UNIVERSITY OF TORONTO

University of Toronto Quality Assurance Process (UTQAP)
Cyclical Review: Final Assessment Report and Implementation Plan

Programs Reviewed:	• Chemical Engineering, BASc • Chemical Engineering & Applied Chemistry, MEng, MASc, PhD
Unit Reviewed:	Department of Chemical Engineering & Applied Chemistry
Commissioning Officer:	Dean, Faculty of Applied Science & Engineering
Reviewers (Name, Affiliation):	1. Professor Jennifer S. Curtis, Dean, College of Engineering, University of California, Davis 2. Professor Marc Deshusses, Civil and Environmental Engineering, Director of the Energy Engineering Program, Duke University 3. Professor Peter Englezos, Professor and Head, Chemical and Biological Engineering, University of British Columbia 4. Professor Andrew Hrymak, Dean, Faculty of Engineering, Western University
Date of Review Visit:	March 3 – 4, 2016
Date Reported to AP&P:	November 1, 2016

1 Outcome

The Committee on Academic Policy and Programs (AP&P) concluded that the Decanal response adequately addressed the review recommendations.

2 Significant Program Strengths

Undergraduate Program

Chemical Engineering, BASc

- Overall quality
  - Strong reputation with a diverse student population in terms of gender, domestic vs. international, and a significant percentage of out of province students
- Objectives
  - Undergraduate degree level expectations in line with CEAB's graduate attributes
  - Program supports students' cognitive, behavioral and affective development—a unique approach for programs of this kind in Canada
  - Department does an excellent job developing students' skills and attitudes for effective leadership, group work, and communication
  - Aligned learning goals and assessment
  - Students are enthusiastic about the program and the clarity around course objectives and degree level expectations
- Admissions requirements
  - In demand program, attracting international students (one in four) and out-of-province students (one in five)
  - The program has 44% female students
- Curriculum and program delivery
  - Opportunities for learning outside of the classroom
  - Faculty are actively engaged and committed to modernizing the curriculum, emphasizing active learning and more project- and team-based learning
  - Maximum accreditation by CEAB, without any concerns
  - Attractive learning atmosphere that facilitates the engagement of the various members of its ecosystem, responsive to student concerns
  - Strategic initiative to modernize the curriculum, specifically to enhance active and experiential learning, the global nature of the engineering profession, advances in learning technologies, and the recognition that intense investments in laboratory instruction are a great opportunity
  - Laboratory renewal task force's work will enable the program to realize its learning objectives within this space
  - Well-organized and resourced undergraduate chemistry lab
  - Students engage in design activities during all four years and it is excellent that there is horizontal integration across different courses
  - Use of technology for the engineering economics course makes it attractive and engaging to students
  - Students are enthusiastic about the opportunity to engage in team projects
  - Students appreciate the opportunity to participate in organized field trips to experience chemical engineering in practice in different settings
  - Opportunity for students to complete interdisciplinary minors

  - International exchange program allows students to complete part of their course work abroad
  - Tenure-track faculty members primarily teach the courses, while industry practitioners are involved in the capstone design project
- Assessment of learning
  - Grade-based methods in lecture-based courses complemented by assessment methods that are suitable for team and project-based learning formats
- Quality indicators
  - Tracks graduate outcomes through alumni surveys
  - Commendable strategic objectives to push teaching excellence to a level above current status
  - Graduates enter a wide array of career opportunities from the chemical process industries and resource-processing sector to high technology, and pursue professional degrees in the health sector
- Students
  - Very enthusiastic about attending the program, the collegial and supportive environment in the department and the easy access to professors
  - Department accommodates student needs
  - Program recognizes and celebrates student success and achievements
  - Diversity is a strength, especially in gender balance and the mix of students' backgrounds/countries of origin
- Support
  - Professors available to students; students appreciate access

