Questionnaire for Evaluation of an Engineering Program - Exhibit 1

Submitted by:

[redacted]

Name of Higher Education Institution

Mechanical Engineering

Program name

September 2017

Date

Canadian Engineering Accreditation Board

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Graduate Attributes

The higher education institution must demonstrate that the graduates of a program possess the attributes under the following headings. The attributes will be interpreted in the context of candidates at the time of graduation. It is recognized that graduates will continue to build on the foundations that their engineering education has provided.

Instructions for criterion 3.1

Please complete Tables 3.1.1 to 3.1.2 for the program to be accredited by using the workbook files included with this package. In addition complete the following information based on the following explanation of headings.

For graduate attribute processes:

Organization and engagement: *Under this heading discuss the organizational structure for the measurement of graduate attributes. Discuss the roles and engagement of faculty members and engineering leadership in this structure.*

For each attribute:

Curriculum maps: *Under this heading discuss the specific characteristic of each course/learning activity that justifies the mapping to the attribute and the level (I,D,A) assigned. Specify the indicator or indicators that apply to each course/learning activity (all may or may not apply to a specific course). Explain the rationale for the selection of those courses/learning activities where data is collected for continual improvement process.*

Indicators: *Under this heading explain the rationale behind the selection of the indicators for the attribute and the justification that the indicators are unique to the attribute or a component of the attribute. Explain further how the data collected demonstrates the full scope of the attribute contained in the CEAB definition.*

Assessment tools: *Under this heading discuss the specific tools/instruments (exam, rubric, report etc.) for each course/learning activity where data is collected that was applied to provide evidence that an attribute (or a component of an attribute) has been demonstrated.*

Assessment results: *Under this heading explain how measurements are distributed over the semesters of the program and justify this distribution in the context of a continual improvement process. Discuss how many courses/learning activities are used in the assessment of the attribute and justify the presence or absence of duplicate measurements in the context of a continual improvement process.*

Organization and engagement

Under this heading discuss the organizational structure for the measurement of graduate attributes. Discuss the roles and engagement of faculty members and engineering leadership in this structure.

Leadership Roles

The Dean ([redacted]) is responsible for all aspects of the Engineering programs in the Schulich School of Engineering (SSE). Responsibility for oversight of activities related to accreditation at the faculty level has been delegated to the Senior Associate Dean, Academic & Planning ([redacted]). Coordination of program quality activities across the faculty is provided by the Advisor, Program Quality Assurance ([redacted]; see Program Quality Assurance Committee below).

At the program level, responsibility for accreditation and program quality activities rests with the Department Heads, assisted by Associate Heads, Undergraduate and/or Program Directors, and the member of the Program Quality Assurance Committee (PQAC). For the Mechanical Engineering program, the Associate Head, Undergraduate ([redacted]), and the PQAC member ([redacted]) assist the Head of Mechanical Engineering ([redacted]) in managing all aspects of the program.

Formal committees

The following formal committee structure has been established to measure and evaluate graduate attributes in the Engineering programs at the Schulich School of Engineering. Except in cases with specific delegated authority noted below, this committee structure makes recommendations to the Engineering Faculty Council (EFC). EFC, chaired by the Dean, is the highest faculty-level governing body for all Engineering programs in the Schulich School of Engineering (SSE).

<u>Department Undergraduate Studies Committee (D-USC)</u>

Chaired by the Associate Head, Undergraduate ([redacted]), the D-USC consists of faculty members in the Department of Mechanical Engineering. D-USC is the program-level curriculum committee with responsibility for the Mechanical Engineering program curriculum, as well as program-level review of student academic standing. D-USC members are normally appointed from full-time academic staff in the department, to ensure that faculty members involved in teaching in the program are also directly responsible for its governance. In 2016-17, the D-USC consists of seven faculty members and one undergraduate administrator. One faculty member of D-USC ([redacted]) chairs the Student Liaison Committee to collect the students' opinion for D-USC.

The D-USC reviews graduate attributes measurement data compiled by the department's Program Quality Assurance Committee (PQAC, see below) representative on a regular basis. The Associate Head and the D-USC also liaises with students in the Mechanical Engineering program to establish a mechanism to gather student feedback and address student concerns. The feedback gathered through this mechanism is documented in meeting notes and forms part of the stakeholder engagement (see "Continual improvement" below). On an annual basis, the D-USC and the department PQAC representative provide a report on graduate attributes measurement results and other information relevant to continual improvement, as well as a proposed action plan to address any program issues identified, to the Engineering Undergraduate Studies Committee (EUSC, see below) for approval.

