UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE & ENGINEERING

Report No. 3407 Revised

MEMORANDUM

To: Faculty Council

From: Professor Markus Bussmann
Chair, Engineering Graduate Education Committee

Date: December 9, 2013 for December 11, 2013 Faculty Council Meeting

Re: **New Collaborative Program in Engineering Education**

REPORT CLASSIFICATION

This is a major policy matter that will be considered by the Executive Committee for endorsing and forwarding to Faculty Council for vote as a regular motion (requiring a simple majority of members present and voting to carry).

SUMMARY

This proposal is for the creation of a collaborative graduate program in engineering education (EngEd) at both the master's and Ph.D. levels. This program will involve units in the Faculty of Applied Science and Engineering (FASE) and the Ontario Institute for Studies in Education (OISE), and be led by FASE.

The program will allow students to explore learning at the nexus of education and engineering practice, focusing the thesis-based research required for their home program in the same area. Topics addressed will span the knowledge base, learning processes, people in engineering programs, surrounding socio-cultural context, and the outcomes that result.

Engineering education research differs from other education research because it considers the distinct aspects of engineering education such as its inherent emphasis on design, quantification, application, systems, constraints, and problem solving. Another distinction is investigation of the broader development of engineers as they acquire their professional identity and competencies.

Like traditional engineering research, research in engineering education can involve the development of innovative tools and technologies. However, it can also focus on understanding better the factors involved in the development of a student from a novice to an engineer, and techniques for improving that educational process.

Establishing this collaborative program will benefit students and faculty interested in EngEd, by creating a community of practice – a place where faculty members and students research, learn, and practice. Coursework will provide OISE and FASE students with a foundation in engineering learning, knowledge, assessment and culture/community along with the theoretical foundations, methods, and topics related to engineering education research. More broadly, creation of this program will strengthen ties between FASE and OISE, and yield research findings that may benefit Science Technology Engineering and Math learning in K-12, university level instruction of engineering, and continued professional training after post-secondary education.

REVISIONS

The original proposal was distributed to Council members on November 27. It has since been revised as follows based upon subsequent input from SGS and the Office of the Vice-Provost, Academic. The only substantive change to the program structure is that the proposed practicum was removed as it was felt that including it would be perceived as adding to the home program degree requirements and potentially extending time to completion. Other editorial changes were made to increase the likelihood that the proposal will be approved by the province's Quality Council:

1. References to OISE as a program participant have been replaced throughout with the "Department of Curriculum, Teaching and Learning". The names of the participating FASE departments have been included in more places.
2. "Collaborative" has been added throughout and other wording has been revised to better emphasise that this is a collaborative program.
3. More emphasis has been added throughout on the foundation provided by the home programs. (pp. 2, 3, 6, 11,12)
4. A clause has been added, acknowledging that the program is dependent on the participation of the CTL department and at least one Engineering department. (p. 2)
5. The order of two paragraphs have been switched. (p. 4)
6. Two sentences have been added to describe how and why this collaborative program is distinct from existing programs. (p. 6)
7. Wording has been added affirming that the collaborative program requirements can be completed as part of the home program requirements. (pp. 6, 8, 21-23)
8. A sentence has been added to more clearly indicate that students who complete the collaborative program at the masters level can enrol in it again at the PhD level. (p. 7)
9. Appendix A has been revised to include the home program degree requirements, to more directly show how the collaborative program requirements are filling elective room within the home program requirements (p. 21-23)
10. A statement has been added, that all graduate units have been consulted and are committed to the collaborative program. (p. 28)

PROPOSAL/MOTION

THAT a new graduate collaborative program in Engineering Education be approved and introduced in the 2014-2015 academic year.

UNIVERSITY OF TORONTO

University of Toronto

Collaborative Program in Engineering Education (Master's and Ph.D. Levels)

Expedited Approval

Name of Proposed Program:	Collaborative Master's and Doctoral Program in Engineering Education
Lead Faculty / Academic Division:	Faculty of Applied Science and Engineering
Lead Faculty / Academic Division Contact:	Professor Markus Bussmann Vice-Dean, Graduate Studies Professor Greg Evans Department of Chemical Engineering & Applied Chemistry
Anticipated Start Date of New Program:	September 2014
Version Date:	December 9, 2013

University of Toronto

Proposal for New Graduate Collaborative Program in Engineering Education

(Expedited Approval)

Table of Contents

1 Program Rationale

This proposal is for the creation of a collaborative graduate program in engineering education (EngEd) at both the master's and Ph.D. levels. This program will involve the Departments of Mechanical and Industrial Engineering (MIE), Chemical Engineering and Applied Chemistry (CHE) and Civil Engineering (CIV) in the Faculty of Applied Science and Engineering (FASE); the Department of Curriculum, Teaching and Learning (CTL) at the Ontario Institute for Studies in Education (OISE); and be led by FASE. Inclusion of units from both of these two faculties is a key aspect of this program. Engineering involves the creative application of science to the design of systems, processes, structures and technologies. Education is the transfer of knowledge, often through a relational process involving instruction and learning. The EngEd Collaborative Program will draw students interested in exploring learning at the nexus of education and engineering, Topics addressed will span the knowledge base, learning processes, people in engineering programs, surrounding socio-cultural context, and the outcomes that result. Engineering education research differs from other education research because it considers the distinct aspects of engineering education such as its inherent emphasis on design, quantification, application, systems, constraints, and problem solving. Another distinction is investigation of the broader development of engineers as they acquire their professional identity and competencies. Like traditional engineering research, research in engineering education can involve the development of innovative tools and technologies. However, it can also focus on understanding better the factors involved in the development of a student from a novice to an engineer, and techniques for improving that educational process.

Five graduate students are currently pursuing research relating to engineering education and approximately 20 students have completed related undergraduate theses over the last five years. Thus there is already significant student interest in EngEd related research. Establishing this collaborative program will benefit graduate students and faculty interested in EngEd, by creating a community of practice – an intellectual and physical place where faculty members and students research, learn, and practice. Coursework will provide students perspectives on learning, knowledge, assessment and culture/community, along with theory, methods, and topics related to engineering education research. More broadly, creation of this program will strengthen ties between FASE and OISE, and yield research findings that may benefit Science Technology Engineering and Math learning in K-12, university level instruction of engineering, and continued professional training after post-secondary education.

2 Participating Programs, Degrees and Names of Units

Graduate program, Ph.D., M.A.Sc., Dept. of Mechanical and Industrial Engineering (MIE), Faculty of Applied Science and Engineering (FASE)

Graduate program, Ph.D., M.A.Sc., Dept. of Chemical Engineering and Applied Chemistry (CHE) , Faculty of Applied Science and Engineering (FASE)

Graduate program, Ph.D., M.A.Sc., Dept. of Civil Engineering (CIV), Faculty of Applied Science and Engineering (FASE)

Curriculum Studies and Teacher Development (CSTD) program, Ph.D., M.A., Dept. of Curriculum, Teaching and Learning (CTL), Ontario Institute for Studies in Education (OISE)

3 Objectives, Added Value for Students

Academic Objectives

The overall objectives of the proposed EngEd Collaborative program are to:

- Facilitate and promote applied EngEd research that can support evidence-based instruction, assessment, and curriculum reform
- Produce graduate students with expertise in engineering education
- Create a forum for faculty and students to develop and expand their interests in EngEd.
- Establish a vibrant community and focal point for EngEd scholarship at the University of Toronto

The EngEd Collaborative Program will serve Masters and Ph.D. level students who are already pursing graduate studies in a number of programs with opportunities to explore a common interest, by providing access to learning experiences that cut across their specific programs. The principal benefit to students will be an improved capacity to pursue, understand, discuss, critique, and apply engineering education related research. This learning will be supported by the completion of related courses and immersion in a learning community. Students will also pursue independent engineering education related research through projects that will normally fit within one or a combination of the following 7 perspectives:

1) Engineer as a Learner Perspective – take the perspective of the student and examine issues such as retention, the learner experience in industry, life-long learning, K-12
2) Engineering Knowledge Perspective – the way knowledge is organized and how this can be used to improve retention of engineering concepts
3) Engineering Assessment Perspective – how do we know if a student has gained knowledge and how do we assess learning in engineering
4) Engineering Community Perspective – examining the learning environment in engineering and looking at policies around engineering such as accreditation of

engineering programs

5) Engineering Methodologies – explore when engineering methodologies are applied to research to investigate issues in one of the other perspectives (e.g., game theory, optimization)
6) Development of Instructional Tools – e.g., the development of engineering instructional tools using engineering research methodologies at the university level, K-12, industry
7) Developing the Whole Engineer - examining the non-technical competencies and characteristics that contribute to successful engineering and how they are taught and learned.

