

FINAL ASSESSMENT REPORT
Graduate Review of Management Sciences
(MAsc, MMSc, MMSc online, PhD and undergraduate option)
May 2013

Review Process

The Self Study was produced in the context of Engineering's Vision 2015 planning exercise. Subcommittees of faculty members worked on different aspects such as undergraduate, graduate, research, funding, etc. The Chair of the Department met with staff to identify weaknesses and strengths. Graduate and undergraduate students met with the Chair, corresponding Associate Chairs and administrators to discuss and identify strengths that should be maintained and challenges that should be addressed.

The review was undertaken by Dr. Oded Berman, Sidney Cooper Chair in Business and Technology, Rotman School, University of Toronto and Dr. Mark Daskin, Clyde W. Johnson Collegiate Professor of Industrial and Operations Engineering and Department Chair, University of Michigan. The site visit occurred on February 7-8, 2013. The site visit on the 7th went as planned: the site visit on the 8th required last-minute changes due to a major snowstorm which closed the university. At very short notice, the meetings for that day were changed to teleconferences. However luckily the reviewers had already had chance to make their site visit the previous day.

The previous OCGS Program Review (2004) at the Graduate level for Management Science noted that much progress had been made since the 1998 review, but commented on nine different issues, to which the Department responded in 2006. OCGS requested a further two-year report, which was submitted in 2009. Issues raised included:

- Integration of the three research areas (Applied Operations Research - AOR, Information Systems - IS, Management of Technology - MOT)
- Achieving Growth Targets
- Admission
- Distribution of Supervision
- The Co-op option
- Graduate Level Course Offerings
- Research Seminar Series
- Re-energizing WATMIMS (**W**ATERloo **M**anagement of **I**ntegrated **M**anufacturing **S**ystems)
- Positioning of Management Sciences

The undergraduate option was reviewed around the same time, and the Department responded in 2005 and also produced a two-year progress report in 2007. There were two main issues at the undergraduate level, namely enrolment in courses other than organizational

behavior (enrolment increased 18%), and improvements in the course scheduling system to make it easier to enroll (this was also addressed, and the university has since built more classrooms holding over 100 students, which removed some of the constraints on scheduling).

Characteristics of the Program

Program Objectives

The main objective of the graduate program in Management Sciences is to train graduate students to study, analyze, and solve management problems within organizations related to the flow and efficiency of processes, socio-technical systems, and information technology.

The master's program is designed for students with an analytical background to prepare them for management positions in technology dependent organizations or staff or advisory positions in organizations which utilize the disciplines represented in the program.

The focus of the MASc is on a thesis master's program. The MMSc is a course work program. For those working in industry or government who wish to obtain an MASc or MMSc on a part-time basis, enrolment in the day classes at the university is possible. Full-time master's students may, if they wish, obtain their degree by means of a cooperative program of study described further below.

There is also a distance education MMSc in the area of management of technology (MMSc Online). It is a full cost-recovery, part-time, degree. Delivery of MMSc Online is by an enhanced distance learning method, with the additional element of optional tutorials delivered by the Internet.

The PhD program is directed to persons who seek university teaching and/or research positions. Its content, which is quite flexible, reflects the research interests of the various members of our faculty.

The objective of the undergraduate option is to provide exposure to management sciences for students enrolled in other undergraduate Engineering programs.

Specific Learning Outcomes

The undergraduate option has four learning outcomes: these are not mapped to the UUDLES since there are no DLEs for options. The graduate programs all share three common core courses, which have associated learning outcomes. Each individual program also has additional learning objectives, which are mapped to the GDLEs, as detailed in the Self Study.

Significant strengths of program

While Management Engineering programs exist in various schools in the US, they are less common in Canada. University of Toronto and McMaster both offer undergraduate options in management within the Faculty of Engineering, however these require additional courses outside those normally required for the Bachelors. The online Master of Management Science is a relatively unique offering within Canada (there are competing online MBA programs, however these offer a different set of skills than a MMSc).

There has been a surge of hiring in the past seven years, and hence the faculty are relatively junior. One full Professor holds the Ontario Research Chair in Public Policy and Sustainable Energy (he is also cross-appointed to another Department in Engineering, as well as a Department in the Faculty of Environment). He is also the Executive Director of WISE, the Waterloo Institute for Sustainable Energy, one of about ten university-funded research centres/institutes.

The reviewers commented that overall they found the programs to be very strong, and the faculty, staff and students to be happy with the department and its degree offerings. They noted the three areas of strength in the department, stated “We see this diverse set of backgrounds to be a major source of strength” and commented that few Engineering Departments would have such diversity. The Department already has many recent appointments, has five positions advertized this year, and several of the senior faculty are likely to retire prior to the next review. They commented that this “creates an environment in which there are many dynamic and exciting junior faculty members” and that “the department is poised to have significant impact and to become a world recognized leader in many of these areas.”