Engineering Undergraduate Studies Committee (EUSC)

The EUSC is a standing sub-committee of the EFC, with a mandate to review and make recommendations to the Dean and EFC on all matters pertaining to undergraduate education at the Schulich School of Engineering. The EUSC is co-chaired by the Senior Associate Dean, Academic & Planning ([redacted]) and the Associate Dean, Student Affairs & International [redacted]), and its responsibilities encompass both review of the curriculum and of student academic standing. The EUSC has specific delegated authority to approve calendar (program) changes within a defined scope. Approval of proposals involving the creation or termination of programs, minors, and specializations remain the responsibility of the EFC.

In its capacity as the faculty-level curriculum committee, the EUSC reviews and approves reports on graduate attributes measurement results, and resulting action plans, for each SSE program on an annual basis. Reporting and action planning is coordinated as much as possible with the [redacted] Curriculum Review process recently established by the Provost's Office [redacted] see below).

Program Quality Assurance Committee (PQAC)

Chaired by the Advisor, Program Quality Assurance ([redacted]), the PQAC is a sub-committee of the EUSC, consisting of representatives from each of the undergraduate degree programs in the SSE. Each Engineering program is represented by a faculty member from the department, who is responsible for leading graduate attributes assessments in the department's programs. The PQAC responsibilities include establishing plans for achievement of accreditation criteria, including measurement of quality via Graduate Attributes and Continual Improvement cycles. The PQAC is responsible for coordination of collection of program information, including course information sheets, instructor data, samples of student work, graduate attribute data and continual improvement data from programs. Administrative staff in each of the SSE department offices, as well as in the Dean's office (administrative staff supporting the Senior Associate Dean, Academic & Planning) provide administrative support for data collection and processing. The chair provides regular reports on PQAC activities to the EUSC.

The PQAC also serves as the primary mechanism for faculty engagement in the Graduate Attributes and Continual Improvement process. Program representatives are responsible for planning the collection of graduate attributes assessments in courses offered in their programs. In preparing the assessment plans, program representatives approach instructors of selected courses to discuss possible assessment activities in these courses. Representatives are also expected to give regular updates on the PQAC activities at department meetings and meetings of department-level curriculum committees (D-USC).

University of Calgary Curriculum Review Process

The University of Calgary has mandated a Curriculum Review process on a five-year cycle for all of its undergraduate programs. The process is faculty-led and guided by the Vice-Provost, Teaching & Learning, according to an established process described on the Provost's Office website at http://www.ucalgary.ca/provost/activities/reviews. The Curriculum Review process is part of the University of Calgary Quality Assurance Review process, which also includes Major Unit Reviews coordinated by the Provost on a five-year cycle. The SSE completed a Major Unit Review in October 2015 and the curriculum review process for all four-year programs in 2017. As noted above, there is significant opportunity for coordination of the CEAB continual improvement process with the university curriculum review.

Information applicable to all graduate attributes

Overview

The Schulich School of Engineering (SSE) Graduate Attributes approach for both curriculum mapping and graduate attributes assessment is built on a tiered framework consisting of the following key components: 1) the CEAB Graduate Attributes (GAs), 2) the SSE Indicators, 3) Course Learning Outcomes, and 4) Assessment Tools. Figure 1 below provides an overview of this framework. More detailed information about components 2-4 is provided in separate sections below.