Academic objectives specific to the Masters and Ph.D. level programs are described within section 5.

Program Size and Anticipated Demand

Creation of a EngEd Collaborative Program was identified as the option that would best serve students and leverage existing strengths. Specifically, we believe that engineering education should not be positioned as being distinct from the more traditional fields of engineering or education. Rather it should bridge between them, building on a solid foundation within these more traditional fields. Using a collaborative structure will ensure that students acquire this solid foundation through their home program. Further, providing students with a traditional foundation that is then enriched in terms of EngEd knowledge and competencies will expand rather than restrict their career opportunities after graduation.

The proposed collaborative program would be modest, with a steady state enrolment of approximately 12 students (50% Master's and 50% Ph.D.), two thirds enrolled through FASE and one third through the CSTD program at OISE. Attaining this enrolment would require that the participating departments together typically admit three to four M.A.Sc./M.A. and two to three Ph.D. students per year. Satisfying this admission rate with high quality students should be achievable given:

i) The recent expressed student interest at UofT
ii) The number of undergraduate student theses with EngEd aspects over the last five years
iii) The recent growth and interest in EngEd in the United States

There is already significant student interest in EngEd related graduate studies and research. This interest should increase with a formalized EngEd collaborative program supported by a marketing campaign. In fact, there are currently five graduate students pursuing EngEd-related thesis topics (four in FASE and one in CTL). Further, a number of staff and lecturers working in FASE are or have pursued graduate degrees at OISE. Anticipating a two to three-fold increase in student interest following the creation and promotion of the proposed EngEd collaborative program is thus realistic. Some faculty in FASE are already being approached by 1-3 students per year, predominantly domestic, who are inquiring about the prospects of pursuing graduate research focused in engineering education at UofT. Further, approximately 20 students have

completed undergraduate theses related to engineering education over the last five years. There are also an increasing number of graduate students at CTL pursuing theses relating to on-line courses and web based learning. These CTL students may be interested in integrating the engineering design process into the development of on-line learning tools, and hence participating in the EngEd Program.

Globally, there is also growing interest in this field. Over twenty graduate engineering education programs have been established in the United States and internationally including Purdue University, Virginia Tech, Clemson University, Utah State University, Chalmers University of Technology (Sweden), Uppsala University (Sweden) and Universidad de las Americas (Mexico). Of note, Purdue University's Dept. of Engineering Education has become a School of Engineering Education with 65 graduate students enrolled in 2013, a 12.1% increase from the previous year. Given this growing interest in engineering education abroad, we should easily be able to sustain a collaborative program with 12 students.

Benefits to Students and their Educational Experience

Establishing this collaborative program will serve students by creating a vibrant community of practice and focal point for the pursuit of EngEd scholarship. Students immersed in this diverse intellectual community will be able to enrich their training and research experience by interacting with EngEd experts and exchanging ideas with likeminded colleagues. The collaborative structure will allow students access to the existing expertise and courses within the partner Faculty.

The program will also formalize studies in Engineering Education through the Collaborative Program with a notation on the student's transcript upon completion, which acknowledges the student's acquired knowledge and expertise. Communicating these objectives and student EngEd competency outcomes to Canadian universities and industry will raise awareness and comprehension of the added value of EngEd graduates.

Students completing the EngEd Collaborative Program will have knowledge at the nexus of education and engineering practice, on top of expertise relevant to their home program of study. Through their Eng Ed related research and course work they will acquire expertise in the application of educational theory within the context of engineering and/or the use of engineering methodologies to the promotion of learning. Depending on the topic, their research projects will provide them with in-depth knowledge of: learning, assessment, instructional tools, teaching methods, course design, program evaluation, and curriculum development. Additional competencies acquired may include coaching, facilitation, knowledge translation and engineering/technology skills. Thus completion of the EngEd Collaborative Program may open the door to career options on top of those normally available to graduates from the respective home programs including: academia, human resources and professional development, the non-profit sector linked to public education (e.g., museums), administration and curriculum development (e.g., Canadian Engineering Accreditation Board), policy analysis for advocacy groups (e.g., Ontario Society for Professional Engineers, Professional Engineers

Ontario, engineering societies for mechanical engineering, chemical engineering, etc.), school boards (K-12) or government.

The EngEd Collaborative Program will add value to students' educational experience by providing a multidisciplinary forum for learning, the exchange of ideas, and pursuing research. Beyond satisfying the academic requirements of their home department, students would complete a number of common learning experiences: one EngEd core half-course, and a no weight seminar course taken annually. In addition, Ph.D. students will take one EngEd-related elective half-course. Completion of these courses will count towards meeting the home program requirements. The program and course requirements, and the distinctions between the Master's and Ph.D. programs, are described in the next section.

Similarities and Distinctions from Existing Programs

No programs currently exist at UofT or in Canada for students with an interest in EngEd. As outlined above, EngEd programs do exist internationally. The proposed EngEd program will be distinct in its collaborative structure. This structure will allow students to build a solid foundation within a traditional field while providing a bridge between these fields. Students will thus acquire depth of expertise in engineering or education through their home programs, along with integrative expertise in engineering education through the collaborative elements.

4 Admission and Program Requirements

Admission Process and Requirements

All Collaborative Program students must first apply to a home degree program within one of the departments participating in the program. In parallel, they can apply to the Collaborative Program but they will need to be admitted to the home program before being admitted to the Collaborative Program. It will be the applicant's responsibility to find an appropriate supervisor interested in supervising them and supporting their thesis research. Thus, applicants will be expected to contact and meet with potential supervisors during the application process. This supervisor will then provide a letter of recommendation in support of the student's application to the Collaborative Program. The supervisor may choose to further support this student's application through discussions with the EngEd Program Director, and when needed the Program Committee. With the approval of the Program Director, the supervisor will then request to the home program that the student be considered for admission. A final decision to admit the student, or not, will then be made by the home program and Department. Admission to the Collaborative Program would follow.

In addition to satisfying the home degree admission requirements, applicants will provide a statement of purpose in which they describe their background or experience relating to engineering, education, or engineering education, and why they are interested in pursuing graduate studies in this field.

Distinction between Master's and Ph.D. Levels

Students can complete the Collaborative Program at the Master's and/or Ph.D. levels. Students participating at the Master's level will take a core EngEd half course equivalent (HCE) that will count towards meeting their home program requirements, and a no-weight seminar course (CR/NCR). Further, as is normally the case for collaborative programs, the thesis requirement for the home program will be focused on a topic in the area of EngEd. At the Ph.D. level, students will take the core and seminar courses, and also complete an EngEd related half course, as one of the electives within their home program course requirements. Overall, the Ph.D. will differ from the Master's in that it will offer more theory through an additional elective course and a more extensive EngEd-related thesis than at the Master's level. A student who has completed this collaborative program may also enrol at the PhD level, with appropriate adjustments to the course requirements as outlined below.

