 2016)
From: September 1, 2016 – June 30, 2020
To: September 1, 2016 – June 30, 2019

SPEZIALE, Sean, Lecturer, Office of the Dean, (ref. Dean’s Report to Senate, May 2018)
From: August 29, 2018 – August 27, 2020
To: September 1, 2018 – August 31, 2021
B. ADMINISTRATIVE APPOINTMENTS
CSIMA, Barbara, Associate Chair, Graduate Studies, Dept. of Pure Mathematics, July 1, 2019 –
June 30, 2022.
LYSY, Martin, Director, Statistical Consulting & Collaborative Research Unit, September 1,
CHENOURI, Shoja, Statistical Consulting & Collaborative Research Unit, March 1, 2019 –
August 31, 2019.

C. RESIGNATIONS
HAN, Peisong, Assistant Professor, Dept. of Statistics and Actuarial Science, effective December
31, 2018.
KATSURAGAWA, Keiko, Research Assistant Professor, David R. Cheriton School of
Computer Science, effective November 2, 2018.

D. RETIREMENT
STRUTHERS, Cynthia, Associate Professor, Dept. of Statistics and Actuarial Science, effective
December 31, 2018.

E. SABBATICALS (for approval by the Board of Governors)
KARIGIANNIS, Spiro, Associate Professor, Dept. of Pure Mathematics, July 1, 2019 –
December 31, 2019, with 85% salary.
LYSY, Martin, Associate Professor, Dept. of Statistics and Actuarial Science, March 1, 2019 –
August 31, 2019, with 85% salary.

(already approval by the Board of Governors)
SANITA, Laura, Associate Professor, Dept. of Combinatorics and Optimization, March 1, 2019
– February 29, 2020, with 94.7% salary.
WAITE, Michael, Associate Professor, Dept. of Applied Mathematics, January 1, 2019 – June
30, 2019, with 100% salary.

F. SPECIAL LEAVE
GORBUNOV, Sergey, Assistant Professor, David R. Cheriton School of Computer Science,
January 15, 2019 – Aug 31, 2019. This is an unpaid leave.

Stephen M. Watt
Dean
For information:

A. APPOINTMENTS

Adjunct Appointments

Graduate Supervision

CHIANG ROJAS, Gustavo, Professor, Department of Biology, December 1, 2018 to November 30, 2021.

KIDD, Karen, Professor, Department of Biology, November 1, 2018 to December 31, 2020.

Research

BEHRAVAN, Javad, Professor, School of Pharmacy, November 1, 2018 to October 30, 2021.

Undergraduate Instruction

TARIO, Allison, Assistant Professor, School of Pharmacy, January 1, 2019 to December 31, 2019.

WONG, Jeffrey, Assistant Professor, School of Pharmacy, January 1, 2019 to December 31, 2020.

Graduate Supervision and Research

LANG, Dustin, Assistant Professor, Department of Physics and Astronomy, September 1, 2018 to August 31, 2023.

WANG, Chong, Assistant Professor, Department of Physics and Astronomy, September 1, 2018 to August 31, 2023.

Graduate Supervision and Graduate Instruction

JUURLINK, David, Professor, School of Pharmacy, November 1, 2018 to October 31, 2021.

SCHWAN, Adrian, Professor, School of Pharmacy, November 1, 2018 to October 31, 2021.

Research and Other

MILNE, Emily, Assistant Professor, School of Pharmacy, November 1, 2018 to October 31, 2021.
Adjunct Reappointments

Graduate Supervision

CONANT, Brewster Jr., Associate Professor, Department of Earth and Environmental Sciences, March 1, 2018 to February 20, 2021.

LEHNHERR, Igor, Assistant Professor, Department of Earth and Environmental Sciences, November 1, 2018 to October 31, 2021.

LIMA, Ana, Assistant Professor, Department of Earth and Environmental Sciences, October 1, 2018 to September 30, 2021.

PARKIN, Gary, Professor, Department of Earth and Environmental Sciences, September 1, 2018 to August 31, 2021.

PEHME, Peeter, Assistant Professor, Department of Earth and Environmental Sciences, October 1, 2018 to September 30, 2021.

Research

BASKERVILLE, N. Bruce, Associate Professor, School of Pharmacy, October 1, 2018 to June 30, 2024.

Undergraduate Instruction

DHAMI, Rita, Assistant Professor, School of Pharmacy, January 1, 2019 to December 31, 2019.

Graduate Supervision and Research

DEMPSON, Brian, Assistant Professor, Department of Biology, January 1, 2018 to December 31, 2021.

Graduate Supervision, Graduate Instruction and Research

VAN CAUWENBERGHE, Owen, Assistant Professor, School of Pharmacy, January 1, 2019 to December 31, 2021.

Cross Appointments

IGBOELI, Okechukwu (Okey), Lecturer, Dean of Science Office, cross appointed to School of Pharmacy, December 1, 2018 to November 30, 2021.

WONG, Alexander, Associate Professor, Department of Systems Design Engineering, cross appointed to School of Optometry and Vision Science, November 1, 2018 to October 31, 2021.
Cross Reappointments

ABUKHDEIR, Nasser Mohieddin, Associate Professor, Department of Chemical Engineering, cross appointed to Department of Physics and Astronomy, September 1, 2018 to August 31, 2021.

GIRELLI, Florian, Associate Professor, Department of Applied Mathematics, cross appointed to Department of Physics and Astronomy, September 1, 2018 to August 31, 2021.

MORARU, Ruxandra, Associate Professor, Department of Applied Mathematics, cross appointed to Department of Physics and Astronomy, September 1, 2018 to August 31, 2021.

POPE, Michael, Assistant Professor, Department of Chemical Engineering, cross appointed to Department of Chemistry, September 1, 2018 to August 31, 2021.

TAM, Michael, Professor, Department of Chemical Engineering, cross appointed to Department of Chemistry, September 1, 2018 to August 31, 2021.

Special Appointment

Undergraduate Instruction

BUTT, Kristi, Lecturer, School of Pharmacy, January 1, 2019 to April 30, 2019.

MICHAUD, Wendy K., Lecturer, Department of Biology, January 1, 2019 to April 30, 2019.

Special Reappointment

Undergraduate Instruction

BEATTIE, Laura, Lecturer, School of Pharmacy, September 1, 2018 to December 31, 2018.

PFISTERER, Steve, Lecturer, Department of Physics and Astronomy, January 1, 2019 to April 30, 2019.

SINGH, Arvind, Lecturer, School of Pharmacy, January 1, 2019 to April 30, 2019.

B. ADMINISTRATIVE REAPPOINTMENTS

DUPONT, Christine, Interim Associate Chair, Undergraduate Studies, Department of Biology, September 1, 2018 to December 31, 2018.
FOR APPROVAL BY THE BOARD OF GOVERNORS

C. SABBATICALS

WARNER, Barry, Professor, Department of Earth and Environmental Sciences, Administrative four for four exchange, May 1, 2019 to August 31, 2019, 100% salary arrangement; Special Leave to Retirement, September 1, 2019 to August 31, 2020, 100% salary arrangement.

R.P. Lemieux
Dean of Science
FOR APPROVAL

Senate Committee Appointments

Motion: To approve the following appointment:

- **Senate Undergraduate Council**: Vivian Dayeh, Department of Biology (replacing Carey Bissonnette) as representative from the Faculty of Science, term to 30 April 2020
Senate Graduate & Research Council met on 14 January 2019 and considered a proposal to establish two new graduate programs. Council agreed to forward the following items to Senate for approval as part of the regular agenda.

Further details are available at: https://uwaterloo.ca/secretariat/committees-and-councils/senate-graduate-research-council

FOR APPROVAL

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NEW PROGRAM

Faculty of Mathematics

1. Motion: To approve a new graduate program - Master of Data Science and Artificial Intelligence (MDSAI) - effective 1 September 2019, as presented in Attachment #1.

Rationale: The Faculty of Mathematics is proposing this new Master’s program to address the growing need for highly qualified personnel in the emerging and world-recognized disciplines of Data Science and AI. The Faculty of Mathematics at the University of Waterloo is strongly positioned to offer a graduate program in Data Science and AI that is strong in all key core areas because of its unique (in the world) blend of internationally recognized academic units, namely the Department of Statistics & Actuarial Science, the Department of Combinatorics and Optimization, and the Cheriton School of Computer Science.

The proposed Master of Data Science and Artificial Intelligence (MDSAI) will be a coursework program with a co-op option. The main objective of this program is to provide the best graduate education to students so that they can meet the growing national and international need for highly qualified personnel in the fields of data science and artificial intelligence. The overarching objectives of the MDSAI are to:

- Develop a broad academic and practical literacy in computer science, statistics, and optimization, with relevance in data science and artificial intelligence, so that students are able to critically select and apply appropriate methods and techniques to extract relevant and important information from data.
- Provide strong core training so that graduates can adapt easily to changes and new demands from industry.
- Enable students to understand not only how to apply certain methods, but when and why they are appropriate.
- Integrate fields within computer science, optimization, and statistics to create adept and well-rounded data scientists.
- Expose students to real-world problems in the classroom and through experiential learning.

These program objectives acknowledge the interdisciplinarity of data science and the importance of building a strong foundation with students.

2. Motion: To approve a new graduate program - Master of Mathematics in Data Science - effective 1 September 2019, as presented in Attachment #2.

Rationale:
The Faculty of Mathematics is proposing this new Master’s program to strategically leverage the breadth and depth of research that currently exists in the Faculty of Mathematics in the field of Data Science. It does so by offering an integrated and multidisciplinary approach to data science that can be best achieved with the three supporting academic units, namely the Cheriton School of Computer Science, the Department of Combinatorics and Optimization, and the Department of Statistics and...
Actuarial Science. Because of this unique, high-quality training, graduates of this new program will be in high demand to fill research positions in industry or academia within Canada and abroad.

The proposed Master of Mathematics in Data Science will be offered as a research program with a thesis requirement (please see the MDSAI brief at attachment #1 for details relating to the coursework option). The main objective of this program is to provide the best graduate education and research experience to students so that they may become experts in data science. The overarching objectives of the Master of Mathematics in Data Science are to:

• Integrate knowledge from the fields of computer science, statistics, and optimization, to develop expertise in the field of data science.
• Learn to conduct research in the field of data science by working under the supervision of an expert.
• Reach a level of expertise in an area of data science that enables the development of an original research contribution in a sub-field of data science.
• Develop a thorough understanding of the methods and techniques used in data science to extract relevant and important information from data.
• Enable students to understand not only how to apply certain methods, but when and why they are appropriate, so they can gain insight on how they may be adapted to create new and improved methods.

These program objectives acknowledge the interdisciplinarity of data science and the importance of developing strong research skills for students.

Jeff Casello  
Associate Vice-President, Graduate Studies and Postdoctoral Affairs

Charmaine Dean  
Vice President, University Research
NEW GRADUATE PROGRAM PROPOSAL
OF
MASTER OF DATA SCIENCE AND ARTIFICIAL INTELLIGENCE

Submitted to the
Ontario Universities Council on Quality Assurance

VOLUME I - PROPOSED BRIEF
SEPTEMBER 2018
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1 Introduction: Learning Objectives and Outcomes

Large and ever increasing amounts of heterogeneous and dynamically changing data are now routinely generated by many business, scientific, and social endeavours. This generation of data will continue to grow in size, complexity, and speed as new application areas such as personalized cancer treatment, continuous genetic tracking, real-time market-making, and triangulation across social networks find value in Canadian society, and as yet unheard of applications take advantage of the data resources that are or could be available in the future.

The field of data science leverages the very large volumes of data generated from these numerous and diverse sources as they become available in our increasingly digital world. From such sources, data-driven approaches to decision-making, inference, and exploration have become the hallmarks of data science and are now becoming widespread in many disciplines (e.g., biological science, medical and health informatics, environmental science, economics, finance, social science, humanities, etc.).

Data science is the study, application, and development of methods that facilitate insight from available data in order to understand, predict, and improve business strategy, products and services, marketing campaigns, medicine, public health and safety, as well as numerous other pursuits. Artificial Intelligence (AI) is the study of machines and software that exhibit intelligence, such as learning, reasoning, planning, recognizing and problem solving. Together, Data Science and Artificial Intelligence develop and share methods and tools designed to address problems increasingly central to our everyday life, business, society, and the environment. The proposed name, "Master of Data Science and Artificial Intelligence", acknowledges this reality.

The methods of data science and artificial intelligence involve elements of statistics, computer science, and optimization. The fact that this training needs to be collaborative between disciplines is widely recognized. To quote the American Statistical Association statement on Data Science: “[a] substantial collaborative effort is needed for it to realize its full potential for productivity and innovation. While there is not yet a consensus on what precisely constitutes data science, three professional communities, all within computer science and/or statistics, are emerging as foundational to data science: (i) database management enables transformation, conglomeration, and organization of data resources, (ii) statistics and machine learning convert data into knowledge, and (iii) distributed and parallel systems provide the computational infrastructure to carry out data analysis". Similarly, as stated in the National Research Council 2013 report "Frontiers of Massive Data Analysis" optimization is one of the

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seven computational "giants of statistical data analysis" and so forms one of the five required areas core to the proposed degree.

There is a growing and widely recognized need for highly qualified personnel in this emerging area. The gap between demand for and supply of Data Scientists is well documented. For example, an article from Datanami³ noted the following: "Back in 2012, the research firm Gartner said there would be a shortage of 100,000 data scientists in the United States by 2020. A year earlier, McKinsey put the national gap in data scientists and others with deep analytical expertise at 140,000 to 190,000 people by 2017, resulting in demand that's 60 percent greater than supply. In 2014, the consulting firm Accenture found that more than 90 percent of its clients planned to hire people with data science expertise, but more than 40 percent cited a lack of talent as the number one problem". Recently the government of Ontario has made significant investments to address this shortage. From the investinontario.com website: “In Ontario, we recognize that a knowledge economy is only as good as its talent. That's why we're strengthening our AI talent pipeline by committing to graduate 1,000 AI-related master's grads per year by 2023, while simultaneously increasing the number of annual STEM grads by 25% to over 50,000."

To address growing provincial, national, and global needs in this area, we propose a new Master of Data Science and Artificial Intelligence (MDSAI) program in the Faculty of Mathematics. A separate brief introduces the Master of Mathematics in Data Science program with a thesis option. These programs will share common infrastructure including new graduate courses and a single graduate director.

1.1 Brief Listing of the Program

This proposed Master of Data Science and Artificial Intelligence will be a coursework program with a co-op option. The degree requirements include nine graduate courses relevant to data science. Most courses are delivered on campus, with possibly one or two courses taught online.

While the program will include a regular option, all students will be admitted to the co-op option. Students will only be allowed to transfer to the regular option after one term and only in special circumstances, such as if they already have a job to which they plan to return upon graduation. Part-time study will be allowed in the regular option.

We expect students to complete the co-op program in four terms (16 months), which includes three study terms and one four-month work term. However, students may apply for an eight-month work term that would lengthen their program to five terms (20 months). Students in the regular option are expected to complete the degree in three terms (one year).

³ “Tracking the Data Science Talent Gap”, Alex Woodie, Datanami, March 25, 2016
The tuition for the program is proposed to be $30,000 for domestic students and $40,000 for international students ($10,000 per study term for domestic students and $13,333 per study term for international students), with the assumption students would take 3 courses per term. Since this is a course-based program, the tuition will be assessed on a per-course basis. This means that domestic students will be assessed tuition at $3,333 for each course they take in a single term and international students will be assessed $4,444 per course. Students in the co-op program will also be assessed the co-op fee.

**Tuition justification**

Some of the reasons for this proposed higher tuition compared to existing MMath programs include the following:

1) There is a very high demand for graduates in DS and AI, and thus graduates of this program are expected to easily find positions with starting salaries in the range $80K-120K. As such, the program is a very good investment for these students.

2) Students in the MDSAI program will by default be enrolled in co-op. The only students who are expected to opt out of co-op are those who currently have a job to which they plan to return upon graduation. During the co-op term, students are expected to make a salary over the 4-month period in the range $15K-20K. In addition to the experiential learning that will occur during this period, the co-op term is an important source of remuneration that will provide financial support to students during their program.

3) More generally, the co-op component of the MDSAI is a distinctive asset of the program that will provide work experience to students and enhance their placement options upon graduation.

4) In addition to its co-op feature, with its 9-course requirement the MDSAI provides students with both the breadth and depth necessary to prepare them for a career in industry.

5) As seen in Table 1, the proposed tuition is in line with what is being charged by other programs in the area of Data Science. With its co-op component and the internationally recognized expertise in the Faculty of Mathematics the program is expected to be competitive.

6) Beyond the resources available at the University of Waterloo, the program is expected to benefit from association with the Vector Institute as a “core AI-related program”. This may include extensive industrial connections through Vector that can advance recruitment for students, as well as scholarships funded by Vector.

<table>
<thead>
<tr>
<th>Program Name</th>
<th>University</th>
<th>Duration and curriculum</th>
<th>Cost for program</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master of Management Analytics</td>
<td>University of Toronto, Rotman School of Management</td>
<td>A 9-month program that requires 14 courses plus capstone projects.</td>
<td>Domestic <strong>Fee</strong>: $46,000 Int’l: $63,000</td>
</tr>
<tr>
<td>Program Name</td>
<td>University</td>
<td>Duration and curriculum</td>
<td>Cost for program</td>
</tr>
<tr>
<td>--------------------------------------------------</td>
<td>---------------------------</td>
<td>-----------------------------------------------------------------------------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>Masters of Applied Computing</td>
<td>University of Toronto</td>
<td>A 16-month program: 8 months of courses and 8-month internship</td>
<td>Domestic Fee: ~$22,000 Int’l: $50,000</td>
</tr>
<tr>
<td>Data Science and Analytics (MSc)</td>
<td>Ryerson University</td>
<td>1-yr FT or 2-yr PT: FT take 3 courses per term</td>
<td>Domestic Fee: $10,869 Int’l: $21,740</td>
</tr>
<tr>
<td>Master of Data Analytics</td>
<td>Western University</td>
<td>One year (2 terms on campus, 1 term internship)</td>
<td>Domestic: $24,665 Int’l: $42,473</td>
</tr>
<tr>
<td>Master of Management Analytics</td>
<td>Queen’s University</td>
<td>5 modules, 2 residences</td>
<td>Domestic: $44,600 Int’l: $67,750</td>
</tr>
<tr>
<td>Master of Data Science</td>
<td>University of British Columbia</td>
<td>10-month, full-time</td>
<td>Domestic Fee: $31,212 Int’l: $42,436</td>
</tr>
<tr>
<td>Professional Master's Program in Big Data</td>
<td>Simon Fraser University</td>
<td>4 semesters (or 16 months) in length. This includes a 4-month co-op placement.</td>
<td>Domestic Fee: $27,591 Int’l: $32,897</td>
</tr>
</tbody>
</table>

1.2 Method Used for Preparation of the Brief

The Mathematics Graduate Office has overseen the preparation of the brief. Contents related to admission and degree requirements were developed by the Data Science Committee, which comprises members of the three units involved in the program. Several faculty-wide meetings were held over the period of April 2017 to January 2018 to provide opportunities for discussion on the MDSAI and Masters of Mathematics in Data Science (thesis option) programs. A half-day workshop was held with the Centre for Teaching Excellence on January 23, 2018 to 1) discuss the vision of the program, 2) to develop program outcomes, 3) map the degree requirements to the Graduate Degree Level Expectations and 4) identify ideal attributes of graduates from the program.

1.3 Objectives of the Program

In its 2012-2017 Strategic Plan, the Faculty of Mathematics identified seven priority areas and associated goals to be pursued by 2017. These priorities and goals were developed with broad consultations that aligned with and complement the University of Waterloo’s Sixth Decade Plan (2007 - 2017), Pursuing Global Excellence: Seizing Opportunities for Canada. The Faculty of Mathematics has since then worked on a new strategic plan for the period 2018-2023, which was about to be approved by Faculty Council at the time where this brief was finalized. However, at the time where this program was developed, the 2012-2017 Plan was still in force and thus was used to inform its creation and design. Nevertheless, this program is also consistent with the upcoming 2018-2023 Plan.