Academic Programs Offered

At the undergraduate level, programs offered include:

- BAsC in Management Engineering (the undergraduate review is occurring in conjunction with the accreditation review, and hence not included in this review)
- Option in Management Sciences

Graduate programs include:

- MMSc
- MMSc (online) in management of technology
- MASc (co-op and regular)
- PhD

There are 3 approved fields in the research programs, as follows:

- Applied Operations Research
- Information Systems
- Management of Technology

Students: Undergraduate

The undergraduate option does not restrict entry (other than being open only to Engineering students, although a large number of students from other Faculties also take these courses). Graduation with this option has increased over the seven years which form the subject of the review, from almost 140 in 2007, to around 200/year in 2011/12. The Department also does a large amount of service teaching to students from all other Faculties.

Students: Graduate

The relatively junior status of the majority of the faculty is an important explanatory factor as to the modest numbers of research students per faculty member in the Department (1.13 per faculty for the MASc, and 1.27 for the PhD). The Department admitted around 16 MASc students per year over the review period, around 32 MMSc students per year, 30 (part-time) MMSc online students, and 7 Doctoral students.

The MASc students finish on average in 2.3 years; the PhD in 6; MMSc students typically complete in 4 terms (1.33 years), and online MMSc students in 8 (2.66). The MASc and MMSc students typically complete around 1 term after the envisaged length of the program; and the completion times for the PhD are longer than is usually desired (and above the average for the Faculty) in Engineering.

The self study provides data for the 2010 entering students (55 of them), of whom 60% were Canadian/permanent resident. The split by individual programs is approximately 50:50 in all programs except the online master's, where almost all the students are Canadian/permanent residents. (Currently although the University of Waterloo offers half-a-dozen online programs, they are predominantly marketed to Canadian students). About 40% of the master's students are women (except for the online program, where only 20% are women, perhaps because these students are later in their careers), and about 25% of the PhD students.

Around 85% of the research students are funded (percentages are similar for both master's and PhD). Students who have passed time limits (2 years for master's, 4 for PhD) typically receive either no or reduced funding, which explains the unfunded students. Funded PhD students receive an average of \$37,000/student/year, and funded research master's students around \$16,000. Note that these amounts include university scholarships which cover the international fee differential fully (for doctoral) and partially (for master's) students, and hence the amount remaining to cover domestic tuition and living expenses is somewhat less generous. About a third of the on-campus MMSc students are funded, and for these the average is around \$13,000/student/year.

The Department aims to have all research master's students publish at least one research article, and all PhD students publish at least two, upon completion. The Department's data on publications of graduates is very incomplete (and relies on information on articles co-published with faculty, likely an underestimate). Over half of graduates publish at least one article. Some of the others take non-academic jobs and have less incentive to publish.

Faculty were surveyed as to the employment of graduates from the seven years under review. The data are incomplete, and are also available only for research and professional programs combined. We assume that these data are primarily for the on-campus students (professional students are already employed prior to enrolment). Of the on-campus students, approximately 60% of the entering class are professional, and 40% are in the research programs. It is also likely that faculty have better data on employment of the research students (who are on campus for longer, and who co-publish with faculty). About 60% of graduates were employed in industry, 25% in academia, and 15% went on to further graduate study. Three-quarters of those employed in industry were working in Canada; half of those taking academic positions remained in Canada, and all but one of those going on to further academic study did so in Canada. It is desired to encourage all Departments to undertake alumni surveys for future reviews, to get better data on post-graduation outcomes.

Faculty

The program has 27.3 faculty (tenure stream and lecturers) of whom 17 have been hired in since 2007 with the inception of the BAsC Management Engineering program (which is being reviewed separately). Hence, the program has a relatively young faculty (of the 24.3 tenure stream faculty, half are Assistant Professors). One faculty member (who is also cross-appointed to another Department in Engineering as well as to the Faculty of Environment) holds the Ontario Research Chair in Public Policy and Sustainable Energy. Despite their relatively junior profile, 7 faculty members are on journal editorial boards or are journal editors.

The Department currently has 8 staff, 6 in administrative positions (supporting the Chair and the academic programs, and 2 staff involved in systems administration.

Reviewers' Recommendations/Departmental response regarding program enhancements

The reviewers were very positive (as quoted above), and offered a number of suggestions for possible improvements, listed below, along with the Departmental responses. These are summarized below (*recommendation in italics*: along with response).