Program and Course Requirements

All students will take the core EngEd course "Instructional Design in Engineering Education". This course will be team taught by faculty from FASE and CTL, with a faculty member affiliated with the EngEd program taking primary responsibility for its delivery. This is a half-course developed specifically for the proposed collaborative program, but open to other students, which will focus on engineering learning, knowledge, assessment and culture/community. Relevant educational theory and conceptual frameworks will be discussed from an engineering perspective, along with distinctive aspects of engineering education and epistemology such as design, problem solving, systems thinking, quantification, teamwork, technical communication, innovation, professionalism, and accreditation. Students will review an existing engineering course or program as a midcourse assignment, and then propose an alternate design for this course as a final project. PhD students who have already completed this course while enrolled in the masters' level EngEd program, will take an alternate elective course approved by the Program Director.

In addition, a required no weight Type I seminar course (CR/NCR), will use presentations, workshops, and discussion to introduce theoretical foundations, methods, and techniques related to engineering education research. Some of the following topics might, for example be covered in a given year with the topics changing year to year: hypothesis generation, concept and knowledge mapping, survey design, mixed methods, ethics approvals, facilitating workshops, proposal writing, preparation of manuscripts, mentoring, on-line learning. Students at both the Master's and Ph.D. levels in the EngEd program will take this course continuously throughout their programs with the PhD students having increasing involvement. A PhD student will participate in the course in their first year, deliver a seminar on their research topic in their second year, and design and deliver one or more instructional workshops in their final year, in addition to making a final presentation on their research. Some weeks may be dedicated to a single topic while others may include a mix of topics such as research updates, journal club, and research fundamentals. Students will be provided with opportunities to gain feedback on their own research from fellow students and faculty. Having students take the seminar course continuously throughout their program will help to build community across all

students in the program. Further, these seminars will be open to faculty and other students, to further build the EngEd community.

In addition to the core and seminar half courses, Ph.D. students will take an elective half-course. The elective course will be completed as part of the existing home program requirements and come from a subset of the existing courses within CTL and FASE. A student will normally select this course from a list of suggested courses:

FASE Courses

- APS1003H: Professional Education and Instruction
- APS1001H: Project Management
- APS1010: Cognitive and Psychological Foundations of Effective Leadership
- APS1011: Concepts and Application of Authentic Leadership
- APS1501H: Leadership and Leading in Groups and Organizations
- APS1018H: History and Philosophy of Engineering
- APS520H1S: Technology, Engineering, and Global Development
- APS530H1S: Appropriate Technology & Design for Global Development
- JEI1901H: Technology, Society and the Environment I
- APS1012H: Management of Innovation in Engineering
- APS1013H: Applying Innovation in Engineering
- MIE1402H: Experimental Methods in Human Factors Research
- MIE1403H: Analytical Methods in Human Factors Research
- MIE1413H: Statistical Models in Empirical Research
- MIE1415H: Analysis and Design of Cognitive Work
- KMD 2001H: Human Centred design

CTL Courses

- CTL1018H: Introduction to Qualitative Inquiry in Curriculum, Teaching and Learning [RM]
- CTL1041H: Research Methods in Education [RM]
- CTL1042H: Instrument Development in Education [RM]
- CTL1306H: Qualitative Research Methods in Education: Concepts and Methods [RM]
- CTL1842H: Mixed Methods Research in Education: Combining Qualitative and Quantitative Inquiries [RM]
- CTL1846H: Assessment for Teaching and Learning
- CTL1608H: Constructive Learning and Design of Online Environments
- CTL1028H: Constructive Feedback in Teaching
- CTL1032H: Knowing and Teaching

- CTL1047H: Self-Assessment
- CTL1206H: Teaching and Learning Science
- CTL1207H: Teaching and Learning about Science: Issues and Strategies in Science, Technology, Society and Environment (STSE) Education
- CTL1211H: Action Research in Science, Mathematics and Technology Education [RM]
- CTL1215H: Teaching and Learning about Science and Technology: Beyond Schools
- CTL1218H: Culture and Cognition in Mathematics, Science and Technology Education
- CTL1603H: Introduction to Knowledge Building

This list may change periodically and students may take alternate courses that better meet their academic needs, with approval of their supervisor. Students will be encouraged to select elective courses offered by the other Faculty so as to broaden their educational experience.

CALENDAR ENTRY

ENGINEERING EDUCATION

Lead Faculty

Faculty of Applied Science and Engineering

Participating Degree Programs

Chemical Engineering and Applied Chemistry, M.A.Sc., Ph.D.
Civil Engineering, M.A.Sc., Ph.D.
Curriculum Studies and Teacher Development, M.A., Ph.D.
Mechanical and Industrial Engineering, M.A.Sc., Ph.D.

Supporting Units

Dept. of Chemical Engineering and Applied Chemistry
Dept. of Civil Engineering
Dept. of Curriculum, Teaching and Learning
Dept. of Mechanical and Industrial Engineering

Overview

The Collaborative Program in Engineering Education is an interdisciplinary program designed for students within home programs in engineering or education who are interested in pursuing courses and research in engineering education. This program allows students to join a small community of scholars interested in research and learning at the nexus of education and engineering practice. A core course provides students with an introduction to engineering learning, knowledge, assessment and culture/community, while the theoretical foundations, methods, and topics related to engineering education research are explored in a seminar course. Research is supervised by a graduate faculty member in a home department. Opportunities exist to assess and apply research findings as part of

instructional initiatives within the Faculty of Applied Science and Engineering. Upon successful completion of the requirements of the home department and the program, students receive the notation "Completed Collaborative Program in Engineering Education" on their transcript.

Contact and Address

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The Collaborative Program in Engineering Education
Faculty of Applied Science and Engineering
TBA
Toronto, Ontario M5S3E5
Canada

Master's Degree Level

Admission Requirements

Applicants must be accepted for admission to a participating graduate unit and comply with the admission procedures of that unit before applying to the Collaborative Program in Engineering Education.

- a curriculum vitae
- a personal statement explaining how their program of study and specific research interests relate to engineering education
- a letter of recommendation from a faculty member confirming their willingness to supervise and support the student's research and outlining why the student would be well suited for the Engineering Education Collaborative Program

Program Requirements

- Satisfy requirements of home degree program and graduate unit
- Completion of core half-course
- Participation in a no weight Type 1 seminar course (CR/NCR)
- Undertake the major paper or thesis required by the home degree program with a focus on Engineering Education under the supervision of one of the collaborative program's core faculty members

Doctoral Degree Level

Admission Requirements

Applicants must be accepted for admission to a participating graduate unit and comply with the admission procedures of that unit before applying to the Collaborative Program in Engineering Education.

- a curriculum vitae
- a personal statement explaining how their program of study and specific research interests relate to engineering education
- a letter of recommendation from a faculty member confirming their willingness to supervise and support the student's research and outlining why the student would be well suited for the Engineering Education Collaborative Program

Program Requirements

- Satisfy requirements of home degree program and graduate unit
- Completion of core half-course
- Participation in a no weight Type 1 seminar course (CR/NCR)
- Completion of an elective engineering education related half-course
- Undertake the major paper or thesis required by the home degree program with a focus on Engineering Education under the supervision of one of the collaborative program's core faculty members

Completion of Program Requirements

All students enrolled in the Collaborative Program must complete the requirements of the Collaborative Program, in addition to the requirements of the degree program in their home graduate unit. The Collaborative Program Director and/or Program Committee is/are responsible for certifying the completion of the Collaborative Program requirements. The home graduate unit is solely responsible for the approval of the student's home degree requirements.