In its strategic plan, the Faculty of Mathematics identified seven strategic priority areas and associated goals to be pursued by 2017. These priorities and goals were developed with broad
consultations that aligned with and complement the University of Waterloo’s *Sixth Decade Plan (2007 - 2017), Pursuing Global Excellence: Seizing Opportunities for Canada.*

Research, graduate education, and undergraduate education are central to the achievement of the Faculty’s mission and vision of success. Of particular relevance to the proposed graduate programs in Data Sciences, the Faculty’s strategic priorities including 1) providing a vibrant research environment and enriched graduate student experience (includes attracting the highest quality graduate students and providing them with the highest quality graduate education); and 2) offering leading-edge, dynamic academic programs.

Moreover, two of the four main thrusts, which together form the mission of the Faculty of Mathematics, were “to provide learning opportunities of unmatched breadth and depth” and “to produce graduates that are in worldwide demand”. The proposed graduate program in Data Science and Artificial Intelligence is a fulfillment of this vision and aligns with the strategic priorities of the Faculty.

This program addresses the growing need for highly qualified personnel in the emerging and world-recognized disciplines of Data Science and AI. The Faculty of Mathematics at the University of Waterloo is strongly positioned to offer a graduate program in Data Science and AI that is strong in all key core areas because of its unique (in the world) blend of internationally recognized academic units, namely the Department of Statistics & Actuarial Science, the Department of Combinatorics and Optimization, and the Cheriton School of Computer Science.

Data science and artificial intelligence have been identified as priority areas for the Faculty of Mathematics by the Dean of Mathematics. This emphasis has resulted in a number of new academic credentials related to Data Science and Artificial Intelligence. For example, an undergraduate major in Data Science began in the Fall of 2017. More precisely, the Faculty now offers a Bachelor of Computer Science in Data Science hosted in the Cheriton School of Computer Science, and a Bachelor of Mathematics in Data Science hosted in the Department of Statistics and Actuarial Science. In addition, the Cheriton School of Computer Science and Department of Statistical & Actuarial Science each created “specializations” for data science (first cohort enrolled in September, 2017) within existing graduate degree programs in anticipation of the proposed program. Moreover, options in Artificial Intelligence have recently been created by the Cheriton School of Computer Science within the Bachelor of Computer Science and the Bachelor of Mathematics in Computer Science. They will be effective in Fall 2018.

**Program objectives**
The main objective of this program is to provide the best graduate education to students so that they can meet the growing national and international need for highly qualified personnel in the fields of data science and artificial intelligence. The overarching objectives of the Master of Data Science and Artificial Intelligence (MDSAI) are to:
• Develop a broad academic and practical literacy in computer science, statistics, and optimization, with relevance in data science and artificial intelligence, so that students are able to critically select and apply appropriate methods and techniques to extract relevant and important information from data.
• Provide strong core training so that graduates can adapt easily to changes and new demands from industry.
• Enable students to understand not only how to apply certain methods, but when and why they are appropriate.
• Integrate fields within computer science, optimization, and statistics to create adept and well-rounded data scientists.
• Expose students to real-world problems in the classroom and through experiential learning.

These program objectives acknowledge the interdisciplinarity of data science and the importance of building a strong foundation with our students.

Learning outcomes
To achieve the program objectives, graduates of the program should be able to do the following:

1. Computational foundations: Demonstrate programming competency and strong computational skills by integrating concepts, theories, and key principles in the field of data science and artificial intelligence.
   o Master the use of tools (e.g., distributed programming, statistical analysis, etc.) that are required for handling, modeling, and extracting information from data stemming from real and concrete problems.
   o Develop a thorough understanding of how computations scale.
   o Develop strong programming skills that are not code-specific.
   o Develop computational maturity in order to quickly learn new technical skills that are relevant to data science and artificial intelligence.

2. Mathematical and Statistical Foundations: Assess the significance and limitations of the tools used and apply rigorous methods to ensure quality results.
   o Challenge the assumptions of tools used; understand the limits of models and their predictions; as well as identifying bias within data sets.
   o Understand and derive theoretical properties of methods involved in machine learning.
   o Develop mathematical and statistical maturity to ensure that the correct interpretation of data is made.
   o Demonstrate the ability to prove important properties of the tools and methods used (e.g., convergence of optimization algorithms used in machine learning, asymptotic properties of estimators, etc.)

3. Working with Data: Develop competency within the field of data science by identifying, evaluating, and assessing the appropriate methods for modelling and processing data.
   o Demonstrate proficiency with statistical analysis of data, including data modelling, data processing and cleaning, and management.
   o Effectively organize and manage datasets.
   o Use appropriate methods for parameter estimation.
   o Select and apply relevant machine-learning algorithms for problem at hand.
   o Ensure that results are assessed for accuracy.
4. Interdisciplinarity: Integrate knowledge and modes of thinking from two or more disciplines so that students are able to approach and resolve complex interdisciplinary problems.
   - Develop an interdisciplinary approach and way of thinking to Data Science and Artificial Intelligence that recognizes the importance of computer science, statistics, and optimization.
   - Learn to appreciate and recognize the importance of domain-specific knowledge from researchers and users involved in the application domains of Data Science and Artificial Intelligence.

5. Independent thinking: Develop independent thinking skills allowing students to explore, identify, and evaluate theoretical and methodological foundations.
   - Develop ability to “think outside the box” and determine whether available tools can adequately answer questions or whether new tools need to be created.
   - Critically evaluate the relevance and credibility of data collected to answer questions posed by end-users.
   - Develop critical and creative thinking by cultivating students’ dispositions in inquisitiveness, intellectual flexibility, curiosity, persistence, and an open-and-fair-minded attitude in trying new methods/techniques.
   - Understand the ethical challenges associated with the issues of bias, privacy, transparency, and accountability.
   - Analyze and articulate their views on legal, ethical and policy implications of new technologies.

6. Professional development: Demonstrate professional capacity and develop strong communication skills.
   - Effectively communicate problem description, methodologies used, and conclusions to a range of audiences (especially to non-technical people) orally, visually, and in writing.
   - Demonstrate the ability to work productively with others to accomplish established goals and manage multiple projects with strict deadlines.

In ensuring the quality of the Master of Data Science and Artificial Intelligence is consistent with the expectations of university degrees in Ontario (as developed by the Ontario Council of Academic Vice Presidents, OCAV), the following program map was developed (Table 2). This program map outlines how the required courses and co-op component will build the depth and breadth of knowledge within students and provide opportunities for them to apply their skills. Most of the required courses focus on developing methodological competencies. The courses and experiential learning components will offer students the opportunity to develop their technical, professional, and communication skills within the field of data science and artificial intelligence.
Table 2: A map of the program’s course content against the Graduate Degree Level Expectations (GDLEs). Ma indicates a major contribution to the GDLE, Mi indicates a minor contribution, and a blank indicates no contribution.

<table>
<thead>
<tr>
<th>Foundational Course (1)</th>
<th>Core Courses (5)</th>
<th>Elective Courses (3)</th>
<th>Other Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>At least one course in each of the following:</td>
<td>At least three courses in each of the following:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GDLE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CS 600</td>
<td>STAT 845</td>
<td>CS 602/CS 795</td>
<td>CO 602 (CS 795)/CO 673/CS 794/650/663</td>
</tr>
<tr>
<td>CS 631</td>
<td>CO 673/CS 794</td>
<td>CO 685</td>
<td>DS 701/702</td>
</tr>
<tr>
<td>CS 651</td>
<td>CO 663</td>
<td>STAT 844</td>
<td>STATS 840/841/842/844/946</td>
</tr>
<tr>
<td>CS 631</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ma</td>
<td>Ma</td>
<td>Ma</td>
<td>Ma</td>
</tr>
<tr>
<td>1. Depth and breadth of knowledge</td>
<td>Ma (breadth)</td>
<td>Ma (depth)</td>
<td></td>
</tr>
<tr>
<td>2. Research and scholarship</td>
<td>Mi</td>
<td>Ma (particularly methodological competence)</td>
<td>Ma (ii,iii)</td>
</tr>
<tr>
<td>3. Level of application of knowledge</td>
<td>Ma</td>
<td>Ma</td>
<td>Ma</td>
</tr>
<tr>
<td>4. Professional capacity/autonomy</td>
<td>Mi</td>
<td>Ma (particularly, critical evaluation of current research and advanced research and scholarship in the discipline)</td>
<td>Minor</td>
</tr>
<tr>
<td>5. Level of communications skills</td>
<td>Ma</td>
<td>Mi</td>
<td>Ma</td>
</tr>
<tr>
<td>6. Awareness of limits of knowledge</td>
<td>Ma</td>
<td>Mi</td>
<td>Ma</td>
</tr>
</tbody>
</table>
Table 3: Learning outcomes mapped to Master's Graduate Degree Level Expectations (GDLE) and its relationship to ensure that students are meeting the program elements in the MDSAI program.

<table>
<thead>
<tr>
<th>GDLE</th>
<th>1. Depth and Breadth of Knowledge</th>
<th>2. Research and Scholarship</th>
<th>3. Level of Application of Knowledge</th>
<th>4. Professional Capacity/Autonomy</th>
<th>5. Level of Communications Skills</th>
<th>6. Awareness of Limits of Knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning Outcomes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A systematic understanding and methodological competence that;</td>
<td>i) Enables a working comprehension of how established techniques of research and inquiry are used to create and interpret knowledge in the discipline;</td>
<td>i) Enables a critical evaluation of current research and advanced research and scholarship in the discipline or area of professional competence;</td>
<td>On the basis of that competence, has shown at least one of the following:</td>
<td>Competence in the research process by applying an existing body of knowledge into the critical analysis of a new question or of a specific problem or issue in a new setting.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ii) Enables a critical evaluation of current research and advanced research and scholarship in the discipline or area of professional competence;</td>
<td>ii) Enables a critical evaluation of current research and advanced research and scholarship in the discipline or area of professional competence;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>i) The development and support of a sustained argument in written form; or</td>
<td>i) Originality in the application of knowledge.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>a. The qualities and transferable skills necessary for employment requiring:</td>
<td>b. The intellectual independence required for continuing professional development;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>i) The exercise of initiative and of personal responsibility and accountability;</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ii) Decision-making in complex situations;</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>iii) The ability to appreciate the broader implications of applying knowledge to particular contexts.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computational foundations: Demonstrate programming competency and strong computational skills by integrating concepts, theories, and key principles in the field of data science.</td>
<td>Ma</td>
<td>Ma</td>
<td>Mi</td>
<td>Ma</td>
<td>Mi</td>
<td></td>
</tr>
<tr>
<td>Mathematical and Statistical Foundations: Assess the significance and limitations of the tools used and apply rigorous methods to ensure quality results.</td>
<td>Ma</td>
<td>Ma</td>
<td>Ma</td>
<td>Ma</td>
<td>Mi</td>
<td>Ma</td>
</tr>
<tr>
<td>Working with Data: Develop competency within the field of data science by identifying, evaluating, and assessing the appropriate methods for modelling and processing data.</td>
<td>Ma</td>
<td>Ma</td>
<td>Mi</td>
<td>Mi</td>
<td>Mi</td>
<td>Mi</td>
</tr>
<tr>
<td>Interdisciplinarity: Integrate knowledge and modes of thinking from two or more disciplines so that students are able to approach and resolve complex interdisciplinary problems.</td>
<td>Mi</td>
<td>Ma</td>
<td>Ma</td>
<td>Ma</td>
<td>Ma</td>
<td>Mi</td>
</tr>
<tr>
<td>Independent thinking: Develop independent thinking skills allowing students to explore, identify, and evaluate theoretical and methodological foundations.</td>
<td>Mi</td>
<td>Ma</td>
<td>Ma</td>
<td>Ma</td>
<td>Ma</td>
<td>Mi</td>
</tr>
<tr>
<td>Professional development: Demonstrate professional capacity and develop strong communication skills.</td>
<td>Ma</td>
<td>Ma</td>
<td>Ma</td>
<td>Ma</td>
<td>Ma</td>
<td>Ma</td>
</tr>
</tbody>
</table>
1.4 Admission Requirements

Applicants will normally have an Honours Bachelor’s degree in data science, computer science, statistics, mathematics or a related field, with a minimum overall B+ (78%) average from a recognized university. In addition, applicants will also have a background in calculus, linear algebra, statistics, and computer science. Experience at the senior level in both computer science and statistics courses is preferred, but not required. Experience at the senior level in at least one of computer science or statistics is required.

Applicants will also need to meet the University of Waterloo’s English Language Proficiency requirements (as detailed in the Graduate Calendar: the higher scores will be required). Students are not required to have prior work experience.

The above requirements, together with the two foundation courses in statistics (STAT 845) and computer science (CS 600), have been carefully designed to make sure all students will be able to complete the core and electives courses required to complete the program. Applicants lacking in background may be admitted on probation and required to take and earn a grade of at least 78% in specified qualifying courses. In particular, students requiring both foundational courses CS 600 and STAT 845 would be required to take at least one of them in a probationary period prior to the program’s start, and this probationary course would not count toward degree credit.

1.5 Program Structure

1.5.a Structure

Applicants are expected to enroll as full-time students into the regular or co-op MDSAI program. Students need to complete nine courses (all of them are 0.5 credit) in order to graduate. This is more than the minimum required number of courses for course-based Master’s programs in the Faculty of Math, (typically eight courses or 4 credits in total). As is the case for all students at the University of Waterloo, students must complete the Academic Integrity Module by the end of their first term. In addition, students in this program must complete an Ethics Milestone, by either taking a course on this topic as one of their electives, or by completing a three-day workshop entitled “Ethics in Data Science and Artificial Intelligence” that will be offered in the Fall term. Normally, full-time regular students will take three courses each term and thus can complete the course requirements in three terms. This course load is reasonable given that students will not have research, TA, or other commitments related to this degree. As part of the degree requirement, students must maintain an average of 75% in their courses.

The (1) foundation and (5) core courses serve to deepen and widen the students’ backgrounds. The (3) elective courses provide students the opportunity to explore new topics and/or deepen their understanding in a particular topic. Once in the program and with the approval of the Director, two of the three electives may be replaced by a significant project under the
supervision of one or more faculty members in data science. The project gives the student the opportunity to plan and carry out a research project. In particular, it gives a chance to students in the co-op option to study an idea/problem they may have encountered during their work term.

A co-op student enrolled into the MDSAI program is granted their degree if they complete the above course requirements, one co-op workterm (4 months), and a work-term report. Students may also apply for a one-term extension of the work term (for a total of two work terms or 8 months).

Please see Table 4 for a summary of the program’s structure and Section 4.4 for more details regarding the curriculum of the program.

Table 4: A table summarizing the program’s structure for full-time regular and co-op students. *Co-op students may apply to extend their work term for a total of 8 months.

<table>
<thead>
<tr>
<th>Term</th>
<th>Co-op option</th>
<th>Co-op option and Project (by permission)</th>
<th>Regular option (by permission)</th>
<th>Regular option with Project (by permission)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Fall</td>
<td>One foundation</td>
<td>One foundation</td>
<td>One foundation</td>
<td>One foundation</td>
</tr>
<tr>
<td></td>
<td>Two core</td>
<td>Two core</td>
<td>Two core</td>
<td>Two core</td>
</tr>
<tr>
<td>2 Winter</td>
<td>Two core</td>
<td>Two core</td>
<td>Two core</td>
<td>Two core</td>
</tr>
<tr>
<td></td>
<td>One elective</td>
<td>One elective</td>
<td>One elective</td>
<td>One elective</td>
</tr>
<tr>
<td>3 Spring</td>
<td>Co-op work term*</td>
<td>Co-op work term*</td>
<td>Two electives</td>
<td>Project</td>
</tr>
<tr>
<td>(and Fall*)</td>
<td>Co-op work term*</td>
<td>Co-op work term*</td>
<td>One core</td>
<td>One core</td>
</tr>
<tr>
<td>4 Fall</td>
<td>Two electives</td>
<td>Project</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>(or Winter*)</td>
<td>One core</td>
<td>One core</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1.5.b Effect of Structure on Quality
The first two academic terms allow students to build strong foundations in computer science, statistics, and optimization. This structure is particularly beneficial since students may take what they have learned in the first two terms and decide for their third academic term whether they would like to deepen their knowledge through taking elective courses or explore certain topics through a special project.

In addition, the program structure gives students two terms to build their conceptual understanding before applying their knowledge to real-world problems they may encounter during their work term. The mandatory work term report will also provide students the opportunity to develop their presentation and writing skills, reflection, critical analysis, and synthesis. When students return for the final academic term, they will continue to build the breadth and depth of their knowledge by either taking the remaining three courses or by engaging with a special project supervised by a faculty member within Data Science.
1.6 Program Content

The development of the MDSAI will prepare well-rounded data science and AI graduates with fundamental and technically integrated skill sets based on features unique to this program. The proposed program 1) integrates ideas and methods from computer science, statistics, and optimization, 2) ensures graduates receive rigorous and fundamental training making them more adaptable to fast-changing technology, applications, and new developments in data science and AI, and 3) provides important experiential learning through a co-operative work experience with an employer.

To ensure all students are properly prepared to take courses in different disciplines, the program features two foundation courses: one in statistics (STAT 845) and one in computer science (CS 600). Students will be assigned to one (or neither) of these foundation courses depending on their backgrounds. Students will then be required to take courses in five different core areas from computer science, statistics, and optimization. These courses, along with the three electives, will build the breadth and depth of their knowledge that allows for interdisciplinary synthesis. The Ethics Milestone will ensure students learn to think critically about the legal, ethical and policy implications of new technologies. Students must be physically present to take courses on campus, which provides them with the opportunity to engage with others students having different academic backgrounds, in such a way that students can become learning resources for one another.

According to the University of Waterloo’s Enrolment and Time Limits, the minimum and normal residence requirements for a Master’s program is two and three terms (respectively) of full-time enrolment. Since, we expect full-time regular and co-op students in the MDSAI to complete the program within three or four terms, respectively, then they will meet the normal residence requirements to graduate with a Master’s from the University of Waterloo.

The courses that are likely to be taken by a large number of students in the program follow a standard sequence of offerings in Fall and Winter terms. All courses are graduate-level courses, as can be seen in Section 4 (they are all either at the 600-, 700-, 800- or 900-level).

1.7 Mode of Delivery

Most of the courses in the Master of Data Science and Artificial Intelligence program are classroom based, with two courses (CS 600 and CS 638) offered online. The Ethics Workshop will be offered on campus and students will need to attend in person, as their participation in the workshop will contribute to their final mark. Students enroll in the co-op option and are expected to remain in it. They also have an opportunity for a significant project in their last term that is the equivalent of two courses.

The courses in the program have been either specially designed for the new data science specializations or the current program (CS 600, STAT 845, STAT 847, CS 658, CS 794 / CO 673)
or have been selected because of their obvious fit with the program’s objectives and learning outcomes. As presented in Table 1, all courses will build the depth and breadth of knowledge in computer science, optimization, and statistics.

The MDSAI students will receive weekly announcements for a variety of seminars in the Faculty of Mathematics. Attending seminars will help students to become familiar with current research in data science and the more general disciplines of computer science, statistics, and optimization.

1.8 Assessment of Teaching and Learning

The students’ level of achievement in meeting the learning outcomes of the program will be evaluated in courses by using a mix of assignments, projects, reports, presentations, midterm exams, and a final exam or project. Although the types of evaluations will vary from year to year, between instructors, and the delivery of the course, Table 5 summarizes the assessments that may be used to evaluate whether the student has achieved the learning outcomes as indicated in Section 1.3 (Objectives of the Program). The assignments, projects, reports, course projects can be assigned individually or in groups; the latter being important for developing relationships with students that have different academic backgrounds, developing their teamwork skills, and for integrating knowledge from two or more disciplines. Projects in core courses will naturally be interdisciplinary. For this reason, we anticipate that even if the projects were assigned individually, then students will have the opportunity to practice different fields of thinking and/or integrate their knowledge from various disciplines.

Table 5: Summary of teaching and learning assessments that may be used to assess the students’ achievement of the program’s learning outcomes.