Graduate Program

Chemical Engineering, MEng, MASc, PhD

- Overall quality
  - Impressive caliber of research and educational programs
  - Collegial atmosphere creates a safe and productive environment for everyone to excel
  - PhD and MASc graduate programs are intimately tied to research
  - Strategic goal of increasing research funding substantially during the next five years will impact the graduate program, likely increasing the need for top students
- Objectives
  - Five common degree level expectations for the programs
  - Sixth expectation reflects the fact that the MEng is a course-based degree, and that the MASc and PhD programs expect students to generate new knowledge or understanding
  - Concerted effort to provide opportunities for students to engage in professional development activities; helps prepare them to meet the other expectations ("level of application of knowledge professional autonomy", "level of communication skills", and "awareness of the limits of knowledge")
  - Commendable introduction of the Student Discovery Award, which is an indicator of achieving excellent performance

- Admissions requirements
  - Department has done an excellent job of broadening the pool of graduate students by admitting non-U of T graduates with a wide spectrum of interests
- Curriculum and program delivery
  - Broad array of research carried out in energy, water, environment, sustainable processing and health
  - Department is engaged in a discussion about course alignment with program goals and is working to ensure sufficient course offerings and access in both terms
  - Likely that the proposed course focusing on Scientific Research Methods will enable students to do their literature search, complete literatures reviews, and formulate their research objectives more effectively
- Assessment of learning
  - Department is proactive in monitoring student progress through the efforts of the Associate Chair and Graduate Coordinator, and with support from knowledgeable staff
- Enrolment
  - Successful MEng enrolment increases over the past five years
- Support
  - Active graduate student association
  - Graduate students feel like part of a department team

Faculty/Research

- Overall quality
  - Bold, ambitious research vision and research directions relevant to society
- Research
  - Level of funding and success in landing competitive grants are remarkable accomplishments that reflect the high quality and relevance of the research in the department
  - Organized into eight clusters, with faculty member participating in 3 or 4 clusters—highlighting the multidisciplinary and collaborative nature of the department
  - The five research priority areas—water, environment, sustainable energy and processes, and health—are relevant and correspond to societal need
  - Significant funding for research in these areas, both from provincial and federal governmental agencies, and from corporation
  - Funding has been on a generally upward trend of about 20% increase per year
  - Funding per faculty is high, on par with top ranked institutions in North America
  - Research centres address important questions and play a major role in bringing investigators together, thereby strategically leveraging financial and human resources
  - Department's plan is to initiate three more similar multi-investigators, multidisciplinary centres in the next five years
  - Encouragement and reward for collaborative research with the other academic units within the Faculty and University equally promoting interdisciplinary efforts

- Faculty
  - Very distinguished faculty, who have earned many U of T, national and international recognitions
  - Assistant professors feel well supported and mentored by senior colleagues
  - Collegial group of faculty, postdoctoral researchers and staff researchers, and graduate students

Administration

- Relationships
  - Very high morale, fostered by positive leadership
  - Supportive and engaged Board of Advisors
- Organizational and financial structure
  - Staff members feel respected and appreciated by faculty and students for the work that they do, and they are included in decision making
  - Very good facilities, with excellent scientific equipment and well-run labs
  - Commendable safety procedures
  - Staff indicate that there are opportunities for enhancing their knowledge and for career development
- Planning / Vision
  - Ambitious and visionary five-year plan draft that clearly aligns with the Faculty and University planning documents
  - Discussions around the strategic plan showed engagement from all stakeholders
- Reputation / Profile
  - Department compares very well with the top 30 or 40 chemical engineering departments in the world
  - Status relative to other institutions points to the relevant work carried out by the department

3 Opportunities for Program Enhancement

Curriculum & Program Delivery

- The reviewers noted that undergraduate students have a great deal of experiential and lab work, but may have less time for research activity.
- The reviewers recommended tracking Ph.D. student outcomes and continuing to prepare students for diverse career pathways. They recommended requiring core coursework in chemical engineering principles.
- The reviewers recommended developing specific indicators of achievement for the research-based graduate degrees so that students know when they have met expectations for scholarship, potentially impacting students' time-to-completion.

Relationships & Planning

- The reviewers encouraged the department to continue its successful work in diversifying the student population.
- The reviewers recommended prioritizing the departments' strategic goals.
- The reviewers encouraged creating stronger relationships with alumni and that the department's Board of Advisors assist the department integrate professional development into the Ph.D. program, as well as with further advancement activities.