5 Degree Level Expectations, Program Learning Outcomes and Program Structure

This collaborative program will provide students with access to multidisciplinary learning experiences relating to engineering education. The principal benefit to students will be an improved capacity to pursue, understand, discuss, critique, and apply engineering education related research. Students will primarily achieve this capacity through the independent pursuit of an engineering education related thesis supported by mentoring from an expert supervisor. This learning will be further supported by the completion of two or more related courses, and emersion in a learning community. Details on the degree level expectations and learning outcomes for the Collaborative Program in Engineering Education **beyond those of** the home program degree requirements are provided below.

Table 1: Master's DLEs

FASE MASTER OF APPLIED SCIENCE (M.A.Sc.) DEGREE LEVEL EXPECTATION (Based on the DLEs approved by the Faculty of Applied Science and Engineering in 2011)	**FASE MASTER OF APPLIED SCIENCE (M.A.Sc.) PROGRAM LEARNING OBJECTIVES AND OUTCOMES** Specific to the proposed EngEd Collaborative Program	**HOW THE PROGRAM DESIGN AND REQUIREMENT ELEMENTS SUPPORT THE ATTAINMENT OF STUDENT LEARNING OUTCOMES** Specific to the proposed EngEd Collaborative Program
EXPECTATIONS: ***The Engineering Education Collaborative Program designator is awarded to Master's students who have demonstrated:***		
1. Depth and Breadth of Knowledge Defined in Engineering Education as a systematic understanding of general educational and research methodologies and their specific application. This is reflected in students who are able to:	• Discuss and critique Engineering Education related research studies, identifying knowledge gaps they address, the strengths and limitations of the research methodologies, and the broader context and implications of the research.	The program design and curricular requirements that ensure these student outcomes for depth and breadth of knowledge is: •The research seminar core course which covers a broad range of engineering education related research topics, frameworks, and methodologies, journal publication critiques, and discussion of current student research studies.
2. Research and Scholarship Defined in Engineering Education as the ability to engage in independent, original research by drawing on existing literature as a basis to: a. formulate research questions and apply methodologies to address these questions, documenting their findings in a comprehensive and accurate manner, b. Evaluate their work, and the research of others, in a thorough, thoughtful and critical manner.	This is reflected in students who are able to: • Prepare a clearly written master's level dissertation outlining the context, methods and novel, knowledge-generating aspects of the project and implications of the research relating to Engineering Education.	The program design and requirement elements that ensure these student outcomes for research and scholarship are: • Expert supervision and guidance that helps students develop an Engineering Education research project and articulate research findings in a comprehensive, written dissertation submitted at the conclusion of the program.
3. Level of Application of Knowledge Defined in Engineering Education as competence in applying an existing body of knowledge in the critical analysis or formulation of a new education related question, or of a specific educational challenge or	Translate research findings into strategies for instructional design or assessment.	The program design and requirement elements that ensure these student outcomes for level and application of knowledge is: •The instructional teaching units created in the core Instructional Design in Engineering Education half-course.

FASE MASTER OF APPLIED SCIENCE (M.A.Sc.) DEGREE LEVEL EXPECTATION (Based on the DLEs approved by the Faculty of Applied Science and Engineering in 2011)	**FASE MASTER OF APPLIED SCIENCE (M.A.Sc.) PROGRAM LEARNING OBJECTIVES AND OUTCOMES** Specific to the proposed EngEd Collaborative Program	**HOW THE PROGRAM DESIGN AND REQUIREMENT ELEMENTS SUPPORT THE ATTAINMENT OF STUDENT LEARNING OUTCOMES** Specific to the proposed EngEd Collaborative Program
opportunity in a new setting. This is reflected in students who are able to:		
4. Professional Capacity/Autonomy Defined in Engineering Education as the qualities and transferable skills necessary for employment requiring the exercise of initiative and of personal responsibility and accountability; the ethical behaviour consistent with academic and research integrity; continuing professional development and, the ability to appreciate the broader socioeconomic and cultural implications of applying and deriving knowledge in specific contexts.	This is reflected in students who are able to: • Demonstrate familiarity with and rigorous adherence to ethical principles in academic conduct and research practices involving students and other human subjects • Describe the broad implications and impacts of Engineering Education research findings on teaching, the engineering profession, and broader society.	The program design and requirement elements that ensure these student outcomes for professional capacity/autonomy are: • Seminars in the seminar course addressing academic integrity, research ethics, and/or submission of ethics approvals required for the pursuit of research • Discussions with expert supervisors and student peers about the implications and impacts of Engineering Education research
5. Level of Communications Skills Defined in Engineering Education as the ability to communicate ideas, issues and conclusions relevant to engineering in a clear, concise and compelling manner. This is reflected in students who are able to:	• Design and present a lecture, seminar or workshop to explain difficult concepts, novel approaches, or conflicting results relating to engineering education in a clear and articulate manner with appropriate consideration of their audience. • Lead, encourage and engage in peer-level advanced scientific discourse on topics related to engineering education, making claims and constructing credible arguments, and defending them logically and concisely using appropriate supporting evidence.	The program design and requirement elements that ensure these student outcomes for level of communication skills is: • The seminar course – will provide students with feedback on presentation skills and a forum to practice, observe and improve these skills
6. Awareness of the Limits of Knowledge Defined in Engineering Education as the capacity to draw appropriate and defendable conclusions while acknowledging the limitations within the supporting data or contextual	• Show objectivity and neutrality in the assessment of engineering education research findings and the criticism of others, relying on logical, systematic, fact-based evaluation. • Articulate the uncertainties,	The program design and requirement elements that ensure these student outcomes for awareness of limits of knowledge are: • A seminar course that will provide the student with

FASE MASTER OF APPLIED SCIENCE (M.A.Sc.) DEGREE LEVEL EXPECTATION (Based on the DLEs approved by the Faculty of Applied Science and Engineering in 2011)	FASE MASTER OF APPLIED SCIENCE (M.A.Sc.) PROGRAM LEARNING OBJECTIVES AND OUTCOMES Specific to the proposed EngEd Collaborative Program	HOW THE PROGRAM DESIGN AND REQUIREMENT ELEMENTS SUPPORT THE ATTAINMENT OF STUDENT LEARNING OUTCOMES Specific to the proposed EngEd Collaborative Program
knowledge. This is reflected in students who are able to:	assumptions and limitations in their data and research findings.	opportunities to discuss the limitations of current knowledge in the broader field and locate their work within this context. • Expert feedback during the preparation of a thesis document on how students position their work and its limitations within the context of the current knowledge in the field and its limitations.

Table 2: Doctoral DLEs

FASE DOCTORAL (Ph.D.) DEGREE LEVEL EXPECTATIONS (Based on the DLEs approved by the Faculty of Applied Science and Engineering in 2011)	FASE DOCTORAL (Ph.D.) PROGRAM LEARNING OBJECTIVES AND OUTCOMES Specific to the proposed EngEd Collaborative Program	HOW THE PROGRAM DESIGN AND REQUIREMENT ELEMENTS SUPPORT THE ATTAINMENT OF STUDENT LEARNING OUTCOMES Specific to the proposed EngEd Collaborative Program
EXPECTATIONS: The Engineering Education Collaborative Program designator is awarded to Ph.D. students who have demonstrated:		
1. Depth and Breadth of Knowledge Defined in Engineering Education as a thorough understanding of the related theoretical foundations, conceptual frameworks, prevailing research methodologies and associated research questions, and their application in curriculum, teaching, learning and assessment. This is reflected in students who are able to:	• Engage in scholarly discourse on the current state of Engineering Education knowledge as a basis to formulate novel insights and develop research questions or hypotheses. • Discuss and critique Engineering Education related research studies, identifying knowledge gaps they address, the strengths and limitations of the research methodologies, and the broader context and implications of the research.	The program design and requirement elements that ensure these student outcomes for depth and breadth of knowledge are: • A research seminar course which reviews and critiques Engineering Education research and thereby exposes students to the underlying theoretical frameworks, hypotheses and methodologies, and the relevance of findings. •Expert feedback and mentoring throughout the completion of an Engineering Education related research project.
2. Research and Scholarship Defined in Engineering Education as	• Prepare a proposal for an Engineering Education related research study that documents a	The program design and requirement elements that ensure these student outcomes for