<table>
<thead>
<tr>
<th>Learning Objectives</th>
<th>Assessments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Assignments</td>
</tr>
<tr>
<td>Computational foundations</td>
<td>x</td>
</tr>
<tr>
<td>Mathematical and Statistical Foundations</td>
<td>x</td>
</tr>
<tr>
<td>Working with Data</td>
<td>x</td>
</tr>
<tr>
<td>Interdisciplinarity</td>
<td>x</td>
</tr>
<tr>
<td>Independent thinking</td>
<td>x</td>
</tr>
<tr>
<td>Professional development</td>
<td>x</td>
</tr>
</tbody>
</table>
As indicated in Section 4.2 (Program Regulations), the students’ performance will also be monitored on a term-by-term basis by the Director. Data on co-op placement and employer evaluations will be collected regularly to assess students’ successes in the experiential learning part of the program. Exit surveys will be conducted to further evaluate students’ ability to find employment upon graduation, and collect their feedback on the program.

At the end of each course, the student will have the opportunity to assess the course content and the instructor’s delivery, thus providing feedback that can be used for future improvement of the course and, more generally, of the program.

1.9 Fields in a Graduate Program (optional)

The Master of Data Science and Artificial Intelligence program does not offer any fields.

2 Human Resources

Table 6 (based on the website https://uwaterloo.ca/data-science) contains a list of 31 faculty members from the Cheriton School of Computer Science, the Department of Combinatorics and Optimization, and the Department of Statistics and Actuarial Science, who are part of the Data Science group in the Faculty of Mathematics.

The courses that are part of the degree requirements for this program are likely to be taught by faculty members from this group. In addition, students who want to replace two courses by a significant project would need to work with one of the faculty members in this group. As the program does not reside in a single academic unit but is instead a Faculty-wide program, faculty members in data science will provide the intellectual support for the program, and are also likely to be involved in the administrative oversight of the program (e.g., admission and steering committees). In addition, one of the Data Science faculty members will be chosen by the Dean to be Director of the graduate programs in Data Science and Artificial Intelligence.
Table 6: A summary of Faculty members in the Data Science group as divided by their units.

<table>
<thead>
<tr>
<th>Cheriton School of Computer Science</th>
<th>Department of Combinatorics and Optimization</th>
<th>Department of Statistics and Actuarial Science</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Shai Ben-David</td>
<td>1. Thomas Coleman</td>
<td>1. Ryan Browne</td>
</tr>
<tr>
<td>2. Gordon Cormack</td>
<td>2. Ricardo Fukasawa</td>
<td>2. Shoja’eddin Chenouri</td>
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<tr>
<td>5. Ihab F. Ilyas</td>
<td>5. Chaitanya Swamy</td>
<td>5. Martin Lysy</td>
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<td>11. Peter van Beek</td>
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<td>12. Justin Wan</td>
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<tr>
<td>13. Yaoliang Yu</td>
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</tbody>
</table>

In addition to the academic support provided by the faculty members involved in the program through teaching and mentoring, students in this program will also receive library support through Rebecca Hutchison, who is the Library Liaison for Mathematics, Computer Science and Physics (please see Section 3.1 for more information). Information technology support for students in this program will be provided by the staff in the Mathematics Faculty Computing Facilities (MFCF, please see Section 3.3 for more information).

**Resources for Graduate Programs Only**

Together the group of Data Science faculty members covers all the areas of expertise that are relevant for this program, as can be seen in the following section. Significant efforts have already been put in place by many individuals in this group to design and teach new courses that were created for the Data Science specializations currently offered by the Cheriton School of Computer Science and the Department of Statistics and Actuarial Science. These faculty members publish papers in the top journals and conference proceedings in data science, AI and related fields, and supervise many students working in the different areas listed in Table 6. Hence students will have experts in data science teaching them the various courses listed in the program, and will therefore be exposed to the latest advances in research in the field.

2.1.a  List of Faculty by Field

Table 7 provides a list of the 31 faculty members for this program. All three academic units are currently hiring new faculty members. Moreover, in both the Cheriton School of Computer Science and the Department of Statistics and Actuarial Science, recruitment in fields related to data science and artificial intelligence is a priority.
Table 7: A list of faculty members involved in the Data Science and Artificial Intelligence program, including their rank, home unit, the particular field(s) of study in which a faculty member is active. A single faculty member may be active in several different fields.

<table>
<thead>
<tr>
<th>Faculty Name</th>
<th>Rank</th>
<th>Unit</th>
<th>Artificial Intelligence</th>
<th>Causal Inference</th>
<th>Computer Systems and Databases</th>
<th>Data Exploration and Analysis</th>
<th>Data Visualization</th>
<th>Ethics in AI</th>
<th>Machine Learning</th>
<th>Numerical Linear Algebra</th>
<th>Optimization</th>
<th>Scientific Computing</th>
<th>Statistical Learning</th>
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<tr>
<td>Ben-David, Shai</td>
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</table>
2.1.b External Operating Research Funding
Not applicable for coursework Masters programs.

2.1.c Graduate Supervision
Not applicable for coursework Masters programs.

2.1.d Commitment of Faculty from Other Graduate Programs/Institutions
All faculty members involved in this program are also involved in other graduate programs in the Faculty of Mathematics. As this is a coursework program and all Data Science faculty members have an active research program, they supervise students in the research-based programs of the Faculty of Mathematics.

2.2 Quality of Faculty

All members of the Data Science group have PhDs in computer science, statistics, mathematics, combinatorics and optimization, computer and information systems, or applied mathematics that are consistent with the program objectives and learning outcomes for the Master of Data Science and Artificial Intelligence. Many of our faculty members are cross-appointed with other academic units in the Faculty of Mathematics and have collectively taught nearly 100 graduate courses relating to data science and artificial intelligence.

The group of faculty members supporting the program have demonstrated that they are leaders and innovators in their respective fields by having participated in nearly 598 conference presentations, published 478 papers in refereed journals, published 447 papers in refereed conferences, authored 20 chapters and 9 books, and wrote 25 technical reports. As further evidence of their leadership and expertise, our faculty have been involved in 50+ domestic and international conferences and/or workshops related to data science as organizers, chairs, session leaders, or other leadership roles. Most of our faculty have several years of editorial experience in relevant journals related to data science and artificial intelligence (e.g., Journal of Statistical Computation and Simulation; Journal of Statistical Computation and Simulation; Journal of Finance and Data Science; Journal of Artificial Intelligence Research; Journal of Machine Learning; Discrete Optimization; Journal of Optimization Theory and Application; Computational Intelligence, etc.). Further, some of our faculty have international collaborations in the field of data science and artificial intelligence with other countries including Swaziland, Israel, United States of America, Hong Kong, United Arab Emirates, Qatar, the Netherlands, etc. Together, they collectively have 32 patents.

In addition to their academic experience, the Data Science faculty are well-rounded researchers. Many of them have non-academic experiences that includes positions such as chief architect of technology, supervisor analyst, advisor, co-founder (of a startup), statistical software programmer, scientific advisor, and consultant. The recent launch of the Waterloo Artificial Intelligence Institute – sponsored jointly by the Faculty of Mathematics and the Faculty of Engineering – will leverage even further our faculty members’ connections with industry partners.
The background, expertise, and experiences of the Data Science faculty will contribute substantively to the proposed MDSAI program. Please see Volume II: Curricula Vitae of the Faculty for more information regarding the faculty’s background.

3 Physical and Financial Resources

3.1 Library Resources

The following was prepared by Rebecca Hutchinson (Liaison Librarian for Computer Science and Statistics & Actuarial Science) regarding Library Resources required for the MDSAI; reviewed by Jennifer Haas (Department Head, Information Services and Resources); and approved by Nick Richbell (Strategic Area Lead, Collection Lifecycle Management) and Beth Sandore Namachchivayya (University Librarian).

3.1.a Level of support summary

The Library provides a high level of support for the existing graduate courses offered through the School of Computer Science and the Department of Statistics & Actuarial Science in the Faculty of Mathematics, and anticipates that this high level of support will extend to the proposed Master of Data Science and Artificial Intelligence Program. Students and faculty members in the proposed program will be encouraged to make use of the teaching, learning and research support services and expertise the Library offers. Current collection strengths would support the new program. No new collections are needed at this time. Should new subject areas emerge or if research intensity develops in subject areas currently outside of collection priorities, the Library is committed to engaging in discussions to articulate collection needs and assess funding implications.

3.1.b Strengths of support provided

The University of Waterloo Library curates a collection with particular strengths in computer science and statistics which includes research databases, full text journals, monographs, numeric data and government publications. Some of the resources of particular interest to these disciplines include IEEE, ACM, Safari Tech, CRCnetBASE and MathSciNet. Texts on data science and big data in general have been collected as appropriate since 2003 to the Instructional Level\(^4\). The subject components of the new courses created for the Data Science specialization include: data sources, databases, and data management; statistics and machine learning; distributed and parallel systems; and optimization. All of these subjects are collected to the Research Level\(^5\) and are well represented in the collection. In addition to the local collection, the University of Waterloo Library partners with other Ontario and Canadian universities to further expand access to computer science, statistics, and data science resources. Such collaborations include the Tri-University Group consortium (University of

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\(^4\) supports undergraduate study

\(^5\) includes major published source materials required for master’s degree program, doctoral study and independent research
Waterloo, University of Guelph, Wilfrid Laurier University), the Ontario Council of University Libraries (OCUL) and the Canadian Research Knowledge Network (CRKN).

The Computer Science and Statistics & Actuarial Science Liaison Librarian is available to provide research, teaching and learning support for graduate students and faculty. Instructional support includes the development of online modules and research guides as well as the preparation of classroom sessions and outcomes-based workshops. For example, the Librarian provides literature survey workshops for Faculty of Mathematics graduate students. These department specific workshops provide students with an understanding of how research is disseminated, the significance of the literature survey portion of their papers, how to create a comprehensive search, and how to determine scientific impact. The Librarian also offers research consultations with individuals to support coursework, research publications, research data management, meeting open access requirements, and copyright.

5.1.a More information
The Library would be happy to meet with the program reviewers to discuss this report and answer their questions. For additional information about University of Waterloo Library and the support it provides for programs, please visit https://uwaterloo.ca/library/about/policies-and-guidelines/support-academic-programs.

5.2 Laboratory Resources
Students will not need laboratory resources.

3.3 Computer Facilities
All faculty and graduate students are provided with an account on the University computing system and the Mathematics Faculty Computing Facility (MFCF) systems. The former gives them access to email, internet, the University Library, five terabytes of cloud storage and other on-campus platforms related to courses and education. The MFCF systems give students and faculty access to specialized software and compute-servers. The servers include several high-performance Linux clusters and two GPU computing systems. The software includes Matlab, Maple, Python, R, Sage, Julia, and CPLEX as well as web-based software development hosted with Jupyter. These resources are accessible either from student and faculty members' laptops or through thin-client workstations that will be provided in the proposed lounge and lab space.

3.4 Space
The Faculty of Mathematics has committed to provide a computer lab for students enrolled in this program and the MMath in Data Science that is proposed in parallel. This will be located in either new space to be acquired over the next three to five years, or in space currently owned by the Faculty which will be re-purposed for this program. For the proposed Master of Data Science and Artificial Intelligence coursework program, a combination lounge/lab with seating for 10 shared by the students is needed. This space will be set up in a way that complies with
the Council of Ontario Universities Space Guidelines. In addition, the Data Science programs will require an office for each of the Graduate Director and Graduate Coordinator.

3.5 Financial Support

The students in this coursework option will not receive financial support.

We recognize that the financial cost to the student enrolled into the coursework option is higher than that for a student in the research thesis program. However, we do not anticipate that many students would enroll into the research thesis program with the intention of switching to the coursework program later on. First, admission into the thesis option requires to find a supervisor willing to take the student on, which requires a non-negligible amount of effort and commitment from the student. Further, coursework students are required to take nine courses whereas research thesis students are required to take four. Even if a research thesis student has completed their four courses, if they should switch to the coursework program, then they will likely need to be enrolled into the program for at least two terms to complete all the required courses (note: the coursework program is three terms in length, not including co-op), meaning that they would still end up paying the higher tuition for at least five additional courses. As is the case for the students who started from the beginning in the coursework coop program, students transferring from the thesis to the coursework program would have access to income from their co-op work term to mitigate the increased costs of the coursework program.

The Faculty also recognizes that the high tuition may prevent some students with less financial resources to take part in the program. To alleviate this potential issue, the Faculty of Mathematics will set up a number of bursaries to support talented students in need. The value and number of the bursaries will be reviewed periodically to take into account the level of fees, the number of enrollments, the mix of the students applying, and the availability of industry-supported scholarships. Initially, the Faculty will support 2 or 3 bursaries of $17,500, an amount consistent with other scholarships for students enrolled in AI-related programs (e.g., Vector Institute scholarships).

4 Curriculum

4.1 The Intellectual Development and the Educational Experience of the Student

The program is carefully designed so that upon graduation, students will have developed into rigorously trained Data Scientists who understand not just “how” a method or algorithm can be applied to a certain problem, but also “why” this method works. The interdisciplinary nature of the program will allow students to gain a deep understanding of how computer science, optimization, and statistics can be used together to solve practical problems. The courses included in the program will also ensure that students have reached the desired learning outcomes and ultimately the program objectives.

In addition to the required coursework, the MDSAI students will be on the mailing list to receive announcements for research seminars taking place in the Faculty of Mathematics. Attending seminars will allow students to become familiar with current research in data science and other related disciplines.
The role of co-op within the program is also important in enhancing the student experience and reinforcing the program objectives as well as the learning outcomes. Co-op provides a unique experiential learning experience in that it allows students the opportunity to apply the materials they have learned in courses, which increases the effectiveness of their learning. Since students can anticipate that they will need to do a work term, the weight of this “milestone” will increase the student’s engagement that leads to the development of skills required for lifelong learning.

To further support their educational experience, students will have access to resources in the Faculty of Mathematics such as the Math Faculty Computing Facility and the Math Graduate Student Association. Services relevant to Math graduate students will be highlighted during the Math Graduate Orientation as well as the MDSAI student handbook, which will be created in the Fall 2018.

Students will also be encouraged to take advantage of the resources and services that are available to all UW students such as: AccessAbility Services, Centre for Career Action, Centre for Teaching Excellence, Counselling Services, GRADventure, Graduate Student Association, Health Services, Student Success Office, Velocity, the Writing and Communication Centre, etc. In particular, the Centre for Career Action and Velocity will be of significance to our students as these resources have workshops regarding searching and applying for meaningful work experiences, as well as building entrepreneurial skills.

Since students within the MDSAI program are not research-based, there are no provisions of funding for travel to conferences.

4.2 Program Regulations

Please refer to Section 1.4 (Admission Requirements) and Section 4.4 (Curriculum) for details regarding the admission standards and policies as well as courses required by the student to complete the program, respectively.

The MDSAI is a nine-course program. Students enroll in the co-op option, but can transfer into the regular option after one term, and with approval of the Director. The regular option is expected to be chosen only when students already have a job to which they plan to return upon graduation, or in the unlikely event that they are unable to find a job to fulfill the work term requirement of the co-op option. We expect most students to enroll full-time (see Section 4.3 about part-time studies). Normally, three courses are taken in each study term. Students in the regular stream can therefore complete the program in three terms (12 months). Once in the program, full-time students may apply to replace two courses in the final term of the program by a significant project, with corresponding courses DS 701 and DS 702. This project requires approval by the Director and at least one of the Data Science faculty members must supervise the student. Upon completion, the supervisor and a second reader will assess the project and assign a grade. As this program is coursework only, there is no need for a thesis evaluation procedure.

Students also take part in co-op, which is managed through the Co-operative Education Department (CED), with the support of the Centre for Career Action (CCA), which provides training and individual student advising services. CED will help prepare students for their first work term by holding preparatory workshops. Students will also have access to the WaterlooWorks job database to search and apply for jobs. Furthermore, CED’s International
team will ensure students receive the required paperwork and guidance to apply for co-op related work permits prior to their arrival on campus. Before a student is allowed to go for their work term, they are required to complete five courses successfully including the foundation course(s). Students may be required to take additional professional courses offered by CED in the Fall and Winter term. During the Winter term, they will apply for their Spring work placement. Normally only a single work term is to be taken as part of the degree requirement, but longer employment at the same employer (up to 8 months) may be arranged with the permission of the Director.

Students must also complete an Ethics Milestone, by participating to a 3-day workshop on “Ethics in Data Science and Artificial Intelligence” that will be offered in the Fall term and scheduled to avoid conflicts with other courses. Alternatively, they can take and pass the course CS 798 Advanced Research Topics on “Artificial Intelligence: Law, Ethics, and Policy”.

In order to remain in good academic standing, students must maintain an average of 75% and a minimum grade of 70% in all of their courses. Progress reports are not required; however, the Director will review students’ overall average every term. Students whose average falls below the program’s minimum requirements may be required to withdraw from the program. The procedure described in the University Calendar to handle such cases will be followed, with details provided in the MDSAI student handbook. The minimum average required by the program is higher than the university’s minimum requirement (70%).

4.3 Part-time Studies
Students must enroll full-time. They may only be allowed to study part-time if they transfer to the regular option, and with the permission of the Director. It should also be noted that the course offerings are not designed for part-time studies. With the exception of CS 600 and CS 638 which are offered online, all other courses will be delivered in-person and on campus. These courses are not typically available during the evenings or weekends, and are not delivered in concentrated modules.

4.4 Curriculum
The University of Waterloo has a minimum full-time enrolment period of two terms for Masters students, which will clearly be met by students in this program. All students in this program will begin in the Fall term (when foundation courses are offered) and continue in the Winter (when two core courses are offered).

Students will take one foundation course, five core courses, and three elective courses. Each of these courses has a weight of 0.5 credit. The foundation and core courses allow the students to build breadth and depth in the components that constitute data science. The electives serve to provide more detailed understanding of a topic, broaden their base, or become more knowledgeable in a given application domain. Table 4 in Section 1.5.a (Structure) outlines the expected course sequence for regular and co-op students.

The degree requirements for this program are as follows:
Foundation
Students are expected to take at most one of the following two courses foundational courses depending on their undergraduate major:

1. CS 600 Fundamentals of Computer Science for Data Science (designed for non-CS major background students)
2. STAT 845 Statistical Concepts for Data Science (designed for non-STAT major background students)

Core
All students are required to take common core courses:

1. STAT 847 Exploratory Data Analysis
2. One of
   a. CS 651 Data-Intensive Distributed Computing (designed for CS major background students), or
   b. CS 631 Data-Intensive Distributed Analytics (designed for non-CS major background students).
3. One of
   a. STAT 841 Statistical Learning: Classification
   b. STAT 842 Data Visualization
   c. STAT 844 Statistical Learning: Function estimation
4. One of
   a. CS 638 Principles of Data Management and Use
   b. CS 648 Database Systems Implementation
   c. CS 680 Introduction to Machine Learning
   d. CS 685 Machine Learning Theory: Statistical and Computational Foundations
5. One of
   a. CO 602 / CS 795 Fundamentals of Optimization
   b. CO 673 / CS 794 Optimization for Data Science
   c. CO 663 Convex Optimization and Analysis

Milestones
1. Ethics Workshop: Students must complete a 3-day workshop on “Ethics in Data Science and Artificial Intelligence” that will be offered in the Fall term. Alternatively, students can complete the course CS 798 Advanced Research Topics on “Artificial Intelligence: Law, Ethics and Policy”.
2. Graduate Studies Work-Term Report (Co-op option only): Students in this program must complete one work term, which is expected to take place in their third term. They are then expected to return to campus for a final study term. In order for students to complete the work report, they must have had a work placement and receive at least a satisfactory evaluation for their co-operative education term. Students are encouraged to complete COOP 601 Career Success Strategies in the term before the start of their work term.

Elective courses
Students must take enough additional elective courses to fulfill the 9-course requirement. These courses must normally be taken from the following list of selected graduate courses. Courses not on the list are subject to the approval of the Graduate Director.