1. *More financial support for MASc and PhD students*: the Department sees three possibilities: additional research funds (as the more junior faculty become established), funding from industrial partnerships (with the help of the Industrial Liaison colleague), and funding from teaching of professional students.
2. *Resist increasing grad numbers at expense of quality*: there has been a large increase in international applications for the MMSc: the Department is moderating the number of international students taken, in order to increase quality.
3. *Reduce teaching loads to allow more time for research*: for those faculty with large supervision loads, the class teaching load is reduced to three (the same as for rest of

Engineering): once the five open positions are filled, it may be possible with these resources to extend the lower teaching load to more faculty. It is noted however that Management Science is more a SSHRC than an NSERC discipline, and the teaching expectations and role of graduate students in faculty research are not the same in both areas.

4. *Consider having foundational courses in summer before fall entry:* the Department does not wish to offer additional graduate courses in spring term; however they will study the possibility of allowing incoming students to take undergraduate foundations courses which are offered in spring.
5. *Offer more advanced versions of the foundational courses for PhD:* this is not possible as the PhD class is too small. However two sections of each of the three foundations courses may be offered (class size is now too large).
6. *Reduce formal course requirements for MASc (relative to MMSc requirements):* it is intended to reduce the requirement to five (from the current eight required for the MMSc): change was approved by the Department April 1 2013.
7. *Additional course work at the PhD level:* currently PhD students take between 3 and 6 courses (those who took the foundations courses in the master's program take only 3). There are no plans to increase this number.
8. *Offer a greater diversity of graduate courses:* this is happening, as the newly-hired faculty move towards teaching a full load. Rules were changed to permit MASc students to take one (500-level) undergraduate course, and MMSc students to take two: this also increases course diversity. The Calendar offerings also understate course availability, as many faculty offer reading courses to suit individual students interests.
9. *Create a PhD internship program:* Students are encouraged to take Mitacs internships.
10. *Develop comparative measures and metrics of student success (jobs at 1,5, 10 years after graduation):* this would be valuable information, but staff support is not currently sufficient to do surveys to measure this.
11. *Integrate the three areas, in*
 - *healthcare*
 - *sustainable energy and smart grids*
 - *data or business analytics*

The Department agrees that making students aware of areas of application, which integrate skill from all three areas, could be valuable.

12. *Re: Option: Have some stochastic modeling and simulation in MSCI 331, and less optimization.* While the Department sees the advantages of this (since option students do not all take MSCI 431, on stochastic modelling), the disadvantage is the MSCI 331 is a requirement also in the BAsC program which requires this material, and therefore has to be taught every term. It is not feasible to provide separate courses, because BAsC students who failed the course and needed to repeat, would not be able to take the option course.
13. *Partner with Psychology and other disciplines for MoT area (Management of Technology):* the Department already works informally with Sociology, Psychology and Economics for example; but does not plan to make this more formal.

14. *Provide more information about courses for grad students, e.g. place course outlines online, hold information sessions:* the Department agrees and plans to change more “topics” courses to regular courses (with defined course descriptions), as well as to post past course outlines on the web.
15. *Expand availability and integrate databases (Quest, OFIS) to enhance support by staff:* will pursue, in conjunction with Graduate Studies Office.

Two-Year Plan

By August 31 2015, the Department will report on the following steps/issues:

1. Additional funding for research students, coming from industrial projects, and from revenue from additional professional students (recommendation 1).
2. Report on average number of courses taken by MASc and PhD students: by offering the option of enrolling in undergraduate courses (MSCI 211, MSCI 263, MSCI 331) in spring for students requiring these foundational skills, this should decrease courses taken as graduate students (and could assist with time to completion) (recommendation 4).
3. Greater diversity of graduate courses (recommendation 8).
4. Create a PhD internship program (recommendation 9).
5. List employment of graduates on website (recommendation 10).
6. Suggest groupings of courses into domains of interest on website (recommendation 11).
7. Change some topics courses to regular courses with course descriptions, to provide greater clarity for students (recommendation 14).

Further progress on recommendation 1, and progress on recommendations 3 and 15 will occur after September 2015, and will be reported on at the next cyclical review. Items 2, 6 and 13 are already in progress; items 5, 7 and 12 will not be actioned (reasons explained briefly above).

The Department has recommended the actions to be taken in response to the review, has received approval of the Dean, and this will be discussed at Senate Graduate and Research Council/Senate Undergraduate Council or both (as relevant) and received at Senate. The Department is responsible for follow-up; any resources required not available in the Department need to come from the Dean.

Timelines

Review visit February 7-8 2013.

Review received by GSO February 9 2013

Departmental response received by GSO April 29 2013

Dean's response received April 29 2013

For discussion at Senate Undergraduate Council May 14 2013

For discussion at Senate Graduate and Research Council May 13 2013

For information at Senate June 17 2013