FASE DOCTORAL (Ph.D.) DEGREE LEVEL EXPECTATIONS (Based on the DLEs approved by the Faculty of Applied Science and Engineering in 2011)	**FASE DOCTORAL (Ph.D.) PROGRAM LEARNING OBJECTIVES AND OUTCOMES** Specific to the proposed EngEd Collaborative Program	**HOW THE PROGRAM DESIGN AND REQUIREMENT ELEMENTS SUPPORT THE ATTAINMENT OF STUDENT LEARNING OUTCOMES** Specific to the proposed EngEd Collaborative Program
the ability to engage in independent, original research by drawing on existing literature as a basis to: a. Formulate research questions or novel hypotheses, identifying, assessing, and applying methodologies to address these questions, documenting their findings in a comprehensive and accurate manner. b. Interpret their research in relation to relevant theory and conceptual frameworks. c. Evaluate their work, and peer work, and the research of others, in a thorough, thoughtful and critical manner. This is reflected in students who are able to:	thorough and thoughtful literature review of relevant educational research; innovative research questions arising from an appropriate conceptual framework built on relevant theory; a strategy and methods to address these questions; and a credible plan to integrate these elements through a study so as to produce a thesis. • Prepare a clearly written PhD level dissertation highlighting the novel, knowledge-generating aspects of the project and implications of the research relating to Engineering Education. •Publish their findings and otherwise participate in peer-level scholarly communication.	research and scholarship are: • Expert supervision and guidance to help students develop and defend an Engineering Education research project and articulate research findings in a research proposal and comprehensive, written dissertation. •Expert mentoring in knowledge transfer through the documentation and preparation for the presentation of their research in Engineering Education forums, such as journals, internal university seminars, or local, national and international academic meetings, conferences and workshops.
3. Level of Application of Knowledge Defined in Engineering Education as competence in applying an existing body of knowledge in the critical analysis or formulation of a new question or of a specific educational challenge or opportunity in a new setting. This is reflected in students who are able to:	•Translate research findings into strategies for instructional design or assessment. •Design and deliver instructional units based upon their research and/or the research findings of others.	The program design and requirement elements that ensure these student outcomes for level of application of knowledge are: • Expert guidance during the preparation of the dissertation and related manuscripts or presentations on the translation of engineering education related knowledge to teaching, learning, assessment, or other applications of engineering education research. • The “Instructional Design in Engineering Education” core course that will instill knowledge of instructional design and provide a forum for students to design and deliver instructional seminars or workshops.
4. Professional Capacity/Autonomy	• Demonstrate familiarity with and	The program design and requirement elements that ensure

FASE DOCTORAL (Ph.D.) DEGREE LEVEL EXPECTATIONS (Based on the DLEs approved by the Faculty of Applied Science and Engineering in 2011)	**FASE DOCTORAL (Ph.D.) PROGRAM LEARNING OBJECTIVES AND OUTCOMES** Specific to the proposed EngEd Collaborative Program	**HOW THE PROGRAM DESIGN AND REQUIREMENT ELEMENTS SUPPORT THE ATTAINMENT OF STUDENT LEARNING OUTCOMES** Specific to the proposed EngEd Collaborative Program
Defined in Engineering Education as the qualities and transferable skills necessary for employment requiring the exercise of initiative and of personal responsibility and accountability; the ethical behaviour consistent with academic and research integrity; continuing professional development and, the ability to appreciate the broader socioeconomic and cultural implications of applying and deriving knowledge in specific contexts This is reflected in students who are able to:	rigorous adherence to ethical principles in academic conduct and research practices involving students and other human subjects • Describe the broad implications and impacts of Engineering Education research findings on teaching, the engineering profession, and broader society.	these student outcomes for professional capacity/autonomy are: • Seminars in the seminar course addressing academic integrity, research ethics, and preparation of appropriate documentation needed to support ethics approval applications. • Discussions with expert supervisors and student peers about the implications and impacts of Engineering Education research •Teaching opportunities through teaching assistantships or mentorship of advanced undergraduate and junior graduate students that demand professional conduct and ethical behaviour.
5. Level of Communication Skills Defined in Engineering Education as the ability to communicate ideas, issues and conclusions in a clear, concise and compelling manner. This is reflected in students who are able to:	• Document Engineering Education research in a thesis and peer review publications, books or other manuscripts, demonstrating an appropriately nuanced appreciation of the relative benefits and shortcomings of complex and/ or ambiguous findings. • Design and present a lecture, seminar or workshop to explain difficult concepts, novel approaches, or conflicting results relating to engineering education in a clear and articulate manner with appropriate consideration of their audience. • Lead, encourage and engage in peer-level advanced scientific discourse on topics related to engineering education, making claims and constructing credible arguments, and defending them	The program design and requirement elements that ensure these student outcomes for level of communication skills are: • The seminar course – will provide students with feedback on presentation skills and a forum to practice, observe and improve these skills • Ongoing feedback and guidance from a supervisor and supervisory committee with expertise in Engineering Education throughout the documentation of their research and the preparation for its presentation or defence.

FASE DOCTORAL (Ph.D.) DEGREE LEVEL EXPECTATIONS (Based on the DLEs approved by the Faculty of Applied Science and Engineering in 2011)	FASE DOCTORAL (Ph.D.) PROGRAM LEARNING OBJECTIVES AND OUTCOMES Specific to the proposed EngEd Collaborative Program	HOW THE PROGRAM DESIGN AND REQUIREMENT ELEMENTS SUPPORT THE ATTAINMENT OF STUDENT LEARNING OUTCOMES Specific to the proposed EngEd Collaborative Program
	logically and concisely using appropriate supporting evidence.	
6. Awareness of Limits of Knowledge Defined in Engineering Education as the capacity to draw appropriate and defendable conclusions while acknowledging the limitations within the supporting data or contextual knowledge. This is reflected in students who are able to:	•Show objectivity and neutrality in the assessment of Engineering Education research findings and the criticism of others, relying on logical, systematic, fact-based evaluation. •Articulate the uncertainties , assumptions and limitations in their data and research findings •Clearly delimit the scope and extent of their expertise within the discipline of Engineering Education	The program design and requirement elements that ensure these student outcomes for awareness of limits of knowledge are: • A seminar course that will provide the student with opportunities to discuss the limitations of current knowledge in the broader field and locate their work within this context. • Expert feedback throughout their research on the positioning of their work and its limitations within the context of the current knowledge in the field.

6 Assessment of Learning

Assessment of leaning will occur both directly through formal mechanisms and indirectly. Formal assessment will be based on:

- Defence of an engineering education related final thesis.
- Academic performance on the two major assignments in the Instructional Design in Engineering Education half-course.
- Academic performance according to course evaluation criteria in the elective half-course.
- An Engineering Education related research proposal and supporting literature review, and its defence through a comprehensive oral examination (Ph.D. students only).
- Regular thesis supervisory committee meetings during which the student outlines progress and future objectives of their engineering education related research project. (Ph.D. students only).