- CO 602 / CS 795 Fundamentals of Optimization
- CO 673 / CS 794 Optimization for Data Science
- CO 650 Combinatorial Optimization
- CO 663 Convex Optimization and Analysis
- CO 769 Topics in Continuous Optimization
- CS 638 Principles of Data Management and Use
 Proposed Program – Master of Data Science and Artificial Intelligence

- CS 648 Database Systems Implementation
- CS 654 Distributed Systems
- CS 680 Introduction to Machine Learning
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- CS 686 Introduction to Artificial Intelligence
- CS 740 Database Engineering
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- STAT 841 Statistical Learning: Classification
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- DS 701/702 Data Science Project 1 & 2

The particular foundation courses that students will take may vary depending on the student’s background as determined by the Director. Should students have insufficient background, then the Director will indicate to students in their admission letter whether remedial courses are required, in which case students may be admitted on a probationary basis.

The following summarizes examples of courses that students are exempt from or require to take depending on their background:
- Students with a Bachelor's degree with a major in Computer Science, equivalent to the University of Waterloo's BMath or BCS (Computer Science), would normally be exempt from CS 600;
- Students with a Bachelor's degree in Statistics, equivalent to the University of Waterloo's BMath (Statistics), would normally be exempt from STAT 845.
- Students who have an honours degree equivalent to the University of Waterloo's BMath or BCS (Data Science), would normally be exempt from both foundation courses.
- Students deemed to have sufficient relevant senior level undergraduate courses in both areas may at the discretion of the Graduate Director be exempted from both foundations course;
- Exemption from any foundation course does not count as a course taken.

Finally, we note that students are required to take an optimization course as part of the core. The course CO 602/CS 795 is accessible to students who may not have the mathematical

\footnote{CO 769, CS 798, CS courses at the 800 level, and STAT courses at the 900 level should be on a topic in Data Science or Artificial Intelligence; they are subject to the approval of the Graduate Director.}

\footnote{Courses pending approval in the Faculty of Mathematics}
background required to directly take more advanced optimization courses offered in the Combinatorics and Optimization department, and will provide them with the background needed should they wish to take these more advanced courses as part of their electives.

4.5 Collateral and Supporting Departments
The units involved in operating this program (teaching and graduate advising) are the Cheriton School of Computer Science, the Department of Combinatorics & Optimization, and the Department of Statistics & Actuarial Science.

All three units have approved the program: C&O approved the program at departmental meeting held on March 9, 2018; Computer Science approved the program at a School Council meeting held on March 14, 2018, and SAS approved the program at a departmental meeting held on March 23, 2018.

4.6 Organizational Structure
Because this program is not offered in a single academic unit but is instead supported by three units, it will operate as a Faculty-based program, similar to the Master of Mathematics in Computational Mathematics.

The Dean appoints the undergraduate and graduate Directors of Data Science and a steering committee for Data Science. The steering committee will have at least one voting member from each of the three units. The positions for undergraduate and graduate Directors may be occupied by the same individual.

A full-time graduate coordinator will be hired to support the two graduate programs. Figure 1 summarizes the organizational chart for Data Science.

![Organizational Chart](image.png)

**Figure 1:** Administrative organization of the Data Science programs within the University of Waterloo.

In the future, any revisions for the program would need to go through the relevant units and then to the Faculty Council for approval.
5 Projected Enrollment

It is expected that the program will admit 30 students per year for the first three years and ramping up to 40 students per year after 7 years (Table 8). The enrollment will be split roughly 50% domestic, 50% international. (This projected balance between domestic and international is based on extrapolating existing graduate enrollment in the Faculty.)

<table>
<thead>
<tr>
<th>YEAR</th>
<th>Fall Intake</th>
<th>Total Fiscal Year Enrolment</th>
<th>TOTAL FISCAL YEAR ENROLMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Domestic</td>
<td>International</td>
<td>Domestic</td>
</tr>
<tr>
<td>2019/20</td>
<td>15</td>
<td>15</td>
<td>29.2</td>
</tr>
<tr>
<td>2020/21</td>
<td>15</td>
<td>15</td>
<td>57.2</td>
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<tr>
<td>2021/22</td>
<td>15</td>
<td>15</td>
<td>58.7</td>
</tr>
<tr>
<td>2022/23</td>
<td>17</td>
<td>17</td>
<td>62.6</td>
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<tr>
<td>2023/24</td>
<td>18</td>
<td>18</td>
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<td>78.2</td>
</tr>
<tr>
<td>2027/28</td>
<td>20</td>
<td>20</td>
<td>78.3</td>
</tr>
</tbody>
</table>
6 Financial Plan

A financial viability analysis and financial plan was prepared in conjunction with Institutional Analysis and Planning’s Budget and Resource Planning Team based on a consolidation of the thesis and course-based academic streams. It was approved by the Provost in August, 2018.
GRADUATE PROGRAM PROPOSAL
OF
MASTER OF DATA SCIENCE AND ARTIFICIAL INTELLIGENCE
AND
MASTER OF MATHEMATICS IN DATA SCIENCE

Submitted to the
Ontario Universities Council on Quality Assurance

VOLUME II – FACULTY CURRICULA VITAE

SEPTEMBER 2018
GRADUATE PROGRAM PROPOSAL
OF
MASTER OF DATA SCIENCE AND ARTIFICIAL INTELLIGENCE
AND
MASTER OF MATHEMATICS IN DATA SCIENCE

Submitted to the
Ontario Universities Council on Quality Assurance

VOLUME III – EXTERNAL REVIEWERS

SEPTEMBER 2018
Prior to form submission, review the new graduate program instructions. For questions about the form submission, contact Trevor Clews, Graduate Studies and Postdoctoral Affairs.

**Faculty:** Mathematics

**Program:** Master of Data Science and Artificial Intelligence (MDSAI) - Co-operative Program

**Program contact name(s):** Christiane Lemieux

**Form completed by:** Jessica Leung

**Note:** new courses and milestones also require the completion/submission of the SGRC Course/Milestone-New/Revision/Inactivation form (PC docx version).

**Proposed effective date:** Term: Fall Year: 2019

**Graduate Studies Academic Calendar (GSAC) section** (include the link to the section (web page) where the new program will be located):

https://uwaterloo.ca/graduate-studies-academic-calendar/mathematics

---

**Proposed Graduate Studies Academic Calendar content:**

<table>
<thead>
<tr>
<th>MASTER OF DATA SCIENCE AND ARTIFICIAL INTELLIGENCE (MDSAI) - CO-OPERATIVE PROGRAM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Program information</strong></td>
</tr>
<tr>
<td>• <strong>Admit term(s)</strong></td>
</tr>
<tr>
<td>o Fall</td>
</tr>
<tr>
<td>• <strong>Delivery mode</strong></td>
</tr>
<tr>
<td>o On-campus</td>
</tr>
<tr>
<td>• <strong>Length of program</strong></td>
</tr>
<tr>
<td>o Four terms (16 months) for full-time students, normally comprising three study terms and one work term. Students may apply for an eight-month work term that would lengthen their program to five terms (20 months).</td>
</tr>
<tr>
<td>• <strong>Program type</strong></td>
</tr>
<tr>
<td>o Master’s</td>
</tr>
<tr>
<td>o Co-operative</td>
</tr>
<tr>
<td>o Professional</td>
</tr>
<tr>
<td>• <strong>Registration option(s)</strong></td>
</tr>
<tr>
<td>o Full-time</td>
</tr>
<tr>
<td>• <strong>Study option(s)</strong></td>
</tr>
<tr>
<td>o Coursework</td>
</tr>
<tr>
<td><strong>Admission requirements</strong></td>
</tr>
</tbody>
</table>

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Proposed Graduate Studies Academic Calendar content:

- **Minimum requirements**
  - Honours Bachelor’s degree or equivalent in data science, computer science, statistics, mathematics or a related field, with a minimum overall average of 78%.
  - Experience at the senior level in at least one of computer science or statistics.

- **Application materials**
  - Résumé/Curriculum Vitae
  - Supplementary information form
  - Transcript(s)

- **References**
  - Number of references: 3
    - Type of references: at least 2 academic sources

- **English language proficiency (ELP)** (if applicable, and the higher score will be required)

**Degree requirements**

**Coursework option:**

- **Graduate Academic Integrity Module (Graduate AIM)**

- **Courses**
  
  Students must complete at least 9 courses: **normally** 1 foundation course, 5 core courses, and 3 elective courses.

  **Foundation Courses**
  Students are expected to take at most 1 of the following 2 foundational courses depending on their undergraduate major:
  1. CS 600 Fundamentals of Computer Science for Data Science (designed for non-CS major background students)
  2. STAT 845 Statistical Concepts for Data Science (designed for non-STAT major background students).

  **Core Courses**
  Students are required to take the following core courses:
  1. STAT 847 Exploratory Data Analysis
  2. 1 of:
     a. CS 651 Data-Intensive Distributed Computing (designed for CS major background students), or
     b. CS 631 Data-Intensive Distributed Analytics (designed for non-CS major background students).
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     b. CS 648 Database Systems Implementation
     c. CS 680 Introduction to Machine Learning
     d. CS 685 Machine Learning Theory: Statistical and Computational Foundations
  5. 1 of:
     a. CO 602 / CS 795 Fundamentals of Optimization
Proposed Graduate Studies Academic Calendar content:

b. CO 673 / CS 794 Optimization for Data Science

c. CO 663 Convex Optimization and Analysis

**Elective Courses**

Students must take enough additional elective courses to fulfill the 9-course requirement. These courses must normally be taken from the following list of selected graduate courses. Courses not on this list are subject to the approval of the Graduate Director.

- CO 602 / CS 795 Fundamentals of Optimization
- CO 673 / CS 794 Optimization for Data Science
- CO 650 Combinatorial Optimization
- CO 663 Convex Optimization and Analysis
- CO 769 Topics in Continuous Optimization (*)
- CS 638 Principles of Data Management and Use
- CS 648 Database Systems Implementation
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- STAT 946 Topics in Probability and Statistics (*)
- DS 701/702 Data Science Project 1 & 2

Note (*): CO 769, CS 798, CS courses at the 800 level, and STAT courses at the 900 level should be on a topic in Data Science or Artificial Intelligence; they are subject to the approval of the Graduate Officer.

In order to remain in good academic standing, students must maintain an average of 75% and a minimum grade of 70% in all their courses. Progress reports are not required; however, the Director will review students’ overall average every term. Students whose average falls below the program’s minimum requirements may be required to withdraw from the program. The minimum average required by the program is higher than the university’s minimum requirement (70%).

- **Link(s) to courses**
  - [Data Science (DS) courses](#)
  - [Combinatorics & Optimization (CO) courses](#)
  - [Computer Science (CS) courses](#)
  - [Statistics (STAT) courses](#)
  - [Graduate course search](#)
Proposed Graduate Studies Academic Calendar content:

- **Milestones**
  - **Ethics Workshop**
    - Students must complete a 3-day workshop on “Ethics in Data Science and Artificial Intelligence” that will be offered in the Fall term. Alternatively, students can complete the course CS 798 Advanced Research Topics on “Artificial Intelligence: Law, Ethics, and Policy”.
  
  - **Graduate Studies Work Report**
    - Students in this program must complete one work term, which is expected to take place in their third term. They are then expected to return to campus for a final study term. Students may also apply for a one-term (4-month) extension of the work term. In order for students to complete the work report, they must have had a work placement and receive at least a satisfactory evaluation for their co-operative education term. Students are encouraged to complete COOP 601 Career Success Strategies in the term before the start of their work term.

**Department website**
[https://uwaterloo.ca/data-science/](https://uwaterloo.ca/data-science/)

**Discover Graduate Studies web page**
[https://uwaterloo.ca/discover-graduate-studies/programs](https://uwaterloo.ca/discover-graduate-studies/programs)

Unit (CS) approval date (03/09/18):
Unit (CO) approval date (03/14/18):
Unit (SAS) approval date (03/23/18):

Reviewed by GSPA (for GSPA use only) □ date (mm/dd/yy):
Faculty approval date (09/18/18):
Senate Graduate & Research Council (SGRC) approval date (mm/dd/yy):
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Program: Master of Data Science and Artificial Intelligence (MDSAI)
Program contact name(s): Christiane Lemieux
Form completed by: Jessica Leung

Note: new courses and milestones also require the completion/submission of the SGRC Course/Milestone-New/Revision/Inactivation form (PC.docx version).

Proposed effective date: Term: Fall Year: 2019

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<tr>
<td>o Professional</td>
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<td>• Registration option(s)</td>
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<tr>
<td>o Full-time</td>
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<tr>
<td>o Part-time</td>
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<tr>
<td>• Study option(s)</td>
</tr>
<tr>
<td>o Coursework</td>
</tr>
<tr>
<td><strong>Admission requirements</strong></td>
</tr>
<tr>
<td>• Minimum requirements</td>
</tr>
</tbody>
</table>
Proposed Graduate Studies Academic Calendar content:

- Students in the Master of Data Science and Artificial Intelligence - Co-operative program can apply to transfer into the Master of Data Science and Artificial Intelligence Program after completing at least one academic term. Admittance will be decided by the Graduate Director on a case-by-case basis.

Degree requirements

Coursework option:

- **Graduate Academic Integrity Module (Graduate AIM)**
- **Courses**

  Students must complete at least 9 courses: **normally** 1 foundation course, 5 core courses, and 3 elective courses.

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Faculty approval date (09/18/18):
Senate Graduate & Research Council (SGRC) approval date (mm/dd/yy):
Senate approval date (mm/dd/yy) (if applicable):
Faculty: Math
Effective term: Term/Year Spring 2020

Course ☐ New ☐ Revision ☐ Inactivation ☐
Milestone ☒ New ☒ Revision ☐ Inactivation ☐

New milestone title: Work Report

For course revisions, indicate the type(s) of changes (e.g. consent, description, title, requisites): N/A

Course Subject code: Choose an item. Course number:
Course Title (max. 100 characters incl. spaces):
Course Short Title (max. 30 characters incl. spaces):
Grading Basis: Choose an item.
Course Credit Weight: 0.00
Course Consent Required: ☐
Course Description: N/A

New course description (for revision only):

Meet Type(s): Lecture Reading Choose an item. Choose an item.
Primary Meet Type: Reading

Requisites:

Special topics course: Yes ☐ No ☐
Cross-listed: Yes ☐ No ☐

Course Subject(s) to be cross-listed with and approval status: N/A

Sections combined/held with:

Rationale for request:
The milestone should be applied to the Master of Data Science and Artificial Intelligence (MDSAI) - Co-operative Program. A work report must be submitted upon completion of a work term. Successful completion of a work term requires students to have been working for (at least) 4-months in employment approved by Co-operative Education and that they receive at least a satisfactory evaluation for their co-operative education term.

Prepared by: Jessica Leung Date: Click here to enter a date.
Faculty: Math
Effective term: Term/Year Fall 2019

Course ☐ New ☐ Revision ☐ Inactivation ☐

Milestone ☒ New ☒ Revision ☐ Inactivation ☐

New milestone title: Ethics Workshop

For course revisions, indicate the type(s) of changes (e.g. consent, description, title, requisites):

Course Subject code: Choose an item. Course number:
Course Title (max. 100 characters incl. spaces):
Course Short Title (max. 30 characters incl. spaces):
Grading Basis: Choose an item.
Course Credit Weight: 0.00
Course Consent Required: ☐
Course Description: N/A

New course description (for revision only):

Meet Type(s): Choose an item. Choose an item.
Primary Meet Type: 

Requisites:

Special topics course: Yes ☐ No ☐
Cross-listed: Yes ☐ No ☐

Course Subject(s) to be cross-listed with and approval status: N/A
Sections combined/heldwith:

Rationale for request:
The Ethics milestone is obtained upon completion of a 3-day workshop organized by the Faculty of Mathematics, entitled “Ethics in Data Science and Artificial Intelligence”. Alternatively, students can be credited for this milestone by taking the course CS 798 Advanced Topics “Artificial Intelligence: Law, Ethics, and Policy” and obtaining a grade of at least 70%. This milestone should be applied to the following programs:

- Master of Data Science and Artificial Intelligence
- Master of Data Science and Artificial Intelligence - Co-operative Program
- Master of Mathematics in Data Science

Prepared by: Christiane Lemieux Date: 4-Sep-18
Faculty: Math
Effective term: Term/Year Fall 2019

Course ☒ New ☒ Revision ☐ Inactivation ☐
Milestone ☐ New ☐ Revision ☐ Inactivation ☐

New milestone title: N/A  Choose an item.

For course revisions, indicate the type(s) of changes (e.g. consent, description, title, requisites):
N/A

Course Subject code: Choose an item.  Course number: 701
Course Title (max. 100 characters incl. spaces): Data Science Project 1
Course Short Title (max. 30 characters incl. spaces):

Grading Basis:  NUMERICAL
Course Credit Weight: 0.50
Course Consent Required: ☒ Department

Course Description: The student will undertake a significant project on a topic related to data science, under the supervision of a faculty member; graduate officer approval required.

New course description (for revision only):

Meet Type(s): Lecture Reading Choose an item. Choose an item.
Primary Meet Type: Reading

Requisites: Master of Data Science and Artificial Intelligence students only. Graduate officer approval required; a supervisor from Data Science is required to supervise the student. Co-req: DS 702.

Special topics course: Yes ☐ No ☐
Cross-listed: Yes ☐ No ☐

Course Subject(s) to be cross-listed with and approval status: N/A
Sections combined/heldwith:

Rationale for request:

Two electives may be replaced by a significant project (DS 701 and DS 702) under the supervision of one or more faculty members in data science. The project gives the student the opportunity to plan and carry out a research project.
Faculty: Math
Effective term: Term/Year Fall 2019

Course ☒ New ☒ Revision ☐ Inactivation ☐
Milestone ☐ New ☐ Revision ☐ Inactivation ☐

New milestone title: N/A Choose an item.

For course revisions, indicate the type(s) of changes (e.g. consent, description, title, requisites): N/A

Course Subject code: Choose an item. Course number: 702
Course Title (max. 100 characters incl. spaces): Data Science Project 2
Course Short Title (max. 30 characters incl. spaces):
Grading Basis: NUMERICAL
Course Credit Weight: 0.50
Course Consent Required: ☒ Department

Course Description: The student will undertake a significant project on a topic related to data science, under the supervision of a faculty member; graduate officer approval required.

New course description (for revision only):

Meet Type(s): Lecture Reading Choose an item. Choose an item.
Primary Meet Type: Reading
Requisites: Master of Data Science and Artificial Intelligence students only. Graduate officer approval required; a supervisor from Data Science is required to supervise the student. Co-req: DS 701.

Special topics course: Yes ☐ No ☐
Cross-listed: Yes ☐ No ☐
Course Subject(s) to be cross-listed with and approval status: N/A
Sections combined/heldwith:

Rationale for request:

Two electives may be replaced by a significant project (DS 701 and DS 702) under the supervision of one or more faculty members in data science. The project gives the student the opportunity to plan and carry out a research project.
NEW GRADUATE PROGRAM PROPOSAL
OF
MASTER OF MATHEMATICS
IN
DATA SCIENCE

Submitted to the
Ontario Universities Council on Quality Assurance

VOLUME I - PROPOSED BRIEF

SEPTEMBER 2018
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1 Introduction: Learning Objectives and Outcomes

Data Science leverages large volumes of data generated from numerous and diverse sources, as well as any new kind of cloud interaction as it becomes available in our increasingly digital world. Some of the sources generating these large volumes of heterogeneous and dynamically changing data are from application areas such as real-time market data, triangulation across social networks, personalized cancer treatment, internet traffic data, and many other applications that are of value in today’s Canadian society.

The field of Data Science studies the application and development of methods that facilitate insight from available data in order to understand, predict, and improve business strategy, products and services, marketing campaigns, medicine, public health and safety, as well as numerous other pursuits. Included in Data Science are data-driven approaches to decision-making, inference, and exploration, which are now used in many disciplines and fields of study such as health sciences, social sciences, economics, finance, humanities, biology, etc.