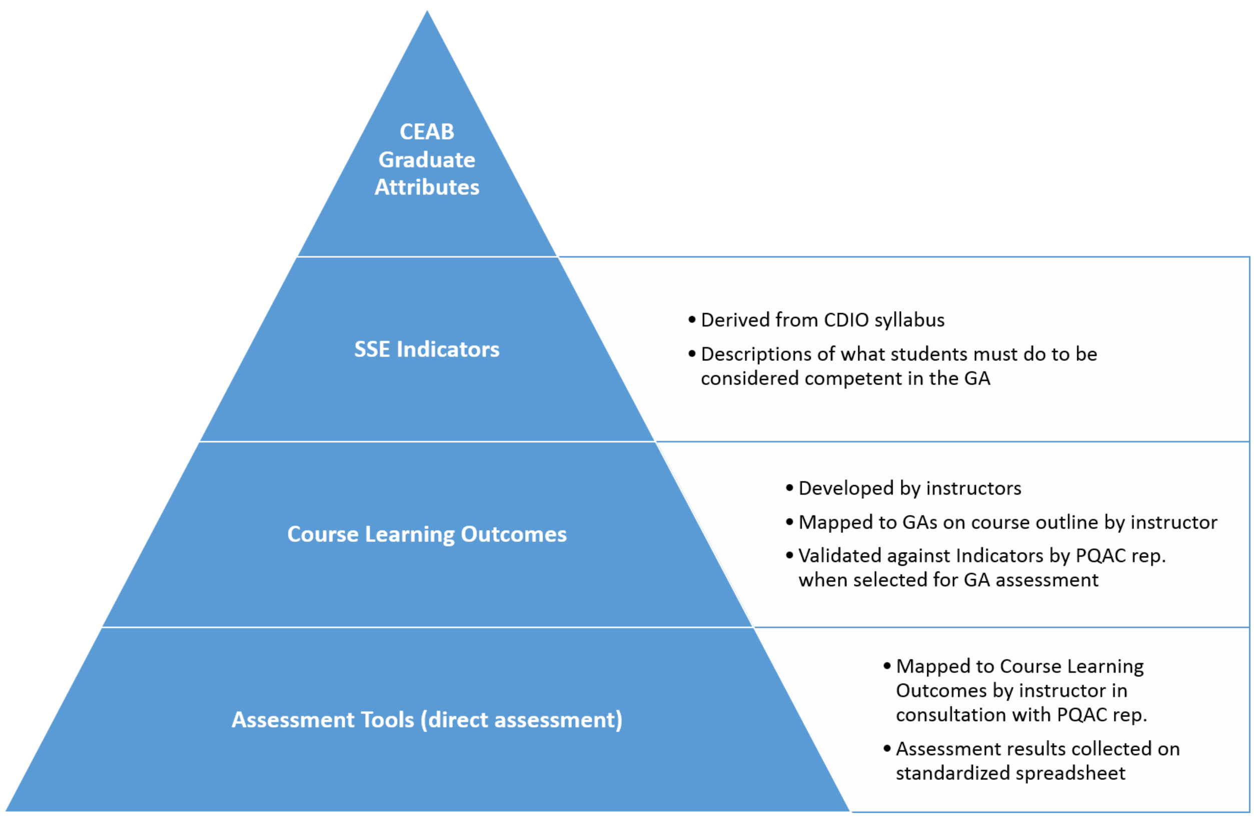

Figure 1: Overview of key components of the SSE Graduate Attributes approach.

Curriculum maps

Curriculum mapping in the SSE began in 2009-10 using an approach based on the CDIO syllabus. This was developed further in 2013-14 by requiring instructors to map course learning outcomes to GAs on all SSE course outlines. The curriculum mapping data presented in this report originates from a renewed mapping exercise conducted in 2016 and refined in four stages described below.

Stage 1: The set of third-level CDIO syllabus[1] topics that correlate with each of CEAB Graduate Attributes 2-12 was defined as described by Cloutier et al., 2010[2]. Instructors were interviewed during Winter and Fall of 2016 to identify which CDIO topics are covered in each course and at what level of instruction (I, D, or A). The resulting questionnaire will be provided on-site in the Graduate Attributes Dossier for reference. The percentage of the applicable CDIO topics that were covered was used as the score for each CEAB Graduate Attribute. The resulting mappings for compulsory courses in the program will be provided on-site in the Graduate Attributes Dossier. CEAB Graduate Attribute 1 (Knowledge Base) was not included in this mapping, as the CDIO syllabus is not discipline-specific. It was deemed that a survey of the Knowledge Base content could be more efficiently done through a review of course outlines and CEAB course information sheets.

Stage 2: The data resulting from Stage 1 was reviewed to identify up to three top-scoring graduate attributes for each course. The resulting sets of (up to) three graduate attributes per course were used as a first draft of the complete curriculum map in 2016.

Stage 3: Subsequently, we have established a system to maintain and update this mapping of CEAB graduate attributes to each course by having instructors review (and if necessary, revise) the mapping on an annual basis as they prepare their course outlines. To facilitate this process, a table indicating the mapping between course learning outcomes and key CEAB graduate attributes is included on the SSE course outline template. The graduate attributes mapping reported on Course Information Sheets and Table 3.1.1 in Appendix 6C was derived from the 2016-17 course outlines. Instructors were also asked to review the Course Information Sheets and allowed to modify the graduate attributes if necessary to ensure that the three graduate attributes reported were appropriate for the course as it was delivered.

Stage 4: For courses selected for direct graduate attributes assessments, PQAC representatives validate the mapping of course learning outcomes to the relevant Graduate Attribute. This is done by verifying that each course learning outcome can be mapped to at least one of the SSE Indicators (see below and Appendix A) for the applicable CEAB Graduate Attribute.