Peer and instructor feedback based upon:

- Presentation of a research proposal the seminar course (Ph.D. students only)
- Presentation of a final research results in the seminar course

- Presentation of a lecture or workshop in the research seminar course (Ph.D. students only)

7 Resources

The Collaborative Program's core faculty members will be available to students in the home program as advisors or supervisors. A core faculty member in the student's home department will be involved in thesis supervision. Core faculty members will contribute to the Collaborative Program through teaching of the core course, seminar course, or supervising students. Some faculty may teach courses in the subject area of the Collaborative Program in the home program. Not all core faculty members need be active in the Collaborative Program every year and, in many cases, simply may remain available to interested students. The list of core faculty members is available in Appendix B. Each participating degree program will contribute to the Collaborative Program through student enrolments, although not necessarily every year.

The Collaborative Program will have a Director and a Program Committee. Together they will be responsible for admitting students to the Collaborative Program and ensuring that the faculty associated with the program have the capacity to supervise all program students. Consequently, an assessment of supervisory capacity will occur twice: once when students are admitted to their home degree program and once on their application to the Collaborative Program.

The University finds that the participation in a Collaborative Program does not normally add significantly to a faculty member's supervisory load. For the most part, students in the Collaborative Program will continue to have their thesis supervised by a faculty member in their home program who also participates in the Collaborative Program.

8 Administration

Please see Appendix C: Memorandum of Agreement

9 Governance Process

Levels of Approval Required	
Graduate unit approval	
Decanal and Provostial sign off	
Faculty Governance approval (FASE)	
AP&P approval	
Program may begin advertising as "Pending Approval"	
Ontario Quality Council approval	

Appendix A: Collaborative Program Requirements & Degree Program Requirements

Department of Mechanical and Industrial Engineering

- **M.A.Sc. in Mechanical and Industrial Engineering**

  M.A.Sc. requirements: Four half courses, two of which must be from within MIE and only one of which can be an APS course.

  The M.A.Sc. Level Collaborative Program Requirements will be completed as electives within the existing home program requirements as follows:

  - The 0.5 FCE EngEd core course will replace the APS course in the MIE program requirements.
  - The seminar course (No weight, CR/NCR) will have no weight and thus add no additional requirement.

- **Ph.D. in Mechanical and Industrial Engineering**

  Ph.D. requirements: five half courses, three of which must be from within MIE and only one of which can be an APS course.

  The Ph.D. Level Collaborative Program Requirements will be completed as electives within the existing home program requirements as follows:

  - The 0.5 FCE EngEd core course will replace the APS course allowed in the MIE program requirements.
  - The seminar course (No weight, CR/NCR) will have no weight and thus add no additional requirement.
  - The 0.5 FCE EngEd related elective course will replace the fifth course in the MIE program requirements.

Department of Chemical Engineering and Applied Chemistry

- **M.A.Sc. in Chemical Engineering**

  M.A.Sc. requirements: Three half courses one of which must be fundamental and two of which must be specialised.

  The M.A.Sc. Level Collaborative Program Requirements will be completed as electives within the existing home program requirements as follows:

- The 0.5 FCE EngEd core course will replace one of the specialised courses in the Chemical Engineering program requirements.
- The seminar course (No weight, CR/NCR) will have no weight and thus add no additional requirement.

- **Ph.D. in Chemical Engineering**

  PhD course requirements: four half courses.

  The Ph.D. Level Collaborative Program Requirements will be completed as electives within the existing home program requirements as follows:

  - The 0.5 FCE EngEd core course will replace one of the courses in the Chemical Engineering program requirements.
  - The seminar course (No weight, CR/NCR) will have no weight and thus add no additional requirement.
  - The 0.5 FCE EngEd related elective course will replace one of the courses in the Chemical Engineering program requirements.

Department of Civil Engineering

- **M.A.Sc. in Civil Engineering**

  M.A.Sc. requirements: five half courses

  The M.A.Sc. Level Collaborative Program Requirements will be completed as electives within the existing home program requirements as follows:

  - The 0.5 FCE EngEd core course will replace one of the courses in the Civil Engineering program requirements.
  - The seminar course (No weight, CR/NCR) will have no weight and thus add no additional requirement.

- **Ph.D. in Civil Engineering**

  PhD course requirements: four half courses.

  Ph.D. Level Collaborative Program Requirements will be completed as electives within the existing home program requirements as follows:

  - The 0.5 FCE EngEd core course will replace one of the courses in the Civil Engineering program requirements.
  - The seminar course (No weight, CR/NCR) will have no weight and thus add no additional requirement.
  - The 0.5 FCE EngEd related elective course will replace one of the courses in the Civil Engineering program requirements.

Department of Curriculum Teaching and Learning

- **M.A. in Curriculum Studies and Teacher Development**

  M.A. requirements: 4.0 full-course equivalents of which at least 2.0 FCEs are normally CTL 1000-level courses undertaken in the Curriculum Studies and Teacher Development program. Students are required to successfully complete CTL 1000H, and a course in research methods from an approved course listing.

  M.A. Level Collaborative Program Requirements will be completed as electives within the existing home program requirements as follows:

  - The 0.5 FCE EngEd core course will replace one of the elective courses in the CSTD program requirements.
  - The seminar course (No weight, CR/NCR) will have no weight and thus add no additional requirement.

- **Ph.D. in Curriculum Studies and Teacher Development**

  PhD course requirements: 3.5 full-course equivalents, of which at least 2.0 FCEs are ordinarily CTL 1000-level courses. Students are also required to complete CTL 1899H, the CSTD Doctoral Proseminar course, CTL 1000H if they did not complete it at the master's level, and one course in research methods from an approved course listing.

  The Ph.D. Level Collaborative Program Requirements will be completed as electives within the existing home program requirements as follows:

  - The 0.5 FCE EngEd core course will replace one of the elective courses in the CSTD program requirements.
  - The seminar course (No weight, CR/NCR) will have no weight and thus add no additional requirement.
  - The 0.5 FCE EngEd related elective course will replace one of the elective courses in the CSTD program requirements.

Appendix B: Core Faculty Research Synopses

All teaching staff identified as members of the Collaborative Program are core faculty of the participating approved graduate programs and have been approved by the chair/director of their home unit for cross-appointment to the Collaborative Program. In bringing forward a proposal for a new Collaborative Program, the concern is that, in addition to being approved members of the graduate teaching staff, all proposed faculty be active in the area of the Collaborative Program. This list highlights peer review publications by the approved faculty members in the Collaborative Program area.

Department of Mechanical and Industrial Engineering

1. **Prof. Susan McCahan**

    a. Publication S. McCahan, P.E. Weiss, K. Woodhouse, R. Andrews, P. Anderson, M. Kortschot, S. Romas, “Engineering Strategies and Practice: Team Teaching a Service Learning Course for a Large Class” Alan Blizzard Award paper, McGraw-Hill Ryerson, 2007. Published as a special booklet by McGraw-Hill Ryerson.
    b. S. McCahan, “Universal Instructional Design Applied in a Design Classroom,” Proceedings of the 2007 ASEE Annual Conference, Honolulu, June 24-27, 2007.
    c. J. Bazylak and S. McCahan “Interactive First-year Engineering Seminar Series”, Proceedings of the Meeting of the Canadian Engineering Education Association, Kingston ON, June 2010.
    d. S. McCahan, L. Romkey and G. Allen, "Development of the Graduate Attribute Quality Assurance Process at the University of Toronto", Proceedings of the Canadian Engineering Education Association Annual Conference, St. John's Nfld., June, 2011.
    e. C. Variawa and S. McCahan “Identifying Language as a Learning Barrier in Engineering,” IJEE, January 2012.