The methods of data science involve elements of statistics, computer science, and optimization. The need for integrated graduate training across disciplines is acutely felt across all industries and is widely recognized. To quote the American Statistical Association statement\textsuperscript{1} on Data Science: “[a] substantial collaborative effort is needed for it to realize its full potential for productivity and innovation. While there is not yet a consensus on what precisely constitutes data science, three professional communities, all within computer science and/or statistics, are emerging as foundational to data science: (i) database management enables transformation, conglomeration, and organization of data resources, (ii) statistics and machine learning convert data into knowledge, and (iii) distributed and parallel systems provide the computational infrastructure to carry out data analysis”. The computational heart of data science is optimization. For example, the National Research Council 2013 report "Frontiers of Massive Data Analysis"\textsuperscript{2} labels optimization as a computational "giant" in the field.

The need for highly qualified personnel in this emerging area is well-known and continues to grow. In particular, recently the government of Ontario has made significant investments to address this shortage. From the investinontario.com


website: "In Ontario, we recognize that a knowledge economy is only as good as its talent. That's why we're strengthening our AI talent pipeline by committing to graduate 1,000 AI-related master's grads per year by 2023, while simultaneously increasing the number of annual STEM grads by 25% to over 50,000."

To address growing global needs in this area, in the current brief we propose a new Master of Mathematics in Data Science (MMATH) program in the Faculty of Mathematics. A separate brief introduces the Master of Data Science and Artificial Intelligence (MDSAI) program, which is a coursework option. The distinctions between the two programs are as follows. First, the MMath students will partake directly in supervisors' funded research projects and will write a thesis, whereas MDSAI students will be educated primarily in the classroom. On the other hand, MDSAI students have the opportunity for co-op (i.e., industry internship as part of the degree). These distinctions exist because the programs are aimed at distinct career objectives. Thesis students are preparing for careers in research either in academia or government and industry data science laboratories, whereas MDSAI students are preparing for positions as analysts and developers.

From a resource perspective, the concurrent operations of the programs has obvious benefits for the University. The programs are mutually supportive, sharing a common director and benefiting from complementary curriculum development.

1.1 Brief Listing of the Program

This proposed Master’s program will only be offered as a research program with a thesis requirement (please see the MDSAI brief for details relating to the coursework option). The program will be delivered on campus, with possibly one or two courses taught online.

The thesis program will be a four- to six-term research program, with most student enrolled full-time. Studying part-time will be allowed on a case-by-case basis. The degree requirements will be four courses and a thesis. The tuition will be the same as for existing Master of Mathematics thesis programs in the Faculty of Mathematics.

1.2 Method Used for Preparation of the Brief

The Mathematics Graduate Office has overseen the preparation of the brief. Contents related to admission and degree requirements were developed by the Data Science Committee, which comprises members of the three units involved in the program. Several faculty-wide meetings were held over the period of April 2017 to January 2018 to provide opportunities for discussion on the Master of Mathematics in Data Science (thesis option). A half-day workshop was held with the Centre for Teaching Excellence on January 23, 2018 to 1) discuss the vision of the program, 2) to
develop program outcomes, 3) map the degree requirements to the Graduate Degree Level Expectations and 4) identify ideal attributes of graduates from the program.

1.3 Objectives of the Program

In its 2012-2017 Strategic Plan, the Faculty of Mathematics identified seven priority areas and associated goals to be pursued by 2017. These priorities and goals were developed with broad consultations that aligned with and complement the University of Waterloo’s Sixth Decade Plan (2007 - 2017), Pursuing Global Excellence: Seizing Opportunities for Canada. The Faculty of Mathematics has since then worked on a new strategic plan for the period 2018-2023, which was about to be approved by Faculty Council at the time where this brief was finalized. However, at the time where this program was developed, the 2012-2017 Plan was still in force and thus was used to inform its creation and design. Nevertheless, this program is also consistent with the upcoming 2018-2023 Plan.

Research, graduate education, and undergraduate education are central to the achievement of the Faculty’s mission and vision of success. Of particular relevance to the proposed graduate program in Data Science, the Faculty’s strategic priorities including 1) providing a vibrant research environment and enriched graduate student experience (includes attracting the highest quality graduate students and providing them with the highest quality graduate education); and 2) offering leading-edge, dynamic academic programs. Moreover, two of the four main thrusts, which together formed the mission of the Faculty of Mathematics, were “to provide learning opportunities of unmatched breadth and depth” and “to produce graduates that are in worldwide demand”. The proposed graduate program in Data Science is a fulfillment of this vision and aligns with the strategic priorities of the Faculty.

The proposed program described in this brief is designed to strategically leverage the breadth and depth of research that currently exists in the Faculty of Mathematics in the field of Data Science. It does so by offering an integrated and multidisciplinary approach to data science that can be best achieved with the three supporting academic units, namely the Cheriton School of Computer Science, the Department of Combinatorics and Optimization, and the Department of Statistics and Actuarial Science. Because of this unique, high-quality training, graduates of this program will be in high demand to fill research positions in industry or academia within Canada and abroad.

Data science has been identified as a priority area for the Faculty of Mathematics by the Dean of Mathematics. This emphasis has resulted in a number of new academic credentials related to Data Science. For example, the Faculty now offers a Bachelor of Computer Science in Data Science hosted in the Cheriton School of Computer Science, and a Bachelor of Mathematics in Data Science hosted in the Department of Statistics and Actuarial Science. In addition, the Cheriton School of Computer Science
and Department of Statistical & Actuarial Science each created “specializations” for data science (first cohort enrolled in September, 2017) within existing graduate degree programs in anticipation of (as placeholders for) the proposed programs.

Program objectives
The main objective of this program is to provide the best graduate education and research experience to students so that they may become experts in data science. The overarching objectives of the Master of Mathematics in Data Science are to:

- Integrate knowledge from the fields of computer science, statistics, and optimization, to develop expertise in the field of data science
- Learn to conduct research in the field of data science by working under the supervision of an expert
- Reach a level of expertise in an area of data science that enables the development of an original research contribution in a sub-field of data science
- Develop a thorough understanding of the methods and techniques used in data science to extract relevant and important information from data
- Enable students to understand not only how to apply certain methods, but when and why they are appropriate, so they can gain insight on how they may be adapted to create new and improved methods

These program objectives acknowledge the interdisciplinarity of data science and the importance of developing strong research skills for our students.

Learning outcomes
To achieve the program objectives, graduates of the program should possess the following:

1. Research Skills: Develop the ability to identify approaches that can be pursued to answer a research question in a way that is consistent with the expectations of the relevant discipline(s)
   - Demonstrate solid knowledge of the existing literature on a topic within the field of data science
   - Learn to design methodologies that are needed to answer a research question and to develop an original contribution in an area within data science
   - Develop ability to formulate interesting paths for future work that are relevant for the chosen topic of research

2. Mathematical and Statistical Foundations: Understand the properties of the tools used in data science and apply rigorous methods to demonstrate why these tools work.
   - Understand and derive theoretical properties of new and existing methods involved in data science.
   - Develop mathematical and statistical maturity to ensure that the correct interpretation of data is made.
Proposed Program – Master of Mathematics in Data Science

3. Computational foundations and working with data: Demonstrate proficiency with statistical analysis of data, including data modelling, data processing, and model interpretation
   - Understand the properties of machine-learning algorithms and the optimization techniques on which they rely

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   - Understand the properties of machine-learning algorithms and the optimization techniques on which they rely

4. Interdisciplinarity: Integrate knowledge and ways of thinking from two or more disciplines so that students are able to approach and resolve complex interdisciplinary problems.
   - Explore how research done in one field could be efficiently transposed to a different area of data science

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   - Explore how research done in one field could be efficiently transposed to a different area of data science

5. Independent thinking: Develop independent thinking skills allowing students to carry out a research project.
   - Develop critical and creative thinking by providing students with a thorough immersion in the research process.

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6. Communication Skills: Demonstrate capacity to disseminate research and communicate with experts within a research community.
   - Effectively communicate problem description, methodologies used, and conclusions in a research thesis and possibly scientific publications.

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To ensure that the quality of the Master of Mathematics in Data Science is consistent with the expectations of university degrees in Ontario (as developed by the Ontario Council of Academic Vice Presidents, OCAV), the following program map was developed (Table 1). This program map outlines how the required courses and the thesis component will build the depth and breadth of knowledge within students and provide opportunities for them to apply their skills. Most of the required courses focus on developing methodological competencies. Both the courses and the thesis will give students the opportunity to develop their technical, professional, and communication skills within the field of data science.
Table 1: A map of the program’s course content against the Graduate Degree Level Expectations (GDLEs). Ma indicates a major contribution to the GDLE, Mi indicates a minor contribution, and a blank indicates no contribution. Students are required to take a minimum of four courses for degree completion. In addition, students that are lacking adequate background in computer sciences and statistics may be required to take CS 600 and STAT 845 (respectively) to ensure they have sufficient backgrounds in both fields. Neither of the remedial courses (CS 600 and STAT 845) count towards the four-course requirements.

<table>
<thead>
<tr>
<th>GDLE</th>
<th>Required Courses</th>
<th>Thesis</th>
<th>Ethics</th>
<th>Academic Integrity Module</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
<tr>
<td>STAT 847</td>
<td>At least one course in each of the following disciplines and themes:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CS 651/631</td>
<td>Discipline</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• CS 680/685/686/786/886</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• CO 602/673/650/663</td>
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<tr>
<td></td>
<td>• STAT 840/841/844/946</td>
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</tr>
<tr>
<td></td>
<td>Themes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Machine learning/statistical learning/optimization</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Computer systems and databases</td>
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<td></td>
<td></td>
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<tr>
<td></td>
<td>• Distributed computing</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>• Data exploration</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Advanced Research Topics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Depth and breadth of knowledge</td>
<td>Ma</td>
<td>Ma</td>
<td>Ma (Depth)</td>
<td>Ma (Depth)</td>
</tr>
<tr>
<td>2. Research and scholarship</td>
<td>Mi</td>
<td>Ma (particularly methodological competence)</td>
<td>Ma (particularly methodological competence)</td>
<td>Ma (ii,iii)</td>
</tr>
<tr>
<td>3. Level of application of knowledge</td>
<td>Ma</td>
<td>Ma</td>
<td>Ma</td>
<td>Ma</td>
</tr>
<tr>
<td>4. Professional capacity/autonomy</td>
<td>Mi</td>
<td>Mi</td>
<td>Ma (particularly, critical evaluation of current research and advanced research and scholarship in the discipline)</td>
<td>Ma (particularly, critical evaluation of current research and advanced research and scholarship in the discipline)</td>
</tr>
<tr>
<td>5. Level of communications skills</td>
<td>Ma</td>
<td>Mi</td>
<td>Ma</td>
<td>Mi</td>
</tr>
<tr>
<td>6. Awareness of limits of knowledge</td>
<td>Mi</td>
<td>Mi</td>
<td>Ma</td>
<td>Mi</td>
</tr>
</tbody>
</table>
Table 2: Learning outcomes mapped to Master's Graduate Degree Level Expectations (GDLE)

<table>
<thead>
<tr>
<th>GDLE</th>
<th>1. Depth and Breadth of Knowledge</th>
<th>2. Research and Scholarship</th>
<th>3. Level of Application of Knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning Outcomes</td>
<td>A systematic understanding of knowledge and a critical awareness of current problems and/or new insights…</td>
<td>A conceptual understanding and methodological competence that: i) Enables a working comprehension of how established techniques of research and inquiry are used to create and interpret knowledge in the discipline; ii) Enables a critical evaluation of current research and advanced research and scholarship...</td>
<td>On the basis of that competence, has shown at least one of the following: i) The development and support of a sustained argument in written form; or ii) Originality in the application of knowledge.</td>
</tr>
<tr>
<td>Research Skills: Develop the ability to identify approaches that can be pursued to answer a research question in a way that is consistent with the expectations of the relevant discipline(s)</td>
<td>Ma</td>
<td>Ma</td>
<td>Ma</td>
</tr>
<tr>
<td>Mathematical and Statistical Foundations: Understand the properties of the tools used in data science and apply rigorous methods to demonstrate why these tools work.</td>
<td>Ma</td>
<td>Ma</td>
<td>Ma</td>
</tr>
<tr>
<td>Computational foundations and working with data: Demonstrate programming competency, computational, and methodological skills relevant to the field of data science.</td>
<td>Ma</td>
<td>Ma</td>
<td>Mi</td>
</tr>
<tr>
<td>Interdisciplinarity: Integrate knowledge and ways of thinking from two or more disciplines so that students are able to approach and resolve complex interdisciplinary problems.</td>
<td>Mi</td>
<td>Ma</td>
<td></td>
</tr>
<tr>
<td>Independent thinking: Develop independent thinking skills allowing students to carry out a research project.</td>
<td>Mi</td>
<td>Ma</td>
<td>Ma</td>
</tr>
<tr>
<td>Communication Skills: Demonstrate capacity to disseminate research and communicate with experts within a research community</td>
<td></td>
<td>Ma</td>
<td></td>
</tr>
</tbody>
</table>
### Table 2 (continued): Learning outcomes mapped to Master's Graduate Degree Level Expectations (GDLE)

<table>
<thead>
<tr>
<th>GDLE</th>
<th>4. Professional Capacity/Autonomy</th>
<th>5. Level of Communications Skills</th>
<th>6. Awareness of Limits of Knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning Outcomes</td>
<td>a. The qualities and transferable skills necessary for employment requiring:</td>
<td>b. The intellectual independence required for continuing professional development;</td>
<td>c. The ethical behavior consistent with academic integrity and the use of appropriate guidelines and procedures for responsible conduct of research; and</td>
</tr>
<tr>
<td>i) The exercise of initiative and of personal responsibility and accountability;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ii) Decision-making in complex situations;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Research Skills: Develop the ability to identify approaches that can be pursued to answer a research question in a way that is consistent with the expectations of the relevant discipline(s)</td>
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<td>Mi</td>
<td></td>
</tr>
<tr>
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<td>Mi</td>
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<td></td>
<td>Mi</td>
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<tr>
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<td>Ma</td>
<td></td>
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<tr>
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<td>Ma</td>
<td>Ma</td>
<td>Ma</td>
</tr>
</tbody>
</table>
1.4 Admission Requirements

Applicants will normally have an Honours Bachelor’s degree in data science, computer science, statistics, mathematics or a related field, with a minimum B+ (78%) average from a recognized university. In addition, applicants will also have a background in calculus, linear algebra, statistics, and computer science. Experience at the senior level in both computer science and statistics courses is preferred, but not required. Experience at the senior level in at least one of computer science or statistics is required. Applicants lacking in background may be admitted on probation and required to take and earn a grade of at least 78% in specified qualifying courses.

Applicants will also need to meet the University of Waterloo’s English Language Proficiency requirements (as detailed in the Graduate Calendar).

Two foundation courses in statistics (STAT 845: Statistical Concepts for Data Science) and computer science (CS 600: Fundamentals of Computer Science for Data Science), are available to provide students missing prerequisites from their Bachelor’s degree with the appropriate background to successfully complete the courses required for the MMath. These two foundation courses will not be counted toward the four-course degree requirement.

1.5 Program Structure

1.5.a Structure

In the proposed program, students will have to take at least four courses that cover the core components of data science and complete a thesis. The completion of these courses meet the University of Waterloo’s minimum requirements for a master’s degree (four one-term courses of 0.5 unit weight each, or 2.0 unit weight total).

Of the four courses, three must be chosen from lists focused on a specific topic within data science, namely, data exploration, distributed computing, or machine learning. These courses serve to deepen and widen the students’ backgrounds. The fourth course provides students the opportunity to explore new topics and/or deepen their understanding in a particular topic. The thesis allows students to develop deeper knowledge, exhibit their understanding, and demonstrates their capabilities within the field of data science. The thesis also allows the student to identify and grapple complex issues critically, independently, and creatively while supervised by an expert in the field.

Normally, students will take one or two courses each term until they have completed their required courses. This course load is reasonable given that students will have other commitments such as the research for their thesis and/or their work as teaching assistants.
As part of the degree requirement, students must maintain an average of 75% in their courses. As is the case for all students at the University of Waterloo, they also need to complete the Academic Integrity Module by the end of their first term. Students also need to complete an Ethics Milestone, by either taking a course on this topic as one of their electives, or by completing a three-day workshop entitled “Ethics in Data Science and Artificial Intelligence” that will be offered in the Fall term. More information regarding the program requirements are outlined in Section 2 and 3 (Human Resources and Physical and Financial Resources, respectively).

1.5.b Effect of Structure on Quality
The duration of the program offers students flexibility to build strong foundations in computer science, statistics, and optimization in a course setting and to develop further depth and expertise through their thesis research. This structure is particularly beneficial since students may develop their foundational skills at the same time as their research skills, and can then apply their newly acquired knowledge into their thesis.

1.6 Program Content

The Master of Mathematics in Data Science has been developed to prepare well-rounded Data Scientists through several unique facets built into the program. More precisely, the proposed program is unique in that it 1) integrates ideas and methods from computer science, statistics and optimization, 2) offers the student an opportunity to do research with experts in their field, 3) ensures graduates receive rigorous training allowing them to easily adapt to fast-changing technologies and developments in data science.

To ensure all students are properly prepared to take courses in different disciplines, the program features two foundation courses: one in statistics (STAT 845) and one in computer science (CS 600). When they are admitted in the program, students will be assigned to one (or neither) of these foundation courses depending on their background. Students will then be required to take four courses in different core areas. The Ethics Milestone will ensure students learn to think critically about the legal, ethical and policy implications of new technologies.

According to the University of Waterloo’s Enrolment and Time Limits, the minimum and normal residence requirements for a master’s program is two and three terms (respectively) of full-time enrolment. Since we expect our thesis students to complete their program in four to six terms, they will meet the normal residence requirements to graduate with a master’s degree from the University of Waterloo.

The courses that are likely to be taken by a large number of students in the program follow a standard sequence of offerings in Fall and Winter terms. All courses are
graduate-level courses (600-, 700-, 800- or 900-level), and more information are detailed in Section 4 (Curriculum).

1.7 Mode of Delivery

Courses: Most of the courses in the Master of Mathematics in Data Science program are classroom based, with two courses (CS 600 and CS 638) offered online. The Ethics Workshop will be offered on campus and students will need to attend in person, as their participation in the workshop will contribute to their final mark. The courses in the program have been either specially designed for the data science specializations that were introduced in the Fall 2017 term, or have been selected because of their obvious fit with the objectives and learning outcomes. As presented in Table 1, all courses will build the depth and breadth of knowledge in computer science, optimization, and statistics.

Seminars: The Master of Mathematics in Data Science students will receive weekly announcements for a variety of seminars in the Faculty of Mathematics. Attending seminars will help students to become familiar with current research in data science and the more general disciplines of computer science, statistics, and optimization.

Thesis: The thesis will allow the student the opportunity to conduct research under the supervision of a faculty member. This component of the program will meet the intended program objectives and learning outcomes by enabling the student to develop a deeper understanding of a specific topic, and synthesize new knowledge. The thesis will be a document that includes an introduction, research content, a conclusion, and a bibliography. The research must be novel and original as in all existing MMath thesis programs. Upon completion, the student will present their work to their supervisor and two readers, who will assess the project and approve the thesis (or not). The Faculty of Mathematics MMath thesis procedure provides additional details regarding the thesis process. See Section 4.4 (Curriculum) for more information regarding the thesis.

1.8 Assessment of Teaching and Learning

Students’ level of achievement in meeting the learning outcomes of the program will be evaluated in courses (e.g., assignments, projects, reports, presentations, midterm exams, and a final exam or project) and through their thesis. The thesis will be evaluated by the supervisor and two readers to ensure that the student’s work has met the academic standards at the University. As indicated in Section 4.2 (Program Regulations), students’ performance will be monitored by their supervisor and the Director on a term-by-term basis.

Although the types of evaluations used in courses will vary from year to year, between instructors, and the delivery of the course, Table 3 summarizes the
assessments that may be used to evaluate whether the student has achieved the learning outcomes as indicated in Section 1.3 (Objectives of the Program). The assignments, projects, reports, course projects can be assigned individually or in groups; the latter being important for developing relationships with students that have different academic backgrounds, developing their teamwork skills, and for integrating knowledge from two or more disciplines. Projects in core courses will naturally be interdisciplinary. For this reason, we anticipate that even if the projects were assigned individually, then students will have the opportunity to practice different fields of thinking and/or integrate their knowledge from various disciplines.