Indicators

The Schulich School of Engineering maintains a set of indicators for each CEAB Graduate Attribute, which provide more specific descriptions of the measureable characteristics associated with each CEAB graduate attribute. This document (attached as Appendix A) was developed based on the third-level CDIO syllabus topics in 2011 as the School first began to develop a Graduate Attributes/Continual Improvement process, and has been subject to minor updates since then. Given the common origin in the CDIO syllabus, the SSE Graduate Attribute Indicators are closely related to the survey used for Stage 1 of the curriculum mapping process described above. The SSE Graduate Attribute Indicators are

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[1] EF. Crawley, J. Malmqvist, WA. Lucas, and DR. Brodeur, “The CDIO Syllabus v2.0
An Updated Statement of Goals for Engineering Education”, Proceedings of the 7th International CDIO Conference, Technical University of Denmark, Copenhagen, June 20 – 23, 2011.
[2] G. Cloutier, R. Hugo, and R. Sellens. “Mapping the Relationship Between the CDIO Syllabus and the 2008 CEAB Graduate Attributes”, Proceedings of the 6th International CDIO Conference, École Polytechnique, Montréal, June 15-18, 2010.

available as a supporting framework to assist instructors in developing course learning outcomes and mapping these learning outcomes to the appropriate CEAB Graduate Attribute.

Course learning outcomes

Course learning outcomes are developed by the instructor for each course as part of the official course outline. Mapping of course learning outcomes to key CEAB graduate attributes on all SSE course outlines facilitates the selection of direct assessments in our courses. Course learning outcomes are designed to map to a single CEAB graduate attribute. When a course learning outcome is selected for GA assessment, the PQAC representative for the program validates the mapping by confirming that the course learning outcome maps to at least one of the SSE indicators for the corresponding GA ("Stage 4" under "Curriculum maps" above).

Assessment tools

Selection of specific assessment data for a course is done by the department PQAC representative in collaboration with the course instructor to ensure that assessments are specific to a particular course learning outcome (and thus, to a specific CEAB graduate attribute). In the data set provided in this document, we have used a variety of direct, course-based assessments, including scores on specific exam problems and rubric-based assessments of written reports and presentations. Assessment results are provided in summary form for each course and each graduate attribute assessed in this document. Details of each assessment and results of individual assessments will be provided on-site in the Graduate Attributes Dossier.

In addition to direct, course-based assessments, we believe there is value in obtaining indirect assessments. In the data set presented in this document, we have included the results of a student survey using a self-efficacy survey developed at the SSE by [redacted] based on a survey originally developed by the CDIO initiative. Recently, we have modified the self-efficacy survey to obtain assessments of the students' efficacy from practicing Engineers who supervise students in the Engineering Internship Program as an alternate point of view (Engineering Competencies Survey). Finally, we have included data based on a teamwork survey administered by [redacted] group in the Department of Psychology at the [redacted] Indirect assessments provide an independent viewpoint (in the case of the self-efficacy and teamwork surveys, the students' own perspective) on the outcomes of an educational program.

We have worked to ensure that each Graduate Attribute is assessed at multiple points in the program (early, mid, late). Chart 1 shows an overview of the coverage of graduate attributes measurements collected and included in the analysis for this accreditation review by Graduate Attribute and year of program.

In the Mechanical Engineering program, we have used an in-house spreadsheet tool, namely, the Integrated Course Design Tool (ICDT) to address two practical needs in data collection. The first need is to minimize the time and effort of instructors to collect the graduate attribute data. The second need is to promote the reliability of collected data that can be interpreted meaningfully for continual improvement. In a nutshell, ICDT makes an explicit mapping between graduate attributes and classroom assessments, and it can be set entirely based on the course outlines prepared by instructors. From the perspective of course instructors, the ICDT data collection process is simply a matter of entering the grade spreadsheet (i.e., the regular grade collection process) and the graduate attribute / learning outcome / assessment mapping information from the course outline. Then, ICDT can extract the relevant data for the assessment of graduate attributes. A spreadsheet model was chosen for the ICDT since spreadsheets are the most familiar and common method of grade collection for faculty members.

We have been applying ICDT for data collection about two years. As the process becomes more standardized, we have trained our office administrator to perform the logistical works. In this way, the data collection duty has been reduced for instructors so that they can focus on student assessment in the context of course learning outcomes. In view of data reliability, we mainly utilize the information from the course outlines to control the nature of data being collected; this is enabled by the ICDT's close link to the SSE course outline.