4 Implementation Plan

Immediate Term (6 months)

- The reviewers noted that undergraduate students have a great deal of experiential and lab work, but may have less time for research activity.
  - Receive the report from the Laboratory Task Force on the role of our labs, and create a process for implementing and integrating the recommendations across the curriculum. Develop a plan to enhance the infrastructure of our flagship Unit Operations Lab, with support from the Dean's Strategic Initiative fund to allow a wider range of experiments, including those that are exploratory in nature, thereby adding a research component
  - Hire a teaching stream appointment for our Unit Operations Lab to replace a retirement
  - Through a student survey and our annual town hall, quantify student demand for research experience (thesis, summer or other} and identify any barriers in achieving this
  - Identify additional channels (e.g., via our website/social media} in which to communicate to our undergraduate students opportunities for the undergraduate thesis, including the potential to link theses to summer research and graduate studies
- The reviewers recommended tracking Ph.D. student outcomes and continuing to prepare students for diverse career pathways. They recommended requiring core coursework in chemical engineering principles.
  - Work with the Chemical Engineering Graduate Students Association to enhance opportunities to connect graduate students with industry, such as revamping our annual industry open house to more fully engage them
  - Work with the Faculty's Hatchery to develop options for graduate students interested in entrepreneurship
  - Through our recently launched ChemEConnect social media platform, develop a roster of graduate alumni who are interested in professionally mentoring and engaging with graduate students, and use the platform to track graduate alumni's careers
  - Participate in the development and implementation of Faculty's piloting of a professional development program for PhD students who are not planning to pursue an academic career
  - Promote the Graduate Professional Skill program administrated by the university's School of Graduate Studies
  - Through the department's graduate curriculum committee, review fundamental course offerings and requirements

  - Roll out the recently developed Research Methods and Project Execution for Graduate Students in Chemical Engineering course as a requirement for all incoming research-stream students
- The reviewers recommended developing specific indicators of achievement for the research-based graduate degrees so that students know when they have met expectations for scholarship, potentially impacting students' time-to-completion.
  - Develop and publicize typical indicators of achievement regarding publication output for MASc and PhD students, and expected time-to-completion for PhD students. Revise PhD reading committee forms to track these measures at committee meetings
  - Enhance communication of the importance of scientific publications and time-to-completion during orientation sessions
  - Communicate expectations more effectively via our updated website
- The reviewers recommended prioritizing the departments' strategic goals.
  - Further develop details of the strategic goals at our annual department retreat. For example, in June 2016, we reviewed all five initiatives with a focus on the first and third
  - Conduct an administrative review, beginning with technical services
  - Develop a strategic planning committee consisting of the leads of each initiative.
  - The committee will meet three times per year to ensure that each initiative is regularly reviewed and that progress is tracked and reported on at department meetings. The first meeting took place on September 20, 2016.
- The reviewers encouraged creating stronger relationships with alumni and that the department's Board of Advisors assist the department integrate professional development into the Ph.D. program, as well as with further advancement activities.
  - Roll out ChemEConnect, our social media platform, to further engage and identify a roster of alumni that allows them to specify how they would like to be involved (e.g., as mentors or guest speakers, with graduate student professional development, etc.)
  - Work with the Board of Advisors to develop a plan to increase and enrich alumni and industry involvement beyond our current endeavours
  - Continue to renew our Board of Advisors with two new members per year
  - Develop a Senior Board of Advisors to continue engaging our "retired" Board members as Department ambassadors without requiring them to be at regular Board meetings
  - Reconsider our annual industry open house (now in its third year) to better engage a wide range of graduate students wanting to enrich their professional development

<u>Medium Term (1-2 years)</u>

- The reviewers noted that undergraduate students have a great deal of experiential and lab work, but may have less time for research activity.
  - Work with two new teaching-stream appointments (J. Farmer hired in July 2016, and another faculty member to be hired in July 2017} to develop additional inquiry- based labs
  - Enhance infrastructure for the Unit Operations Lab
  - Fundraise and gradually implement/test new experiments