Table 3: Summary of teaching and learning assessments that may be used to assess the students’ achievement of the program’s learning outcomes.

<table>
<thead>
<tr>
<th>Learning Objectives</th>
<th>Assignments</th>
<th>Projects</th>
<th>Reports</th>
<th>Midterm Exams</th>
<th>Final Exam</th>
<th>Course Project</th>
<th>Thesis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research Skills</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Mathematical and Statistical Foundations</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Computational Foundations</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interdisciplinarity</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td>x</td>
<td>Depends on thesis</td>
</tr>
<tr>
<td>Independent thinking</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Professional development</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

1.9 Fields in a Graduate Program (optional)

The Master of Mathematics in Data Science program does not offer any fields.

2 Human Resources

Table 4 below contains a list of 31 faculty members from the Cheriton School of Computer Science, the Department of Combinatorics and Optimization, and the Department of Statistics and Actuarial Science, who are part of the Data Science group in the Faculty of Mathematics. Among the group, 30 out of 31 are regular faculty members in the Faculty of Mathematics, and one is a Research Professor specializing in Ethics in Artificial Intelligence. These 31 individuals are the core faculty members for this program (as listed in Table 5).
Table 4: A summary of faculty members in the Data Science group as divided by their units.

<table>
<thead>
<tr>
<th>Cheriton School of Computer Science</th>
<th>Dept. of Combinatorics and Optimization</th>
<th>Dept. of Statistics and Actuarial Science</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Shai Ben-David</td>
<td>1. Thomas Coleman</td>
<td>1. Ryan Browne</td>
</tr>
<tr>
<td>2. Gordon Cormack</td>
<td>2. Ricardo Fukasawa</td>
<td>2. Shoja'eddin Chenouri</td>
</tr>
<tr>
<td>5. Ihab F. Ilyas</td>
<td>5. Chaitanya Swamy</td>
<td>5. Martin Lysy</td>
</tr>
<tr>
<td>11. Peter van Beek</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Justin Wan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Yaoliang Yu</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Of the 31 faculty members, 18 are Professors, five are Assistant Professors, and seven are Associate Professors. As mentioned above, the list also includes a Research Professor. All regular faculty members, except two, have the Approved Doctoral Dissertation Status (ADDS), where they have demonstrated advisory qualifications and are given the privilege to be the sole supervisor of a PhD student (Table 3). The remaining two faculty members are limited to sole supervision of Master’s students and co-supervision of doctoral students until they qualify for ADDS. With more than two dozen full-time faculty members that specialize in various fields within data science, the program will have sufficient numbers of quality experts who are able to teach and supervise students within the program.

Volume II of the proposed brief (Curricula Vitae of the Faculty) includes a list of courses that the faculty have taught which are relevant to data science.

In addition to the academic support provided by the faculty members involved in the program through teaching and mentoring, students in this program will also receive library support through Rebecca Hutchison, who is the Library Liaison for Mathematics, Computer Science and Physics (please see Section 3.1, Library Resources, for more information).

Resources for Graduate Programs Only
Together the group of Data Science faculty members covers all the areas of expertise that are relevant for this program. Significant efforts have already been put in place by many individuals in this group to design and teach new courses that were created for the Data Science specializations currently offered by the Cheriton School of Computer Science and the Department of Statistics and Actuarial Science. These faculty members frequently publish papers in top journals and conference.
proceedings in data science and related fields, and supervise many students working in the different areas listed in Table 3. As a result, students will have experts in data science teaching them the various courses listed in the program, and will therefore be exposed to the latest advances in research in the field. They will also benefit from the expertise of their chosen supervisor(s) to guide their thesis research.

2.1 Faculty, Research Funding, and Graduate Supervision

2.1.a List of Faculty by Field

All members of the Data Science group are core faculty who are expected to be involved in thesis supervision. In addition, all our faculty have PhDs (e.g., computer science, statistics, mathematics, combinatorics and optimization, computer and information systems, applied mathematics, etc.) that are consistent with the program objectives and learning outcomes for the Master of Mathematics in Data Science (please see Volume II: Curricula Vitae of the Faculty). Many of our faculty members are cross-appointed within other academic units in the Faculty of Mathematics.

All three academic units are currently hiring new faculty members. Moreover, recruitment in fields related to data science is a priority for both the Cheriton School of Computer Science and the Department of Statistics and Actuarial Science.

Of the three categories (see below), 30 out of the 31 faculty members in data science fall under Category 2 where they are involved in teaching and/or supervision in this program as well as other graduate programs, and one of them (who is a Research Professor) is in Category 3:

- **Category 1:** tenured or tenure-track faculty members whose graduate involvement is primarily in the graduate program under review. For this purpose, the masters and doctoral streams of a program are considered as a single program. Membership in the graduate program, not the home unit, is the defining issue.
- **Category 2:** tenured or tenure-track faculty members who are involved in teaching and/or supervision in other graduate programs in addition to participating in the graduate program under review.
- **Category 3:** other participating faculty: this category may include those participating in teaching graduate courses on a regular basis, continuing lecturers, emeritus professors with supervisory privileges and/or persons appointed from government laboratories or industry as adjunct professors. For professionals programs this may include on-going contract faculty. Please explain who would fall into this category at your institution.

Although the proposed program does not have any particular fields of study, Table 5 identifies the fields within data science that faculty members have self-identified to be conducting active research. This summary indicates that our researchers have ideal expertise in teaching and supervising students within the field of data science.
Table 5: A list of faculty members involved in the Data Science program, including their rank, home unit, the particular field(s) of study in which a faculty member is active.

<table>
<thead>
<tr>
<th>Faculty Name</th>
<th>Rank</th>
<th>Unit</th>
<th>Field of study</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Artificial Intelligence</td>
</tr>
<tr>
<td>Ben-David, Shai</td>
<td>Professor</td>
<td>CS</td>
<td>x</td>
</tr>
<tr>
<td>Browne, Ryan</td>
<td>Assistant Professor</td>
<td>SAS</td>
<td></td>
</tr>
<tr>
<td>Chenouri, Shojaeddin</td>
<td>Associate Professor</td>
<td>SAS</td>
<td>x</td>
</tr>
<tr>
<td>Coleman, Thomas</td>
<td>Professor</td>
<td>CO</td>
<td></td>
</tr>
<tr>
<td>Cormack, Gord</td>
<td>Professor</td>
<td>CS</td>
<td></td>
</tr>
<tr>
<td>Fukasawa, Ricardo</td>
<td>Associate Professor</td>
<td>CO</td>
<td></td>
</tr>
<tr>
<td>Ghodsi, Ali</td>
<td>Associate Professor</td>
<td>SAS</td>
<td></td>
</tr>
<tr>
<td>Grossman, Maura</td>
<td>Research Professor</td>
<td>CS</td>
<td></td>
</tr>
<tr>
<td>Hoey, Jesse</td>
<td>Associate Professor</td>
<td>CS</td>
<td></td>
</tr>
<tr>
<td>Hofert, Marius</td>
<td>Assistant Professor</td>
<td>SAS</td>
<td></td>
</tr>
<tr>
<td>Ilyas, Ihab</td>
<td>Professor</td>
<td>CS</td>
<td></td>
</tr>
<tr>
<td>Koenemann, Jochen</td>
<td>Professor</td>
<td>CO</td>
<td></td>
</tr>
<tr>
<td>Larson, Kate</td>
<td>Professor</td>
<td>CS</td>
<td></td>
</tr>
<tr>
<td>Li, Yuying</td>
<td>Professor</td>
<td>CS</td>
<td></td>
</tr>
<tr>
<td>Lysy, Martin</td>
<td>Assistant Professor</td>
<td>SAS</td>
<td></td>
</tr>
<tr>
<td>Oldford, Wayne</td>
<td>Professor</td>
<td>SAS</td>
<td>x</td>
</tr>
<tr>
<td>Ozu, M. Tamer</td>
<td>Professor</td>
<td>CS</td>
<td></td>
</tr>
<tr>
<td>Poupart, Pascal</td>
<td>Associate Professor</td>
<td>CS</td>
<td></td>
</tr>
<tr>
<td>Sanita, Laura</td>
<td>Associate Professor</td>
<td>CO</td>
<td></td>
</tr>
<tr>
<td>Schonlau, Matthias</td>
<td>Professor</td>
<td>SAS</td>
<td>x</td>
</tr>
<tr>
<td>Steiner, Stefan</td>
<td>Professor</td>
<td>SAS</td>
<td>x</td>
</tr>
<tr>
<td>Swamy, Chaitanya</td>
<td>Professor</td>
<td>CO</td>
<td></td>
</tr>
<tr>
<td>Tuncel, Levent</td>
<td>Professor</td>
<td>CO</td>
<td></td>
</tr>
<tr>
<td>van Beek, Peter</td>
<td>Professor</td>
<td>CS</td>
<td>x</td>
</tr>
<tr>
<td>Vavasis, Stephen</td>
<td>Professor</td>
<td>CO</td>
<td></td>
</tr>
<tr>
<td>Wan, Justin</td>
<td>Associate Professor</td>
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</tr>
<tr>
<td>Wolkowicz, Henry</td>
<td>Professor</td>
<td>CO</td>
<td>x</td>
</tr>
<tr>
<td>Yu, Yaoliang</td>
<td>Assistant Professor</td>
<td>CS</td>
<td>x</td>
</tr>
<tr>
<td>Zhu, Mu</td>
<td>Professor</td>
<td>SAS</td>
<td></td>
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<tr>
<td>Zhu, Yeying</td>
<td>Assistant Professor</td>
<td>SAS</td>
<td>x</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>2</td>
</tr>
</tbody>
</table>
2.1.b External Operating Research Funding

The following table represents the amount of funding available to support core faculty research and funds that are potentially available to support students’ work, mostly through the provision of graduate research studentship/assistantships. As seen in this table, over the past seven years, faculty members in Data Science have obtained funding and/or grants from a variety of sectors (whether internally or externally).

Table 6 (7 Years) - Operating Research Funding ($) by Source and Year¹ for: Data Science

<table>
<thead>
<tr>
<th>Fiscal Year²</th>
<th>Tri-Agency</th>
<th>Public Sector and Non-Profit Funding</th>
<th>Private Sector Funding</th>
<th>Internal Awards</th>
<th>Equipment Awards</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011/12</td>
<td>$801,372</td>
<td>$1,166,282</td>
<td>$265,859</td>
<td>$0</td>
<td>$103,295</td>
<td>$2,336,808</td>
</tr>
<tr>
<td>2012/13</td>
<td>$865,500</td>
<td>$1,252,891</td>
<td>$64,416</td>
<td>$0</td>
<td>$189,761</td>
<td>$2,372,568</td>
</tr>
<tr>
<td>2013/14</td>
<td>$866,150</td>
<td>$1,141,402</td>
<td>$67,500</td>
<td>$0</td>
<td>$7,000</td>
<td>$2,082,052</td>
</tr>
<tr>
<td>2014/15</td>
<td>$923,651</td>
<td>$1,431,956</td>
<td>$726,508</td>
<td>$0</td>
<td>$464,805</td>
<td>$3,546,920</td>
</tr>
<tr>
<td>2015/16</td>
<td>$857,135</td>
<td>$342,349</td>
<td>$623,524</td>
<td>$15,000</td>
<td>$34,538</td>
<td>$1,872,546</td>
</tr>
<tr>
<td>2016/17</td>
<td>$1,214,324</td>
<td>$457,721</td>
<td>$722,615</td>
<td>$15,000</td>
<td>$165,852</td>
<td>$2,575,512</td>
</tr>
<tr>
<td>2017/18</td>
<td>$1,067,807</td>
<td>$271,116</td>
<td>$791,721</td>
<td>$0</td>
<td>$22,538</td>
<td>$2,153,182</td>
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<tr>
<td>Totals</td>
<td>$6,595,939</td>
<td>$6,063,717</td>
<td>$3,262,143</td>
<td>$30,000</td>
<td>$987,789</td>
<td>$16,939,588</td>
</tr>
</tbody>
</table>

Notes:
1. Data is reported on the primary investigator only. Table includes research awards for primary investigators identified in Table 5.
2. The fiscal year used when reporting research awards is the fiscal year used by the government. The government fiscal year runs from April 1 until March 31, thus the 2011/12 fiscal year runs from April 1, 2011 until March 31, 2012.

Inclusions and Exclusions by each Award Category:
- **Tri-Agency** - Excludes equipment grants (e.g. NSERC RTI.)
- **Public Sector and Non-Profit Funding** - Excludes equipment grants and internal awards (e.g. CFI, UW-RIF, UW-SSHRC).
- **Private Sector** - Includes funding received from Industry partners.
- **Internal Awards** - Includes UW-RIF and UW_SSHRC.
- **Equipment Awards** - Includes NSERC-RTI and CFI.

It is worth noting that the average NSERC grant in Computer Science is significantly larger than in mathematics and statistics.
2.1.c Graduate Supervision

Below is a summary of faculty members with supervisory experience in Data Science. More precisely, Table 7 includes current and completed master’s students, PhDs, and Post-Doctoral Fellows (PDF) by faculty members in Data Science. Over their entire career, Data Science faculty members have successfully supervised over 250 Master’s students, 92 PhD students, and 49 PDF. At the time that this brief was written, they currently supervise 33 master’s students, 47 PhDs, and 10 PDFs. The group of faculty members in Data Science includes a range of early, mid, and late-career researchers.

We note that some faculty members in Computer Science currently have a large number of supervised or co-supervised PhD students, as they are in areas of very high demand.
Table 7: The number of current master’s, PhD, and PDF supervised by faculty members in Data Science, as well as the total number of supervisions throughout their entire career. The appointment type and academic unit (CO=Department of Combinatorics and Optimization; CS=Cheriton School of Computer Science; SAS=Department of Statistics and Actuarial Sciences) are as recorded in Human Resources.

<table>
<thead>
<tr>
<th>Faculty Name</th>
<th>Rank</th>
<th>Home Unit</th>
<th>Master</th>
<th>PhD</th>
<th>PDF</th>
<th>Career Master</th>
<th>PhD</th>
<th>PDF</th>
<th>Current Master</th>
<th>PhD</th>
<th>PDF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ben-David, Shai</td>
<td>Professor</td>
<td>CS</td>
<td>7</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Browne, Ryan</td>
<td>Assistant Professor</td>
<td>SAS</td>
<td>6</td>
<td>5</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
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<td></td>
</tr>
<tr>
<td>Chenouri, Shojaeddin</td>
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<td>SAS</td>
<td>18</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
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<tr>
<td>Coleman, Thomas</td>
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<td>CO</td>
<td>9</td>
<td>2</td>
<td>0</td>
<td>4</td>
<td>2</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Cormack, Gord</td>
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<td>20</td>
<td>10</td>
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<td>0</td>
<td>1</td>
<td>0</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Fukasawa, Ricardo</td>
<td>Associate Professor</td>
<td>CO</td>
<td>6</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>1</td>
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</tr>
<tr>
<td>Ghodsi, Ali</td>
<td>Associate Professor</td>
<td>SAS</td>
<td>9</td>
<td>5</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>0</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Grossman, Maura</td>
<td>Research Professor</td>
<td>CS</td>
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<td>0</td>
<td>0</td>
<td>0</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Hoey, Jesse</td>
<td>Associate Professor</td>
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<td>5</td>
<td>8</td>
<td>2</td>
<td>2</td>
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2.1.d Commitment of Faculty from Other Graduate Programs/Institutions

All faculty members involved in this program are also involved in their academic unit’s own existing graduate programs.
2.2 Quality of Faculty

All members of the Data Science group have PhDs in areas that are consistent with the program objectives and learning outcomes for the Master of Mathematics in Data Science. Many of our faculty members are cross-appointed with other academic units in the Faculty of Mathematics and have collectively taught nearly 100 graduate courses relating to data science.

Among our 31 faculty, they all have demonstrated that they are leaders and innovators in their respective fields by having participated in nearly 598 conference presentations, published 478 papers in refereed journals, published 447 papers in refereed conferences, authored 20 chapters and 9 books, and wrote 25 technical reports. As further evidence of their leadership and expertise, our faculty have been involved in 50+ domestic and international conferences and/or workshops related to data science as organizers, chairs, session leaders, or other leadership roles. Most of our faculty have several years of editorial experience in relevant journals related to data science and artificial intelligence (e.g., Journal of Statistical Computation and Simulation; Journal of Statistical Computation and Simulation; Journal of Finance and Data Science; Journal of Artificial Intelligence Research; Journal of Machine Learning; Discrete Optimization; Journal of Optimization Theory and Application; Computational Intelligence, etc.). Further, some of our faculty have international collaborations in the field of data science and artificial intelligence with other countries including Swaziland, Israel, United States of America, Hong Kong, United Arab Emirates, Qatar, the Netherlands, etc. Together, they collectively have 32 patents.

In addition to their academic experience, the Data Science faculty are well-rounded researchers. Many of them also have non-academic experiences that includes positions such as chief architect of technology, supervisor analyst, advisor, co-founder (of a startup), statistical software programmer, scientific advisor, and consultant.

The background, expertise, and experiences of the Data Science faculty will contribute substantively to the proposed program. Please see Volume II: Curricula Vitae of the Faculty for more information regarding the faculty’s background.

3 Physical and Financial Resources

3.1 Library Resources

The following was prepared by Rebecca Hutchinson (Liaison Librarian for Computer Science and Statistics & Actuarial Science) regarding Library Resources required for the MMath in Data Science program; reviewed by Jennifer Haas (Department Head, Information Services and Resources); and approved by Nick Richbell (Strategic Area
3.1.a Level of support summary

The Library provides a high level of support for the existing graduate courses offered through the School of Computer Science and the Department of Statistics & Actuarial Science in the Faculty of Mathematics, and anticipates that this high level of support will extend to the proposed Master of Mathematics in Data Science Program. Students and faculty members in the proposed program will be encouraged to make use of the teaching, learning and research support services and expertise the Library offers. Current collection strengths would support the new program. No new collections are needed at this time. Should new subject areas emerge or if research intensity develops in subject areas currently outside of collection priorities, the Library is committed to engaging in discussions to articulate collection needs and assess funding implications.

3.1.b Strengths of support provided

The University of Waterloo Library curates a collection with particular strengths in computer science and statistics which includes research databases, full text journals, monographs, numeric data and government publications. Some of the resources of particular interest to these disciplines include IEEE, ACM, Safari Tech, CRCnetBASE and MathSciNet. Texts on data science and big data in general have been collected as appropriate since 2003 to the Instructional Level\(^9\). The subject components of the new courses created for the Data Science specialization include: data sources, databases, and data management; statistics and machine learning; distributed and parallel systems; and optimization. All of these subjects are collected to the Research Level\(^{10}\) and are well represented in the collection. In addition to the local collection, the University of Waterloo Library partners with other Ontario and Canadian universities to further expand access to computer science, statistics, and data science resources. Such collaborations include the Tri-University Group consortium (University of Waterloo, University of Guelph, Wilfrid Laurier University), the Ontario Council of University Libraries (OCUL) and the Canadian Research Knowledge Network (CRKN).

The Computer Science and Statistics & Actuarial Science Liaison Librarian is available to provide research, teaching and learning support for graduate students and faculty. Instructional support includes the development of online modules and research guides as well as the preparation of classroom sessions and outcomes-based workshops. For example, the Librarian provides literature survey workshops for Faculty of Mathematics graduate students. These department specific workshops

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\(^9\) supports undergraduate study

\(^{10}\) includes major published source materials required for master’s degree program, doctoral study and independent research
provide students with an understanding of how research is disseminated, the significance of the literature survey portion of their papers, how to create a comprehensive search, and how to determine scientific impact. The Librarian also offers research consultations with individuals to support coursework, research publications, research data management, meeting open access requirements, and copyright.