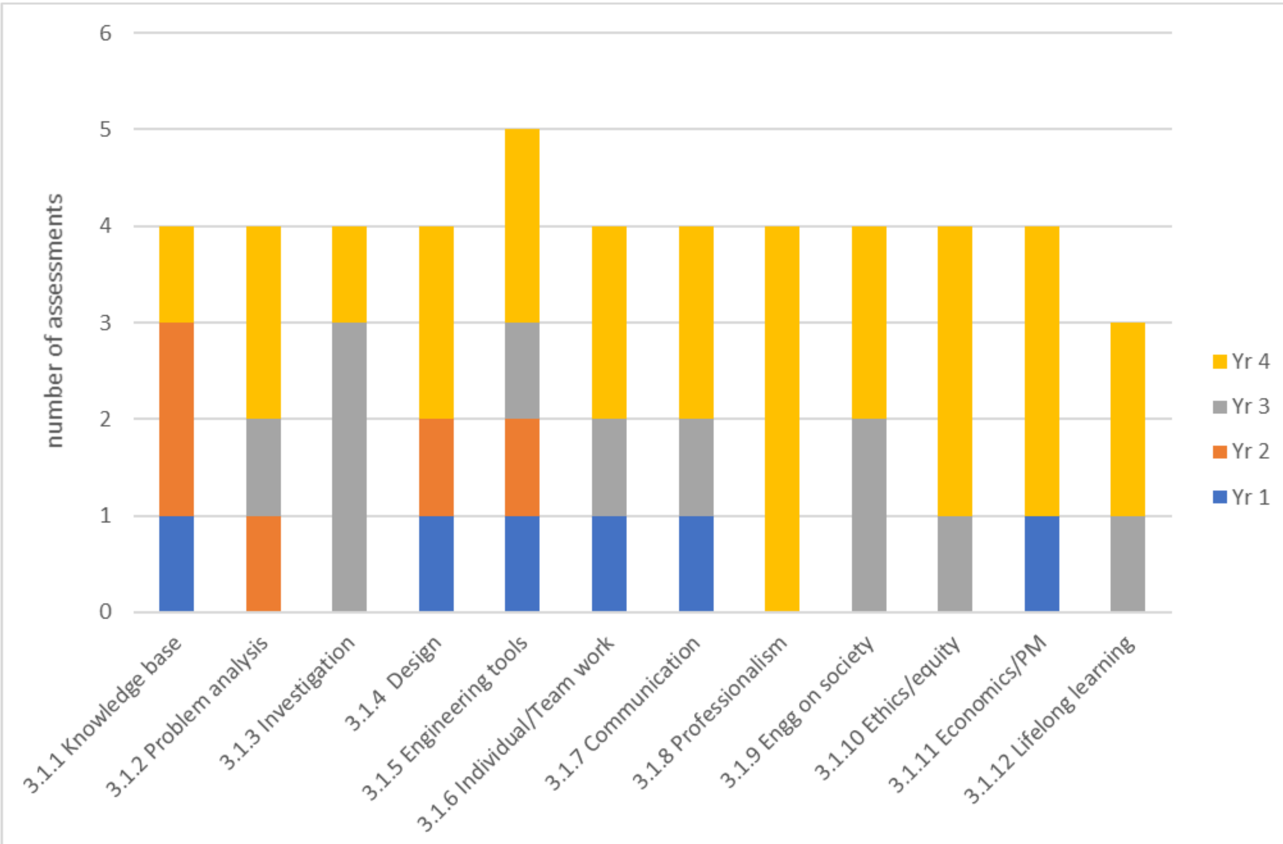

Chart 1: Overview of graduate attributes assessments collected from the SSE standard graduate attributes data collection plan.

Assessment results

We have developed a standard report used to summarize student achievement in the context of graduate attributes assessed in a course. Summary output in the form of histograms are provided in this document; more detailed reports for each course assessed will be provided on-site in the Graduate Attributes Dossier.

Performance descriptors: We have summarized our results in terms of five performance descriptors, ranging from Unsatisfactory to Excellent. The Program Quality Assurance Committee has adopted definitions of the five performance descriptors as shown in Table 1 below.