- The reviewers recommended tracking Ph.D. student outcomes and continuing to prepare students for diverse career pathways. They recommended requiring core coursework in chemical engineering principles.
  - Revamp our industry open house to more directly engage graduate students
  - Engage graduate student alumni as mentors in the graduate program to develop professional and innovation/entrepreneurial skills
  - Implement recommended changes to fundamental course offerings and requirements
- The reviewers encouraged the department to continue its successful work in diversifying the student population.
  - Work with the Faculty's new Director of Engineering Pathways and Indigenous Partnerships to enhance recruitment and outreach to First Nations, Metis and Inuit communities
  - Continue to work with the Faculty on undergraduate and graduate recruitment strategies designed to enhance diversity
  - Work with and continue to support the National Society of Black Engineers (NSBE) student chapter at UofT in their outreach to high school students.
  - Enhance advertisement of our graduate program, including Graduate Research Days, though social media

<u>Longer Term (3-5 years)</u>

- The reviewers noted that undergraduate students have a great deal of experiential and lab work, but may have less time for research activity.
  - Significantly shift the nature of experiential learning with less time in "routine labs" and more time focusing on inquiry-based components
  - By understanding the student demand for and barriers to the research experience, enable a research experience for all interested undergraduate students
- The reviewers recommended tracking Ph.D. student outcomes and continuing to prepare students for diverse career pathways. They recommended requiring core coursework in chemical engineering principles.
  - 1,000 engaged alumni registered in ChemEConnect, 20% of whom are graduate alumni
- The reviewers recommended prioritizing the departments' strategic goals.
  - The reviewers noted the high degree of faculty buy-in of the department's vision and strategic initiatives. The department leadership team (chair and associate chairs) noted the reviewers' suggestion to prioritize our five strategic goals, and discussed this with the chair of our Board of Advisors and strategic planning facilitator and mentor, Daryl Wilson. We are heeding his advice and that of the Board to refrain from prioritizing our goals at this early stage. While we appreciate that this is ambitious, we intend to pursue all five initiatives over the next five years. We recognize that each initiative will have various levels of involvement and will continuously reflect on and adjust them. The initiatives are:
    1. Initiate large multi-researcher/multi-disciplinary (MR/MD) collaborative programs around our vision
    2. Create a modern chemical engineering curriculum aligned with our vision
    3. Elevate teaching excellence, effectiveness and impact

4. Catalyze the synergy of our external networks with our internal capability for societal and economic impact
5. Reorganize and streamline administrative support systems efficiency to drive overall organizational and space effectiveness

- Significant, measurable progress on all five initiatives

- The reviewers encouraged creating stronger relationships with alumni and that the department's Board of Advisors assist the department integrate professional development into the Ph.D. program, as well as with further advancement activities.
  - 1,000 alumni engaged through ChemEConnect with 200 "actively engaged" (participating in at least one departmental activity each year)

5 Executive Summary

The spokesperson for the Reading Group reported that the summary covered the full Review report. The Group agreed that the Dean's administrative response overall addressed the identified issues. The Reading Group commented on the strength of the review and the response. Questions were raised relating to doctoral student time to completion, faculty invention disclosure, the global ranking of the department, engagement with alumni and recruitment of gender minorities.

Dean Amon reported that while various initiatives were underway to improve time to completion, the current time to completion was consistent with other departments. Turning to disclosure of faculty inventions and Departmental ranking, Professor Allen, Chair of the Department of Chemical Engineering & Applied Chemistry, noted that as many of the Department's faculty collaborated with other departments, such as the Department of Biomedical Engineering, statistics concerning disclosure of inventions and Departmental rankings did not always accurately capture current reality. In many cases, faculty in the Department conducted research within subdisciplines in the Department so when considering Departmental rankings this should be considered. With respect to alumni engagement, Professor Allen outlined several initiatives to increase faculty engagement which included both online as well as in-person outreach. Finally, Professor Allen noted that the Department would be open to examine initiatives to attract students from gender minorities.

No follow-up report was requested.