3.1.c More information
The Library would be happy to be meet with the program reviewers to discuss this report and answer their questions. For additional information about University of Waterloo Library and the support it provides for programs, please visit https://uwaterloo.ca/library/about/policies-and-guidelines/support-academic-programs.

3.2 Laboratory Resources
Most students in the thesis option will not need laboratory resources. Those students who do require laboratory space will use laboratories provided by their research supervisors. For example, some data science students might sit in the new Data Systems Lab of the Cheriton School (Refer to the Daily Bulletin article of 2017-09-28.).

3.3 Computer Facilities
All faculty and graduate students are provided with an account on the University computing system and either the Computer Science Faculty Computing Facility (CSCF) or the Mathematics Faculty Computing Facility (MFCF) systems depending on the affiliation of their supervisor. The University computing system gives students access to email, internet, the University Library, five terabytes of cloud storage and other on-campus platforms related to courses and education. The MFCF/CSCF systems give students and faculty access to specialized software and compute-servers. The servers include several high-performance Linux clusters and two GPU computing systems. The software includes Matlab, Maple, Python, R, Sage, Julia, and CPLEX as well as web-based software development hosted with Jupyter. These resources are accessible either from student and faculty members' computers and laptops or through thin-client workstations that will be provided in the proposed lounge and lab space. Students with specialized computing needs will also use the laboratory facilities of their supervisors; for example, students whose supervisors belong to the Data Systems group of the Cheriton School will have access to the Data Systems Laboratory.
3.4 Space

It is expected that desk space for approximately 15 additional students is needed. In addition, the Data Science programs will require an office for a graduate director and another office for a graduate coordinator.

The Faculty of Mathematics has committed to provide a computer lab for students enrolled in the Master of Mathematics in Data Science, which would also have a lounge area available for the students from the MDSAI program, which is proposed in parallel. This new space will be acquired over the next three to five years or the space will be repurposed from the Faculty for this program.

3.5 Financial Support

The students are guaranteed support for the duration of the degree (at least five terms) on the condition that they make adequate progress and satisfactory performance on their assigned assistantships. The funding package will be the same for all students in the program, regardless of the department or school of their supervisor. Students in this program will be supported in a manner similar to existing Master of Mathematics research students, namely, a combination of federal, provincial, and university-level scholarships, graduate research studentships (GRS), Graduate research assistantships (GRA) funding from advisors, and teaching assistantships.

For domestic students, a minimum amount of $8,000/term would be offered, as a combination of federal, provincial, and university-level scholarships/awards, graduate research studentship (GRA)/GRS funding from advisors, teaching assistantships (one per term), and other unit-level awards/scholarships. For students without a major award, the level of GRA/GRS/unit-level funding is expected to be around $3,200/term. Domestic students with an admission average of 80% or more and who maintain an average of 80% in the program will receive $1,000 per term via the Domestic Graduate Student Award funded by the Faculty of Mathematics.

For international students, using a similar combination, a minimum amount of $11,333/term would be guaranteed in funding, and would require $4,500/term in GRA/GRS/unit-level funding. These amounts are well above the University of Waterloo’s minimum funding requirements.

Full time students are able to switch to part-time studies. However, part-time students would no longer be eligible for funding.

4 Curriculum

4.1 The Intellectual Development and the Educational Experience of the Student

The program is carefully designed so that upon graduation, students will have developed into rigorously trained Data Scientists who understand not just “how” a
method or algorithm can be applied to a certain problem, but also “why” this method works. The interdisciplinary nature of the program will allow students to gain a deep understanding of how computer science, optimization, and statistics can be used together to solve practical problems. The courses included in the program and research training culminating in the thesis will also ensure that students have reached the desired learning outcomes and ultimately the program objectives.

In addition to the required coursework, the Master of Mathematics in Data Science students will be on the mailing list to receive announcements for research seminars taking place in the Faculty of Mathematics. Attending seminars will allow students to become familiar with current research in data science and other related disciplines.

To further support their educational experience, students will have access to resources in the Faculty of Mathematics such as the Math Faculty Computing Facility and the Math Graduate Student Association. Services relevant to Math graduate students will be highlighted during the Math Graduate Orientation as well as the Master of Mathematics in Data Science student handbook, which will be developed prior to the program start.

Students will also be encouraged to take advantage of the resources and services that are available to all UW students such as: AccessAbility Services, Centre for Career Action, Centre for Teaching Excellence, Counselling Services, GRADventure, Graduate Student Association, Health Services, Student Success Office, Velocity, the Writing and Communication Centre, etc. In particular, the Centre for Career Action and Velocity will be of significance to our students as these resources have workshops regarding searching and applying for meaningful work experiences, as well as building entrepreneurial skills.

Students will be encouraged to present their research at conferences and to participate to graduate student seminars. Since students the Master of Mathematics in Data Science program is a research-based program, students will be able to apply for funding for travel to conferences that is available in each academic unit in the Faculty (provided partly from funds from the Mathematics Graduate Office) and the Graduate Studies and Postdoctoral Affairs. This is in addition to available funding from their supervisor.

4.2 Program Regulations

Please refer to Section 1.4 (Admission Requirements) and Section 4.4 (Curriculum) for details regarding the admission standards and policies as well as courses required by the student to complete the program, respectively. Language requirements will match the minimum admissions requirements by the University. Student must complete the University of Waterloo’s Academic Integrity module, and fulfill their teaching assistantships. The students enrolled in the Master of Mathematics in Data Science program do not have the option of participating in co-op.
To meet the Master of Mathematics program requirements, students are required to take at least four courses and complete their thesis (typically within two years or six terms). As mentioned in Section 3.5, financial support will be guaranteed for five terms. The Master of Mathematics in Data Science is distinct from the Master of Data Science and Artificial Intelligence (MDSAI) in that the former focuses on research and requires a thesis while the latter is a coursework-only master’s program.

Students must also complete an Ethics Milestone by participating in a three-day workshop on “Ethics in Data Science and Artificial Intelligence” that will be offered in the Fall term and scheduled to avoid conflicts with other courses. Alternatively, they can take the course CS 798 Advanced Research Topics on “Artificial Intelligence: Law, Ethics, and Policy”.

In order to remain in good academic standing, students must maintain an average of 75% and a minimum grade of 70% in all of their courses. Progress reports are not required; however, the Director will review students’ overall average every term. Students whose average falls below the program’s minimum requirements may be required to withdraw from the program. The minimum average required by the program is higher than the university’s minimum requirement (70%).

For the Master of Mathematics in Data Science, students are required to write a research thesis. The thesis topic is to be selected with a faculty member who serves as the thesis supervisor. Details regarding the thesis process is outlined in Section 4.4 (Curriculum).

4.3 Part-time Studies
We expect that most students will enroll full-time. Students who initially enroll full-time may be allowed to switch to part-time studies with the permission of the Graduate Director. Although the program is open to part-time students, we expect most students to be enrolled full-time as they would not be able to receive funding otherwise. In addition, most courses (except for two) are not conducive to part-time studies as they are available on campus only, are not typically available during the evenings or weekends, and are not delivered in concentrated modules.

4.4 Curriculum
The University of Waterloo has a minimum full-time enrolment period of two terms for master’s students, which will clearly be met by students in this program. Students in this program will normally begin in the Fall term, although applicants seeking admission in other terms will be considered on a case-by-case basis, with those requests evaluated based on the student’s particular course needs and their availability.

Students will complete at least four courses. Students lacking adequate background in computer science may be required to take CS 600 (Fundamentals of Computer Science for Data Science), and students lacking adequate background in statistics may
be required to take STAT 845 (Statistical Concepts for Data Science). Neither of these courses will be counted toward the four course requirement. The four courses should include:

1. STAT 847: Exploratory Data Analysis
2. Exactly one of:
   • CS 631: Data-Intensive Distributed Analytics, or
   • CS 651: Data-Intensive Distributed Computing
3. At least one of:
   • CS 680: Intro. machine learning
   • CS 685: Machine learning theory
   • CS 686: Intro. to Artificial Intelligence
   • CS 795 / CO 602: Fundamentals of optimization
   • CS 794 / CO 673: Optimization for data science
   • CO 650: Combinatorial Optimization
   • CO 663: Convex Optimization and Analysis
   • CS 786: Probabilistic inference
   • CS 886: Advanced topics in Artificial intelligence
   • STAT 840: Computational inference
   • STAT 841: Statistical learning: Classification
   • STAT 844: Statistical Learning: Function Estimation
   • STAT 946: Topics in probability and statistics
4. The fourth course is normally chosen from the following list. Courses not on this list are subject to the approval of the Graduate Director.

**Machine learning/statistical learning/optimization**
- CS 680: Intro. machine learning
- CS 685: Machine learning theory
- CS 686: Intro. to Artificial Intelligence
- CS 795/CO 602: Fundamentals of optimization
- CS 794/CO 673: Optimization for data science
- CO 650: Combinatorial Optimization
- CO 663: Convex Optimization and Analysis
- CO 769: Topics in Continuous Optimization\(^{11}\)
- CS 786: Probabilistic inference
- CS 885: Advanced Topics in Computational Statistics\(^{11}\)
- CS 886: Advanced topics in Artificial intelligence
- STAT 840: Computational inference
- STAT 841: Statistical learning: Classification
- STAT 844: Statistical Learning: Function Estimation
- STAT 946: Topics in probability and statistics\(^{11}\)

**Computer systems and databases**

\(^{11}\) Note: CO 769, CS 798, CS courses at the 800 level, and STAT courses at the 900 level should be on a topic in Data Science; they are subject to the approval of the Graduate Director.
• CS 638: Principles of database management
• CS 648: Database systems implementation
• CS 656: Computer networks
• CS 657: System performance evaluation
• CS 658: Computer security and privacy
• CS 740: Database engineering
• CS 741: Non-traditional databases
• CS 742: Parallel and distributed databases
• CS 743: Principles of database management
• CS 755: Systems and network architectures and implementation
• CS 848: Advanced topics in databases

**Distributed computing**
• CS 654: Distributed systems
• CS 856: Advanced topics in distributed computing

**Data exploration**
• STAT 842: Data Visualization

**Other**
• CS 798: Advanced Research Topics

Students must also complete the Ethics Milestone.

The thesis requirement consists of the writing of a research thesis and the topic is selected with the guidance of a faculty member in Data Science who serves as the student’s supervisor. The thesis should contain original work in data science, defined as follows (see Section 1): data science is the study and development of methods to extract patterns, knowledge and insight from available data. Data science also comprises the application of these methods in order to understand, predict, and improve business strategy, products and services, scientific, medical and engineering inquiry, public health and safety, as well as other societal pursuits.

The master's thesis is to be submitted electronically to the Faculty of Mathematics Graduate Office with the “Agreement to Read MMath Thesis Form” for a display period of two weeks. The thesis defence consists of a 20-minute presentation by the candidate, followed by detailed questioning by the committee members. A final version of the thesis is to be given to the examining committee at least two weeks before the scheduled defence date.

The examining committee includes the thesis supervisor and two readers. The thesis supervisor and at least one of the additional readers should be members of the Data Science group. The second reader may be any regular faculty member in the University of Waterloo. The thesis should contain original work on data science. The supervisor and committee members should ensure that the thesis is well written and relevant to the discipline. Credit for the master's thesis is assigned when the supervisor and the two readers approve the thesis and the supervisor returns the signed “Thesis Acceptance Certification” form to the Graduate Director.
4.5 Collateral and Supporting Departments

The units involved in operating this program (teaching and graduate advising) are the Cheriton School of Computer Science, the Department of Combinatorics & Optimization, and the Department of Statistics & Actuarial Science. The program has been approved by votes in the three units on the following dates: C&O: 2018-03-09; CS: 2018-04-11; SAS: 2018-04-20.

4.6 Organizational Structure

The Master of Mathematics in Data Science program is not offered in a single academic unit, but is instead supported by three units. For this reason, this program (along with the MDSAI) will operate as a Faculty-based program, similar to the Master of Mathematics in Computational Mathematics.

The Dean appoints the undergraduate and graduate Directors of Data Science and a steering committee for Data Science. The steering committee will have at least one voting member from each of the three units. The same individual may occupy the positions for the undergraduate and graduate Directors.

A full-time graduate coordinator will be hired to support the two graduate programs. Figure 1 summarizes the organizational chart for Data Science.

Figure 1: Administrative organization of the Data Science programs within the University of Waterloo.

In the future, any revisions for the program would need to go through the relevant units and then to the Faculty Council for approval.
5 Projected Enrolment

Thesis option
It is expected that the program will admit 50 students per year for the first three years ramping up to 70 students per year after 7 years\(^\text{12}\). The enrollment will be split roughly 50% domestic, 50% international. These projected numbers for domestic and international students are based on extrapolating existing graduate enrollment in the Faculty and are not net increase relative to existing programs.

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\(^\text{12}\)It is estimated that approximately 50% of the enrolment in this new program will be students who are net new to the institution. We also anticipate some students will be likely to take the MMath in Data Science instead of a different MMath program currently offered at UW once this option becomes available.
6 Financial Plan

A financial viability analysis and financial plan was prepared in conjunction with Institutional Analysis and Planning’s Budget and Resource Planning Team and was approved by the Provost in August, 2018.
GRADUATE PROGRAM PROPOSAL
OF
MASTER OF DATA SCIENCE AND ARTIFICIAL INTELLIGENCE
AND
MASTER OF MATHEMATICS IN DATA SCIENCE
Submitted to the
Ontario Universities Council on Quality Assurance

VOLUME II – FACULTY CURRICULA VITAE

SEPTEMBER 2018
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VOLUME III – EXTERNAL REVIEWERS

SEPTEMBER 2018
Prior to form submission, review the new graduate program instructions. For questions about the form submission, contact Trevor Clews, Graduate Studies and Postdoctoral Affairs.

Faculty: Mathematics

Program: Master of Mathematics (MMath) in Data Science

Program contact name(s): Christiane Lemieux

Form completed by: Jessica Leung

Note: new courses and milestones also require the completion/submission of the SGRC Course/Milestone-New/Revision/Inactivation form (PC docx version).

Proposed effective date: Term: Fall Year: 2019

Graduate Studies Academic Calendar (GSAC) section (include the link to the section (web page) where the new program will be located):

https://uwaterloo.ca/graduate-studies-academic-calendar/mathematics

Proposed Graduate Studies Academic Calendar content:

MASTER OF MATHEMATICS (MMATH) IN DATA SCIENCE

Program information

- Admit term(s)
  - Fall

- Delivery mode
  - On-campus

- Length of program
  - 4 to 6 terms

- Program type
  - Master’s
  - Research

- Registration option(s)
  - Full-time
  - Part-time

- Study option(s)
  - Thesis

Admission requirements
Proposed Graduate Studies Academic Calendar content:

- **Minimum requirements**
  - A four-year Honours Bachelor’s degree or equivalent in data science, computer science, statistics, mathematics or a related field, with a minimum overall average of 78%.
  - Experience at the senior level in computer science or statistics.

- **Application materials**
  - Résumé/Curriculum Vitae
  - Supplementary information form
  - Transcript(s)

- **References**
  - Number of references: 3
  - Type of references: at least 2 academic

- **English language proficiency (ELP) (if applicable)**

**Degree requirements**

**Thesis option:**

- **Graduate Academic Integrity Module (Graduate AIM)**

- **Courses**

  Students must complete at least 4 courses. Students lacking adequate background in computer science may be required to take CS 600 Fundamentals of Computer Science for Data Science, and students lacking adequate background in statistics may be required to take STAT 845 Statistical Concepts for Data Science. Neither of these courses may be counted toward the 4 course requirement. The 4 courses must include:

  1. STAT 847 Exploratory Data Analysis
  2. Exactly 1 of:
     - CS 631 Data-Intensive Distributed Analytics, or
     - CS 651 Data-Intensive Distributed Computing
  3. At least 1 of:
     - CS 680 Intro. machine learning
     - CS 685 Machine learning theory
     - CS 686 Intro. to Artificial Intelligence
     - CS 795 / CO 602 Fundamentals of optimization
     - CS 794 / CO 673 Optimization for data science
     - CO 650 Combinatorial Optimization
     - CO 663 Convex Optimization and Analysis
     - CS 786 Probabilistic inference
     - STAT 840 Computational inference
     - STAT 841 Statistical learning: Classification
     - STAT 844 Statistical Learning: Function Estimation
     - STAT 946 Topics in probability and statistics
  4. The fourth course is normally chosen from the following list:
     - Machine learning / statistical learning / optimization
       - CS 680 Intro. machine learning
       - CS 685 Machine learning theory
       - CS 686 Intro. to Artificial Intelligence
       - CS 795/CO 602 Fundamentals of optimization
       - CS 794/CO 6xx Optimization for data science
Proposed Graduate Studies Academic Calendar content:

- CO 650 Combinatorial Optimization
- CO 663 Convex Optimization and Analysis
- CO 769 Topics in Continuous Optimization (*)
- CS 786 Probabilistic inference
- CS 885 Advanced Topics in Computational Statistics (*)
- CS 886 Advanced topics in Artificial intelligence
- STAT 840 Computational inference
- STAT 841 Statistical learning: Classification
- STAT 844 Statistical Learning: Function Estimation
- STAT 946 Topics in probability and statistics (*)

Computer systems and databases
- CS 638 Principles of database management
- CS 648 Database systems implementation
- CS 656 Computer networks
- CS 657 System performance evaluation
- CS 658 Computer security and privacy
- CS 740 Database engineering
- CS 741 Non-traditional databases
- CS 742 Parallel and distributed databases
- CS 743 Principles of database management
- CS 755 Systems and network architectures and implementation
- CS 848 Advanced topics in databases (*)

Distributed computing
- CS 654 Distributed systems
- CS 856 Advanced topics in distributed computing (*)

Data exploration
- STAT 842 Data Visualization

Other
- CS 798 Advanced Research Topics (*)

(*) Note: CO 769, CS 798, CS courses at the 800 level, and STAT courses at the 900 level should be on a topic in Data Science; they are subject to the approval of the Graduate Director.

- Link(s) to courses
  - Combinatorics & Optimization (CO) courses
  - Computer Science (CS) courses
  - Statistics (STAT) courses
  - Graduate course search

- Milestones
  - Ethics Workshop
    - Students must complete a 3-day workshop on “Ethics in Data Science and Artificial Intelligence” that will be offered in the Fall term. Alternatively, students can complete the course CS 798 Advanced Research Topics on “Artificial Intelligence: Law, Ethics, and Policy”.
  - Master’s Thesis
    - Students must complete a thesis in the field of data science, under the supervision of a faculty member in Data Science. The student must also complete a 20-minute oral presentation.
Proposed Graduate Studies Academic Calendar content:
https://uwaterloo.ca/data-science/ (a new webpage with more information regarding the program will be created)

Discover Graduate Studies web page
https://uwaterloo.ca/discover-graduate-studies/programs

Reviewed by GSPA (for GSPA use only) □ date (mm/dd/yy):
Faculty approval date (09/18/18):
Senate Graduate & Research Council (SGRC) approval date (mm/dd/yy):
Senate approval date (mm/dd/yy) (if applicable):
Faculty: Math
Effective term: Term/Year Fall 2019

Course ☐ New ☐ Revision ☐ Inactivation ☐
Milestone ☒ New ☒ Revision ☐ Inactivation ☐

New milestone title: Ethics Workshop

For course revisions, indicate the type(s) of changes (e.g. consent, description, title, requisites):

Course Subject code: Choose an item.
Course number:
Course Title (max. 100 characters incl. spaces):
Course Short Title (max. 30 characters incl. spaces):
Grading Basis: Choose an item.
Course Credit Weight: 0.00
Course Consent Required: ☐
Course Description: N/A

New course description (for revision only):

Meet Type(s): Choose an item. Choose an item.
Primary Meet Type:
Requisites:

Special topics course: Yes ☐ No ☐
Cross-listed: Yes ☐ No ☐
Course Subject(s) to be cross-listed with and approval status: N/A
Sections combined/heldwith:

Rationale for request:
The Ethics milestone is obtained upon completion of a 3-day workshop organized by the Faculty of Mathematics, entitled “Ethics in Data Science and Artificial Intelligence”. Alternatively, students can be credited for this milestone by taking the course CS 798 Advanced Topics ““Artificial Intelligence: Law, Ethics, and Policy”” and obtaining a grade of at least 70%. This milestone should be applied to the following programs:
- Master of Data Science and Artificial Intelligence
- Master of Data Science and Artificial Intelligence - Co-operative Program
- Master of Mathematics in Data Science

Prepared by: Christiane Lemieux Date: 4-Sep-18
Senate Undergraduate Council met on 13 November 2018 and 11 December 2018 and agreed to forward the following items to Senate for approval. Council recommends these items be included in the regular agenda.