Department of Chemical Engineering and Applied Chemistry

2. **Prof. Greg Evans**

    a. Evans G.J. E. Reed, D. Reeve, A Satkunarajah and A. Simpson “Infusing leadership Instruction into the Curriculum of Chemical Engineering Students” Canadian Society for Chemistry Conference, Hamilton, Canada, June 2009.
    b. Evans, G. J., McGuire, M. and Tihanyi, D., “Using Environmental Consulting as a Team Design Project: Role Play to Reality”, Canadian Engineering Education Association (CEEA) Conference, Queen’s University, Kingston, June 8, 2010.

c. Evans G.J., D.W. Reeve and A.E. Simpson "Introducing Leadership Learning in Engineering Classrooms" Canadian Engineering Education Conference, Kingston Jun 7-9, 2010.
d. Evans G.J., P. Sheridan, D. Reeve, M. McGuire, K. Minnella, E. Oliva-Fisher, L. Wilkinson, and T. McAlary. "Incorporating Team Effectiveness as a Learning Objective in the Design Project within a Technical Core" Canadian Engineering Education Association, Montréal, Canada, 2013.
e. P. K. Sheridan, G. Evans, and D. Reeve, "A Proposed Framework for Teaching Team-effectiveness in Team-based Projects," American Society of Engineering Education Annual Conference and Exposition, San Antonio, Texas, 2012.

3. Prof. Doug Reeve

a. Reeve, D. A. Simpson, V. Kumar, E. Masters, D. Colcleugh, and G.J. Evans "Leaders of Tomorrow- A Leadership Development Program for Engineering Students at the University of Toronto" American Society for Engineering Education - St Lawrence section regional workshop, Toronto, Oct. 2007.
b. P. K. Sheridan, D. Reeve, and G. Evans, "Student perceptions and use of an inventory to facilitate learning of individual team-effectiveness," Canadian Engineering Education Association, Montréal, Canada, 2013.
c. P. K. Sheridan, J. Phillips, L. El Gammal, G. Evans, and D. Reeve, "A Team-effectiveness Inventory for Guided Reflection and Feedback," American Society of Engineering Education Annual Conference and Exposition, Atlanta, Georgia, 2013.
d. P. K. Sheridan, D. Reeve, and G. Evans, "Guiding useful self- and peer-assessments of team-effectiveness in a first year engineering design course," Canadian Engineering Education Association, Winnipeg, Canada, 2012.
e. Simpson, A. E., Evans, G.J.; Reeve, D.W. "A Summer Leadership Program for Undergraduate Chemical Engineering Students" Canadian Engineering Education Conference, Kingston Jun 7-9, 2010.

Department of Civil Engineering

4. **Prof. Bryan Karney**
   a. Karney, B.W., Malekpour, A. and Salehi, H. (2010). "An exploratory approach to teaching gradually varied flow," J. of Hydro-Environment Research, Vol 6.
   b. Karney, B.W. (2009). "Effective motivation of engineering mathematical motivation," CMS 2009, Mathematical Education, Annual Conference of the Canadian Mathematical Society, Windsor Ontario, December 5, 2009.
   c. Kennedy, C.A, Hyde, R.A., and Karney, B.W. (2002). "Development of environmental knowledge and attitudes in engineering students," Bulletin of Science, Technology & Society, 22(6), 460-473.

d. Hyde, R.A., and Karney, B.W. (2001). “Environmental education research: implications for engineering education,” J. of Engineering Education, 90, April, 267-275.
e. Hyde, R.A., Karney, B.W., and Kennedy, C.A. (2000). “Fishing for a new way to teach environmentally sensitive engineering practice,” Bulletin of Science, Technology & Society, 20(5), Oct., 383-392.

Department of Curriculum Teaching and Learning

5. Prof. Doug McDougall

a. Radakovic, N.* & McDougall, D. (2012). Using dynamic geometry software for teaching conditional probability with area-proportional Venn diagrams. International Journal of Mathematical Education in Science & Technology, 43(7), 1-5.
b. Stoilescu, D.* & McDougall, D. (2011). Gender Digital Divide and Challenges in Undergraduate Computer Science Programs. Canadian Journal of Education, 34(1), 308-333.
c. Stoilescu, D.* & McDougall, D. (2010). Starting to Publish Academic Research as a Doctoral Student. International Journal of Doctoral Studies, 5, 79-92.
d. Lee, J.* & McDougall, D.A. (2010). Secondary school teachers’ conceptions and their teaching practices using graphing calculators. International Journal of Mathematical Education in Science & Technology, 41(7), 857-872.
e. Fantilli, R.* & McDougall, D.E. (2009). A study of novice teachers: Challenges and supports in the first years. Teaching and Teacher Education, 25(6), 825-841.
f. Jang, E.E., McDougall, D.E., Herbert, M., Pollon, D., & Russell, P. (2008). Integrative mixed method data analytic strategies in research on school success in challenging circumstances. Journal of Mixed Methods Research, 2(3), 221-247.

6. Prof. Clare Brett

a. Zingaro, D., Oztok, M., Brett, C. & Hewitt, J. (2013). Exploring Asynchronous and Synchronous Tool Use in Online Courses, Computers & Education, 60 (1), 87–94.
b. Freeman, W. & Brett, C. (2012). Prompting authentic blogging practice in an online graduate course. Computers & Education, 59, 1032-1041.
c. Oztok, M. & Brett, C. (2011). Social presence and online learning: A review of the research. The Journal of Distance Education, 25(3), 1-10.
d. Brett, C. (2009). Educational Perspectives on digital communications technologies. Journal of E-Learning 6(3), 281-291.

7. Prof. Jim Slotta

a. Peters, V. L., & Slotta, J. D. (2010). Scaffolding knowledge communities in the classroom: New opportunities in the Web 2.0 era. In M. J. Jacobson & P.

Reimann (Eds.), Designs for learning environments of the future: International perspectives from the learning sciences (pp. 205-232). Secaucus, NJ: Springer.

b. Slotta, J. D. (2010). Evolving the classrooms of the future: The interplay of pedagogy, technology and community. In K. Mäkitalo-Siegl, F. Kaplan, J. Zottmann & F. Fischer(Eds.). Classroom of the Future. Orchestrating collaborative spaces. (215-242). Rotterdam: Sense.
c. Krajcik, J., Slotta, J.D., McNeil, K. and Reiser, B. (2008). Designing Learning Environments to Support Students' Integrated Understanding. In Y. Kali, M. C. Linn, & J. E. Roseman (Eds.), Designing Coherent Science Education. New York: Teachers College Press.
d. Berge, O. and Slotta, J. (2006). "Learning Technology Standards and Inquiry-Based Learning." In: A. Koohang (Ed). Principles and Practices of the Effective Use of Learning Objects. Informing Science Press.
e. Linn, M.C. and Slotta, J.D. (2006) When, why and how do students learn from each other? In: A. O'Donnell, J.L. van der Linden, & C.E. Hmelo (Eds.) Collaborative Learning, Reasoning, and Technology. 2001 Rutgers Invitational Series in Education, Lawrence Erlbaum.

8. Prof. Erminia Pedretti

a. Pedretti, E., & Nazir, J. (in press). Currents in STSE education: Mapping a complex field, 40 years on. Science Education. (1-26).
b. Tan, M., & Pedretti, E. (2010). Negotiating the complexities of environmental education: A study of Ontario teachers. Canadian Journal of Science, Mathematics and Technology Education. 10(1), 61-78.
c. Bencze, L., Hewitt, J., & Pedretti, E. (2009). Personalizing and contextualizing multimedia case methods in university-based science teacher education: An important modification for promoting technological design in school science. Research in Science Education. 39, 93-109.
d. Pedretti, E., Bencze, L., Hewitt, J., Romkey, L, & Jivraj, A. (2008). Promoting issues-based STSE perspectives in science teacher education: Problems of identity and ideology. Science and Education.17(8/9), 941-960.
e. Pedretti, E. (2006). Informal science education: Critical conversations and new directions. Canadian Journal of Science, Mathematics and Technology Education, 6(1), 1-4.