Table 1: SSE Performance descriptors

Performance descriptor	**Interpretation** *Performance (behavior or skill level) relative to the designated graduate attribute*	**Approximate corresponding letter grade***
Unsatisfactory	Clearly sub-standard behaviour or skill level. Improvement is essential to meet minimum standards for the experience level.	F
Below expectations	Performance falls below the desired standard. Some improvement is required to fully meet minimum standards for the experience level.	D to C-
Meets expectations	Demonstrates reasonable competency and effectiveness considering the experience level.	C to B
Exceeds expectations	High level of performance. Better than expected given the experience level.	B+ to A-
Excellent	Superior behaviour or skill. Substantially above expectations considering the experience level.	A to A+

**if representative of overall performance in a course*

Summary of graduate attribute assessment

This report documents the information of graduate attributes of the Mechanical Engineering program for the accreditation process in 2017. At the course level, the data collection and analysis process was assisted by an in-house spreadsheet tool, namely Integrated Course Design Tool (ICDT) to streamline the instructors' efforts and promote their engagement in the process. At the program level, surveys were used to collect feedbacks from students (self-efficacy survey) and industry (internship supervisor survey). From the analysis, ten (out of twelve) graduate attributes indicate satisfactory results, and no specific actions are required at the program level. There are two attributes that need specific actions for continual improvement. The first one is GA #5: Use of engineering tools, where the curricular contents of computer programming requires some revisions for the specific needs of mechanical engineering students. The second one is GA #8: Professionalism, where the recognition of codes and standards should be distinguished from their technical applications. Further, we identified five graduate attributes, which assessment processes can be improved to better inform the students' performance in these areas. These attributes include Design (GA #4), Individual and team work (GA #6), Professionalism (GA #8), Ethics and equity (GA #9), and Life-long learning (GA #12).

Graduate attribute #1 A knowledge base for engineering

Canadian Engineering Accreditation Board definition:
Demonstrated competence in university level mathematics, natural sciences, engineering fundamentals, and specialized engineering knowledge appropriate to the program.

Curriculum maps:
The learning activities selected for assessment of GA #1, as well as the rationale for selecting these learning activities, are summarized in Table 1.1 below.

Table 1.1: Summary of learning activities used to assess GA #1 A knowledge base for engineering.

Learning activity	I/D/A	Rationale for choice of learning activity
ENGG 201	I	This course provides fundamental knowledge in the behaviour of fluids and solids. It is foundational for engineering physics and chemistry.
MATH 375	D	This course covers the contents of differential equations specific for engineering and science students. This math skill is foundational to describe various kinds of material and mechanical properties.
ENME 339	A	This course covers 2-D, 3-D modeling and engineering drawings, which are considered specialized engineering knowledge in mechanical engineering.
Self-efficacy survey	A	The self-efficacy survey is an indirect measurement, designed to provide an independent viewpoint (the student's own perspective) on the program outcomes.

Indicators and Assessment tools:
Specific course learning outcomes were used as sub-indicators for direct assessments. Assessment tools for direct measurements include project and final exam questions from the courses listed in Table 1.1 above. Complete details of all course learning outcomes (sub-indicators) and assessment tools used will be available on-site in the Graduate Attributes Dossier for each course assessed, as well as for the self-efficacy survey. Table 1.2 below provides some examples at each level of instruction intended to allow the visiting team to assess the overall approach to assessing this graduate attribute.

Table 1.2: Examples of indicators and assessment tools for GA #1 A knowledge base for engineering.

Indicator	Course learning outcome (sub-indicator)	Rationale for course learning outcome	Assessment tool
1.3	**Perform hydrostatic pressure calculations and basic fluid flow calculations. (ENGG 201, I)**	The behavior and properties of fluid flows are fundamental in many mechanical systems.	*Final Exam Question 5* Question asks students to determine the pressure difference of an inclined pipe under various conditions.
1.2	**Solve first order differential equations with applications. (MATH 375, D)**	The resolution of first-order different equations is fundamental to analyze various engineering systems.	*Final Exam* The final exam is taken as the summative assessment of student learning.
1.3	**Develop 2-D and 3-D models using SolidWorks. (ENME 339, A)**	Besides the mathematics and natural sciences, graphical modeling is taken as one essential specialized knowledge in mechanical engineering.	*Project* It requires students to develop 3-D models of a product, along with the 2-D drawings.
1.2 1.3	**Self-efficacy survey questions assessing confidence in ability to perform tasks related to related to GA #1.**	Validation of the self-efficacy survey is described in "Information applicable to all graduate attributes" above.	Responses on a five-point Likert scale ranging from "No confidence" to "Total confidence". Questions relate to students personal reflection on their experiences throughout the program such as the effectiveness of the teaching and learning.

Assessment results:
The results of assessments for this graduate attribute are summarized in Chart 1.1 below. Assessments have been collected in one 200-level and two 300-level courses to indicate the learning of knowledge base at early years of the program. While higher Unsatisfactory and Below Expectations levels are observed from ENGG 201, the overall results in MATH 375 and ENME 339 are satisfactory. One interpretation is that students need some time to adapt the learning environment at the university, and thus their academic performance improves in their second year. It is also reflected in the self-efficacy survey results that students are confident with their knowledge base for engineering. Based on the results to date, it does not seem appropriate to recommend specific actions.