Further details are available: https://uwaterloo.ca/secretariat/committees-and-councils/senate-undergraduate-council

FOR APPROVAL

NEW ACADEMIC PLANS

Faculty of Arts
English Language and Literature

1. Motion: To approve the proposed three-year general English Literature and Rhetoric plan as described below, effective 1 September 2019.

Continuation in this academic plan requires a cumulative minimum overall average of 60% and cumulative minimum English major average of 65%.

Eligibility for graduation in the Three-Year General English Literature and Rhetoric academic plan includes successful completion of the following requirements:

1. Appropriate Program-level requirements. See Bachelor of Arts Degree Requirements.

2. English Plan-level requirements:
   o a minimum English major average of 65%
   o at least six academic course units (12 courses) in English, including:
     - two ENGL courses at the 100-level, excluding ENGL 119, and ENGL 129R/EMLS 129R, ENGL 191/SPCOM 191, ENGL 192/SPCOM 192, and ENGL 193/SPCOM 193 (see Note 1)
     - Survey of British Literature: ENGL 200A, ENGL 200B
     - Criticism: ENGL 251
     - Introductory Rhetoric: one of ENGL 292, ENGL 306A
     - Literature: two of ENGL 305A, ENGL 305B, ENGL 310A, ENGL 310B, ENGL 310C, ENGL 313, ENGL 315, ENGL 316, ENGL 318, ENGL 322, ENGL 325/GSJ 325, ENGL 330A, ENGL 330B, ENGL 342, ENGL 343, ENGL 344, ENGL 345, ENGL 346, ENGL 347, ENGL 348, ENGL 350A, ENGL 350B, ENGL 361, ENGL 362/THPERF 386, ENGL 363/THPERF 387, ENGL 364, ENGL 410A, ENGL 410B, ENGL 410C, ENGL 410D, ENGL 410E, ENGL 410F/GSJ 410F, ENGL 430A, ENGL 430B, ENGL 451A, ENGL 451B, ENGL 460A, ENGL 460B, ENGL 460C, ENGL 460D, ENGL 463, ENGL 484, ENGL 485, ENGL 486
     - History and Theory of Rhetoric: one of ENGL 309A, ENGL 309C
403/DAC 400, ENGL 406, ENGL 407, ENGL 408A, ENGL 408B, ENGL 408C, ENGL 409A, ENGL 470A, ENGL 470B, ENGL 470C, ENGL 471, ENGL 472
  • Elective: one additional ENGL course at the 200-level or above (see Notes 1, 3, and 4)

Notes
1. Students may use only two English courses at the 100-level to fulfill English plan requirements; additional 100-level English courses may count as degree electives. Courses transferred from other institutions without a specific course designation (e.g., ENGL 1XX) may only be counted towards the English electives.
2. ENGL 200A, ENGL 200B, ENGL 251 are strongly recommended for second year.
3. Students are reminded that they may not double count courses to fulfill degree plan requirements. For example, ENGL 306A may be counted as fulfilling the Introductory Rhetoric category or in the Professional Writing, Communication Design; Forms of Media and Critical Analysis; History and Theory of Language category, but it cannot be counted as fulfilling both.
4. A maximum of two of the following courses may be used to fulfill Three-Year General English plan requirements: ENGL 210E, ENGL 210F, ENGL 210G, ENGL 210H, ENGL 210I/LS 291, ENGL 309E, ENGL 376R, ENGL 377R. The following English courses do not fulfill English course requirements for the Three-Year General English plans: ENGL 119, ENGL 129R/EMLS 129R, ENGL 191/SPCOM 191, ENGL 192/SPCOM 192, ENGL 193/SPCOM 193. These courses are designed primarily to make students aware of the different functions of language in various contexts and to assist them in improving their writing.
5. Although the Department of English Language and Literature provides advisors to help students choose their academic plans, arrange their courses, and conform with the University, Faculty, and Department regulations, students are urged to study the Undergraduate Calendar very carefully because they are themselves responsible for failure to abide by these regulations.

Rationale: Some Arts students choose to leave the four-year programs owing to financial constraints, a change in career choice, or admission into a professional degree program such as law. If these students are pursuing a plan in English Rhetoric and Literature or Rhetoric, Media, and Professional Communication, they cannot transition easily into the three-year General English Literature plan, which is modelled on the four-year English Literature major plans. Instead of finding that they can finish their degree more quickly, they often find that they have several courses left to complete. The new three-year English major plans in Rhetoric and Literature and Rhetoric, Media, and Professional Communication will allow students to obtain a three-year degree in the other areas in which we offer four-year plans.

The new plans have been drafted using the Four-Year General plans as a guide. They stick as closely as possible to the four-year plans while reducing the number of required courses for the major from 16 (four-year plans) to 12 (three-year plans). Each plan distributes the Special Topics courses throughout the other required categories, according to the particular topic and historical period on which the Special Topics courses focus.

Faculty of Arts
English Language and Literature

2. Motion: To approve the proposed three-year general English Rhetoric, Media, and Professional Communication plan as described below, effective 1 September 2019.

Continuation in this academic plan requires a cumulative minimum overall average of 60% and cumulative minimum English major average of 65%.

Eligibility for graduation in the Three-Year General English Rhetoric, Media, and Professional Communication
academic plan includes successful completion of the following requirements:

1. Appropriate Program-level requirements. See Bachelor of Arts Degree Requirements.

2. English Plan-level requirements:
   - a minimum English major average of 65%
   - at least six academic course units (12 courses) in English, including:
     - two ENGL courses at the 100-level, excluding ENGL 119, and ENGL 129R/EMLS 129R, ENGL 191/SPCOM 191, ENGL 192/SPCOM 192, and ENGL 193/SPCOM 193 (see Note 1)
     - Survey of British Literature: ENGL 200A, ENGL 200B
     - Criticism: ENGL 251
     - Introductory Rhetoric: one of ENGL 292, ENGL 306A
     - Literature: one of ENGL 305A, ENGL 305B, ENGL 310A, ENGL 310B, ENGL 310C, ENGL 313, ENGL 315, ENGL 316, ENGL 318, ENGL 322, ENGL 325/GSJ 325, ENGL 330A, ENGL 330B, ENGL 342, ENGL 343, ENGL 344, ENGL 345, ENGL 346, ENGL 347, ENGL 348, ENGL 350A, ENGL 350B, ENGL 361, ENGL 362/THPERF 386, ENGL 363/THPERF 387, ENGL 364, ENGL 410A, ENGL 410B, ENGL 410C, ENGL 410D, ENGL 410E, ENGL 410F/GSJ 410F, ENGL 430A, ENGL 430B, ENGL 451A, ENGL 451B, ENGL 460A, ENGL 460B, ENGL 460C, ENGL 460D, ENGL 463, ENGL 484, ENGL 485, ENGL 486
     - History and Theory of Rhetoric: one of ENGL 309A, ENGL 309C
     - Professional Writing: one of ENGL 210E, ENGL 210F, ENGL 210G, ENGL 210H, ENGL 210I/LS 291, ENGL 210J
     - Communication Design: one of ENGL 371, ENGL 392A, ENGL 392B, ENGL 403/DAC 400, ENGL 408A, ENGL 408B, ENGL 408C, ENGL 470C, ENGL 471, ENGL 472
     - Elective: one additional ENGL course at the 200-level or above (see Notes 1, 3, and 4)

Notes
1. Students may use only two English courses at the 100-level to fulfil English plan requirements; additional 100-level English courses may count as degree electives. Courses transferred from other institutions without a specific course designation (e.g., ENGL 1XX) may only be counted towards the English electives.
2. ENGL 200A, ENGL 200B, ENGL 251 are strongly recommended for second year.
3. Students are reminded that they may not double count courses to fulfil degree plan requirements. For example, ENGL 306A may be counted as fulfilling the Introductory Rhetoric category or the Forms of Media and Critical Analysis; History and Theory of Language category, but it cannot be counted as fulfilling both.
4. A maximum of two of the following courses may be used to fulfil Three-Year General English plan requirements: ENGL 210E, ENGL 210F, ENGL 210G, ENGL 210H, ENGL 210I/LS 291, ENGL 309E, ENGL 376R, ENGL 377R. The following English courses do not fulfil English course requirements for the Three-Year General English plans: ENGL 119, ENGL 129R/EMLS 129R, ENGL 191/SPCOM 191, ENGL 192/SPCOM 192, ENGL 193/SPCOM 193. These courses are designed primarily to make students aware of the different functions of language in various contexts and to assist them in improving their writing.
5. Although the Department of English Language and Literature provides advisors to help students choose their academic plans, arrange their courses, and conform with the University, Faculty, and Department regulations, students are urged to study the Undergraduate Calendar very carefully because they are themselves responsible for failure to abide by these regulations.
Rationale: Some Arts students choose to leave the four-year programs owing to financial constraints, a change in career choice, or admission into a professional degree program such as law. If these students are pursuing a plan in English Rhetoric and Literature or Rhetoric, Media, and Professional Communication, they cannot transition easily into the three-year General English Literature plan, which is modelled on the four-year English Literature major plans. Instead of finding that they can finish their degree more quickly, they often find that they have several courses left to complete. The new three-year English major plans in Rhetoric and Literature and Rhetoric, Media, and Professional Communication will allow students to obtain a three-year degree in the other areas in which we offer four-year plans.

The new plans have been drafted using the Four-Year General plans as a guide. They stick as closely as possible to the four-year plans while reducing the number of required courses for the major from 16 (four-year plans) to 12 (three-year plans). Each plan distributes the Special Topics courses throughout the other required categories, according to the particular topic and historical period on which the Special Topics courses focus.

Faculty of Arts
English Language and Literature

3. Motion: To approve the proposed Creative Writing Specialization as described below, effective 1 September 2019.

The Creative Writing Specialization requires successful completion of four courses:

- ENGL 210C, ENGL 335
- two of ENGL 332 (see Note), ENGL 336, THPERF 366

Note
ENGL 332 is a repeatable course. Individual instructors choose the topic or genre of creative writing on which the course will focus. Students may take the course for credit a maximum of twice, provided that the topics in the two iterations of the course are distinct from each other.

Rationale: Creative writing courses are regularly offered and consistently popular. Students with an interest in developing their creative writing skills often take all three of the courses currently on offer. With the introduction of a fourth, repeatable Creative Writing course, ENGL 332 in 2019, a Creative Writing Specialization is feasible. At present, four published creative writers teach most sections of the three courses now on offer; there is strong interest in teaching it. THPERF 366 features scriptwriting and other forms of creative writing for performance.

Faculty of Arts
French Studies

4. Motion: To approve the proposed inactivation of existing certificates and creation of new diplomas in French Language as described below, effective 1 September 2019.

For students registered in degree programs or any non- or post-degree academic plan at the University of Waterloo, two diplomas are offered: French Language I and French Language II. Students must successfully complete 2.5 academic course units (five courses) with a cumulative average of 65% as follows:

French Language I
FR 151, FR 152, FR 192A, FR 192B and one other course taught in French at the 200-level or above.
French Language II
FR 192A, FR 192B, FR 251, FR 252 and one other course taught in French at the 200-level or above.

Notes
1. Diplomas I and II are mutually exclusive. Only one diploma can be granted.
2. Diplomas are not awarded to students pursuing a French plan.

Rationale: These changes are a result of the newly adopted academic curriculum definitions and guidelines. To conform to the newly established guidelines, the certificates offered in Faculty of Arts are being retitled to diplomas. They will also be made available to all students across campus, including non- or post-degree students.

The fifth course requirement was formerly any “course taught in French above the FR 151 level.” Students cannot take another 100-level course to fulfil the fifth course requirement, under either plan. The only 100-level course students used to be able to take to fulfil this requirement was FR 197 (French Culture & Literature: Origins to 1715), which has been renumbered to FR 296 two years ago. The language is being updated to reflect this.

Faculty of Arts
Germanic and Slavic Studies

5. Motion: To approve the proposed inactivation of the existing certificate and creation of a new diploma in Croatian Language as described below, effective 1 September 2020.

Students registered in degree programs or any non- or post-degree academic plan at the University of Waterloo may pursue the Diploma in Croatian Language.

Students must successfully complete two academic course units (four courses) with a minimum cumulative average of 70% as follows:

- CROAT 101, CROAT 102, CROAT 201, CROAT 202

Note
Not all courses are offered on a yearly basis.

Rationale: These changes are a result of the newly adopted academic curriculum definitions and guidelines. To conform to the newly established guidelines, the certificates offered in Faculty of Arts are being retitled to diplomas. They will also be made available to all students across campus, including non- or post-degree students.

Faculty of Arts
Germanic and Slavic Studies

6. Motion: To approve the proposed inactivation of the existing certificate and creation of a new diploma in Dutch Language as described below, effective 1 September 2020.

Students registered in degree programs or any non- or post-degree academic plan at the University of Waterloo may pursue the Diploma in Dutch Language.

Students must successfully complete two academic course units (four courses) with a minimum cumulative average of 70% as follows:

- DUTCH 101, DUTCH 102, DUTCH 201, DUTCH 202
Note
Not all courses are offered on a yearly basis.

Rationale: These changes are a result of the newly adopted academic curriculum definitions and guidelines. To conform to the newly established guidelines, the certificates offered in Faculty of Arts are being retitled to diplomas. They will also be made available to all students across campus, including non- or post-degree students.

Faculty of Arts
Germanic and Slavic Studies

7. Motion: To approve the proposed inactivation of the existing certificate and creation of a new diploma in German Language as described below, effective 1 September 2020.

Students registered in degree programs or any non- or post-degree academic plan at the University of Waterloo may pursue the Diploma in German Language.

Students must successfully complete two academic course units (four courses) in GER, with the exclusion of courses taught in English, with a minimum cumulative average of 70%.

Notes
1. This diploma is not open to students pursuing a German academic plan.
2. Not all courses are offered on a yearly basis.

Rationale: These changes are a result of the newly adopted academic curriculum definitions and guidelines. To conform to the newly established guidelines, the certificates offered in Faculty of Arts are being retitled to diplomas. They will also be made available to all students across campus, including non- or post-degree students.

Faculty of Arts
Germanic and Slavic Studies

8. Motion: To approve the proposed inactivation of the existing certificate and creation of a new diploma in Russian Language as described below, effective 1 September 2020.

Students registered in degree programs or any non- or post-degree academic plan at the University of Waterloo may pursue the Diploma in Russian Language.

Students must successfully complete two academic course units (four courses) in RUSS or REES, with the exclusion of courses taught in English, with a minimum cumulative average of 70%.

Note
Not all courses are offered on a yearly basis.

Rationale: These changes are a result of the newly adopted academic curriculum definitions and guidelines. To conform to the newly established guidelines, the certificates offered in Faculty of Arts are being retitled to diplomas. They will also be made available to all students across campus, including non- or post-degree students.
Faculty of Arts
Spanish and Latin American Studies

9. Motion: To approve the proposed inactivation of the existing certificate and creation of a new diploma in Latin American Studies as described below, effective 1 September 2019.

Students registered in degree programs or any non- or post-degree academic plan at the University of Waterloo may pursue the Diploma in Latin American Studies.

The Diploma in Latin American Studies requires successful completion of two academic units (four courses) taught in English with a minimum cumulative average of 70%, selected from the following:

- Four of SPAN 150, SPAN 217, SPAN 218, SPAN 400, SPAN 410, SPAN 418

Note
The diploma is not open to students pursuing a Spanish plan.

Rationale: These changes are a result of the newly adopted academic curriculum definitions and guidelines. To conform to the newly established guidelines, the certificates offered in Faculty of Arts are being retitled to diplomas. They will also be made available to all students across campus, including non- or post-degree students.

Faculty of Arts
Spanish and Latin American Studies

10. Motion: To approve the proposed inactivation of existing certificates and creation of new diplomas in Spanish Language as described below, effective 1 September 2019.

For students registered in degree programs or any non- or post-degree academic plan at the University of Waterloo, two diplomas are offered: Spanish Language I and Spanish Language II. Students must successfully complete 2.0 academic course units (four courses) with a cumulative minimum average of 70% as follows:

Spanish Language I
SPAN 101, SPAN 102, SPAN 201A, SPAN 201B

Spanish Language II
SPAN 201A, SPAN 201B, SPAN 301A, SPAN 301B

Notes
1. Diplomas I and II are mutually exclusive. Only one diploma can be granted.
2. These diplomas are not open to students pursuing a Spanish plan.

Rationale: These changes are a result of the newly adopted academic curriculum definitions and guidelines. To conform to the newly established guidelines, the certificates offered in Faculty of Arts are being retitled to diplomas. They will also be made available to all students across campus, including non- or post-degree students.

Mario Coniglio
Associate Vice-President, Academic
Report of the Vice-President, Research and International to Senate
January 2018

Nobel Prize Ceremony

Physics and Astronomy Professor Donna Strickland received her 2018 Nobel Prize in Physics at the Nobel Ceremony in Stockholm, Sweden on December 10, 2018. Professor Strickland participated in a number of Nobel events throughout the week including meeting with the Canadian Ambassador to Sweden, Heather Grant; touring the Karolinska Institutet and meeting with the President, Ole Petter Ottersen; and presenting the Nobel Physics Lecture at Stockholm University.

Canada Research Chairs

Four University of Waterloo researchers have been named new or renewing Canada Research Chairs (CRC).

New:

Nicole Nolette (French Studies) – SSHRC Tier 2 Canada Research Chair in Minority Studies ($500,000 over five years)

Duane Cronin (Mechanical and Mechatronics Engineering) – NSERC Tier 1 Canada Research Chair in Trauma Biomechanics and Injury Prevention ($1.4 million over seven years)

Renewal:

Alexander Wong (Systems Design Engineering) – NSERC Tier 2 Canada Research Chair in Artificial Intelligence and Medical Imaging ($500,000 over five years)

Linda Nazar (Chemistry) – NSERC Tier 1 Canada Research Chair in Solid State Energy Materials ($1.4 million over seven years)

International Research Highlights

The Velux Foundation has funded two novel research projects totaling $475,000.

The first project, “Improving Vision in Adults with Macular Degeneration”, with Ben Thompson, School of Optometry and Vision Science is a two-year collaboration with the Hong Kong Polytechnic University to assess whether neuro-modulation improves vision and reading in macular degeneration, and to determine whether it enhances peripheral-reading training. The project has the potential to revolutionize the treatment of patients with central vision loss due to diseases such as juvenile or age-related macular degeneration.

The second project, “Does Social Support Availability Promote Cognitive Function in Middle- and Older-Aged Adults?” with Mark Oremus, School of Public Health and Health Systems is a two-year project that examines whether social support availability affects cognitive function in middle- and older-aged adults.
The Bill & Melinda Gates Foundation has funded two projects totaling $447,000.

The first project, “WHO Essential Diagnostics Models Applied in Specific Sub-Saharan African Countries” with Principle Investigator Susan E. Horton, School of Public Health and Health Systems, aims to use expert technical insight and country data, to model how the WHO Essential Diagnostics List (EDL) might be applied in sub-Saharan African countries. The researchers will provide templates to show how the models can be applied to other sub-Saharan African countries, and develop a spreadsheet application which other countries could use as a tool to examine the costs and outcomes of better access for their own country.

The second project, “Foodborne Disease Epidemiology, Surveillance and Control in African LMIC,” is led by Tine Hald, Technical University of Denmark and Shannon Majowicz, School of Public Health and Health Systems. The project will take a One Health approach that links public-health surveillance data with pathogen occurrence data from food, animals and the environment, to provide the best evidence of the health impact of, and the relative contribution of different courses for foodborne infections in African low-middle-income countries (LMIC).