Appendix C: Memorandum of Agreement

University of Toronto
MEMORANDUM OF AGREEMENT

Collaborative Master's and Ph.D. Program in Engineering Education

[October 2013]

Memorandum of Agreement concerning a Collaborative Graduate Program in Engineering Education

1. Brief Description

In order to develop cooperative and multidisciplinary graduate education and research in Engineering Education, the following graduate units have been consulted and agree to the participation of graduate programs and associated degrees in the collaborative program:

1. Dept. of Mechanical and Industrial Engineering
   Graduate Program, M.A.Sc. and Ph.D.

2. Dept. of Chemical Engineering and Applied Chemistry
   Graduate Program, M.A.Sc. and Ph.D.

3. Dept. of Civil Engineering
   Graduate Program, M.A.Sc. and Ph.D.

4. Dept. of Curriculum Teaching and Learning
   CSTD Program, M.A. and Ph.D.

2. Admission and Program Requirements and Completion

2.1 Admission Requirements

Applicants must be accepted into a graduate degree program before being accepted into a collaborative program, and must meet the admission requirements of both the home graduate unit and the collaborative program.

2.2 Program Requirements

The student must register first in the home graduate unit/program. Thereafter, upon acceptance to the collaborative program, the student will register in the collaborative program. The student must meet all degree requirements of the participating graduate unit/program, as well as the requirements of the Collaborative Program.

- 0.5 FCE required core course
- seminar course (CR/NCR, no weight)
- 0.5 FCE elective course (Ph.D. Only)

2.3 Program Completion

Upon certification by the collaborative program director that all requirements of the collaborative program have been fulfilled, the designation "Completed [insert session date] – Collaborative Program [insert degree short-form] in Engineering Education" is shown on the graduate transcript. The home graduate unit recommends the granting of the degree.

3. Role of Participating Graduate Units

Each participating graduate unit shall retain its constitutional control over admissions and home program requirements, and is responsible to provide adequate research supervision by a member of the graduate faculty in the unit. Students in the Collaborative Program normally are supervised by a member of the Collaborative Program's core faculty, or have a core faculty member as a member of the supervisory committee (where supervision and a supervisory committee are required). Participating graduate units include reference to the collaborative program in the SGS Calendar entry, on the graduate unit website, and in other advertising material related to the home program. Core faculty members are identified with the collaborative program via the director's office. Core faculty members remain available to contribute to the collaborative program through teaching, supervision and participation in the delivery of seminar series and other collaborative program learning elements, and may serve on the collaborative program committee. Not all faculty members necessarily participate each year and, in many cases, may simply remain available to interested students. Some faculty may teach courses in the subject area of the collaborative program in the home program.

4. Administration of the Program

4.1 Program Director

The Program Committee initiates and recommends the appointment of a new director to the Dean of SGS, after consultation with chairs/directors of participating graduate units and with the Collaborative Program Director. The Dean of the School of Graduate Studies will approve the appointment of the Director for terms normally up to five years (renewable).

The duties of the Director are as follows:

a) Chairs the program committee, and ensures that the program committee has appropriate representation, according to the memorandum of agreement.
b) Maintains appropriate content of program entry in the SGS Calendar, the website, and any other promotional material.
c) Administers the Collaborative Program including applications, admissions, recordkeeping, and budget.
d) Approves individual admissions to the Collaborative Program, and ensures that students are formally enrolled in the collaborative program as soon as possible.
e) Approves individual student programs in conformity with the standards of the collaborative program and ensures that students registered in the program have supervisory arrangements in accordance with the program's requirements; monitors the progress of students in the program; ensures that appropriate academic advising is available to students in the program.
f) Ensures that a collaborative program core faculty member is a member of each student's thesis examination committee.
g) Certifies completion of program requirements for each student enrolled in the program.
h) Ensures that students, who complete the requirements of a Collaborative Program, receive the appropriate notation on their graduate transcripts.
i) Submits for governance approval to the Faculty Graduate Dean's Office recommendations for changes to core course/s or the program and its requirements, or related academic matters.
j) Maintains communication with the heads of participating graduate units regarding activities and evaluation of the collaborative program.
k) Provides reports to the Faculty Graduate Dean's Office or SGS on the program's activities, including registration and graduation figures, as required and/or requested.
l) Ensures that the memorandum of agreement is followed and kept up-to-date, including:
    - Monitors changes to admission and/or program requirements in participating
    - programs that might affect collaborative program requirements
    - Recommends additions/deletions of participating programs to collaborative
    - program, ensuring continuity of program for students already registered
    - Provides lead Faculty Graduate Dean's Office with up-dated memorandum of agreement or addenda when changes are made.
m) Requests, in final year of term, that the program committee provide a recommendation to the D&VPGE for the directorship for the next five-year term, recusing him/herself from the process.
n) Prepares self-study and related activities according to UTQAP review procedures and schedules.

4.2 Program Committee

The collaborative program is administered by a program committee normally consisting of one core graduate faculty member from each participating home program. The program committee shall be chaired by the program director.

The Program Committee will initially consist of Profs. Evans (CHE, FASE), McCahan (MIE, FASE) and Brett (CTL, OISE). In addition to their normal responsibilities, program committee will:

- Execute responsibilities delegated by the Program Director
- Actively promote and facilitate the growth and sustainability of the program including the recruitment of students, faculty and resources.

Membership on the Program Committee will be reviewed every three years and rotate as needed among the Collaborative Program faculty members.

4.3 Administration: General

The EngEd program will be supported by a part time administrator (30%). This individual will facilitate the Director's activities, provide logistical support for the courses, seminars and other student activities, and handle the day-to-day administrative duties for the collaborative program. They would likely be shared with some other program, centre or institute.

5. Supporting Units (FASE, CIV, MIE, CHE and CTL)

The majority of the resources required will be provided by FASE (see below). The supporting departments will provide instructors to support the delivery of the two core courses.

6. Resource Issues

FASE will provide the space to house the envisioned EngEd community, with desks for 10 to 15 students. This space will be within FASE and ideally will be co-located near or with the Institute for Leadership Education in Engineering (ILead), which would allow the possibility for expansion of the longer term, to include space for a few post-docs and/or sessional instructors.

Administrative support to support the operation of the EngEd Collaborative Program will also be provided by FASE, through a 30% FTE position. This support will be used to facilitate the Director's activities, provide logistical support for the courses, seminars and other student activities, and handle the day-to-day administrative duties for the collaborative program. Finally, a small operating budget of $10000/year will be provided to cover the costs for items such as advertising, web site, hospitality etc.

Instructors for teaching the two core courses will be provided by the participating units, with this additional teaching load shared between the units roughly in proportion to the number of students they have participating in the program.

School of Graduate Studies
University of Toronto
MEMORANDUM OF AGREEMENT (cont'd):

SIGNATURE PAGE

Collaborative Master's and Ph.D. Program in Engineering Education

[October 2013]

UNIT AGREES TO PARTICIPATE IN ACCORDANCE WITH ALL TERMS OUTLINED IN THIS MEMORANDUM OF AGREEMENT

Collaborative Program Director (designate):

_____ Date: _____

Director's Name

Graduate Units Participating in Collaborative Program:

_____ Date: _____

Chair/Director, Graduate Unit

_____ Date: _____

Chair/Director, Graduate Unit

_____ Date: _____

Chair/Director, Graduate Unit

_____ Date: _____

Chair/Director, Graduate Unit

Continue listing all participating graduate units.

Supporting Unit(s)

None

Faculty of Applied Science and Engineering (Lead Faculty)

_____ Date: _____

Vice-Dean, Graduate Studies

School of Graduate Studies & Vice-Provost, Graduate Education:

_____ Date: _____

Dean, School of Graduate Studies and Vice-Provost, Graduate Education