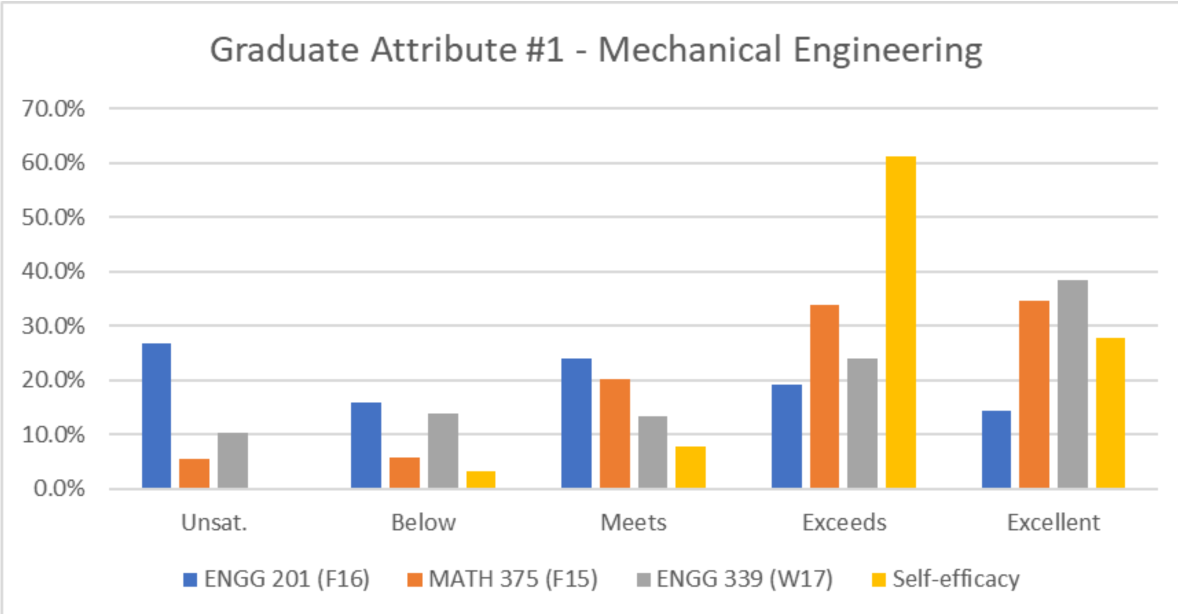

Chart 1.1: Overview of assessment results for GA #1.

Graduate attribute #2 Problem analysis

Canadian Engineering Accreditation Board definition:
An ability to use appropriate knowledge and skills to identify, formulate, analyze, and solve complex engineering problems in order to reach substantiated conclusions.

Curriculum maps:
The learning activities selected for assessment of GA #2, as well as the rationale for selecting these learning activities, are summarized in Table 2.1 below.

Table 2.1: Summary of learning activities used to assess GA #2 Problem analysis.

Learning activity	I/D/A	Rationale for choice of learning activity
ENGG 349	D/A	This course covers the topic of dynamics. It requires students to analyze the planar motions of rigid bodies, along with Newton's second law, work / energy and momentum.
ENME 461	I/D/A	This is the first course in mechatronics. It involves the analysis of mechanical, electrical and thermal systems. It also analyzes the system response from step and sinusoidal inputs.
ENME 585	A	This course further analyzes system behaviour based on polynomial and sinusoidal inputs. Additional analysis techniques root locus and frequency response plots.
Self-efficacy survey	A	The self-efficacy survey is an indirect measurement, designed to provide an independent viewpoint (the student's own perspective) on the program outcomes.

Indicators and Assessment tools:
Specific course learning outcomes, identified by the instructor on the official course outline as related to GA #2, were used as sub-indicators for direct assessments. Assessment tools for direct measurements include midterm and final exam questions from the courses listed in Table 2.1 above. Complete details of all course learning outcomes (sub-indicators) and assessment tools used will be available on-site in the Graduate Attributes Dossier for each course assessed, as well as for the self-efficacy survey. Table 2.2 below provides illustrative examples at each level of instruction intended to allow the visiting team to assess the overall approach to assessing this graduate attribute.

Table 2.2: Examples of indicators and assessment tools for GA #2 Problem Analysis.

Indicator	Course learning outcome (sub-indicator)	Rationale for course learning outcome	Assessment tool
2.1	**Analyze the planar motion of particles, rigid bodies, and systems of rigid bodies. (ENGG 349, D)**	This examines students to apply basic kinetics to analyze common problems in mechanical systems. Such analytical skills in dynamics are fundamental.	*Final Question 3* This question asks students to determine the acceleration of a collar (restricted to a linear motion) that is driven by a connection rod with rotational motion on the other end.
2.1	**Obtain dynamic models of mechanical, electrical, thermal, fluidic and combined systems. (ENME 461, I)**	This examines the analytical skills in the behavior of a dynamic system using differential equations. Such analytical skills are essential in mechatronics and control systems.	*Midterm Exam #2* This midterm has three questions, which cover the analysis of the classical spring-damper system.
2.1	**Characterize the performance of a system in terms of its response to step and sinusoidal inputs using graphical techniques. (ENME 585, A)**	This examines students to analyze a transfer function in a control system. It is fundamental in the control of mechanical systems.	*Midterm Exam #2* Given a transfer function, this midterm asks students to design lag and lead compensators and evaluation PID control.
2.1 2.2 2.3	**Self-efficacy survey questions assessing confidence in ability to perform tasks related to related to GA #2.**	Validation of the self-efficacy survey is described in "Information applicable to all graduate attributes" above.	Responses on a five-point Likert scale ranging from "No confidence" to "Total confidence". Questions relate to students personal reflection on their experiences throughout the program such as the effectiveness of the teaching and learning.

Assessment results:
The results of assessments for this graduate attribute are summarized in Chart 2.1 below. Assessments have been collected in one 300-level, one 400-level, and one 500-level course to ensure that assessment points are available across most years of the program. While higher Unsatisfactory and Below Expectations levels are observed from ENGG 349, the results from upper year courses are more satisfactory. Along with the positive self-efficacy survey results, students should be acquiring adequate problem analysis skills in the program, and they are confident about it at the end. Based on the results to date, it does not seem appropriate to recommend specific actions.

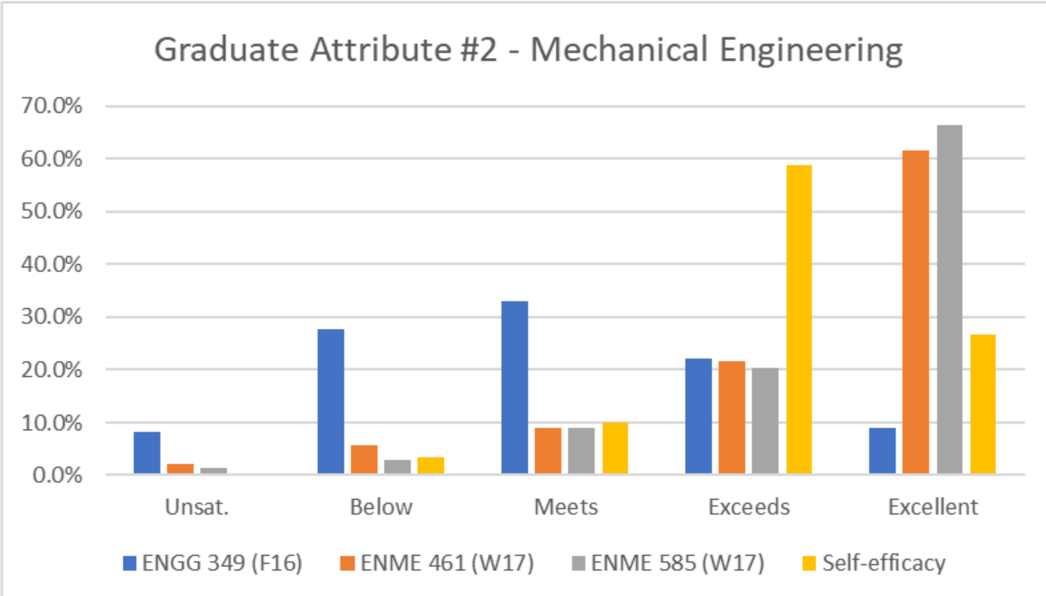

Chart 2.1: Overview of assessment results for GA #2.

Graduate attribute #3 Investigation

Canadian Engineering Accreditation Board definition:
An ability to conduct investigations of complex problems by methods that include appropriate experiments, analysis and interpretation of data, and synthesis of information in order to reach valid conclusions.

Curriculum maps:
The learning activities selected for assessment of GA #3, as well as the rationale for selecting these learning activities, are summarized in Table 3.1 below.

Table 3.1: Summary of learning activities used to assess GA #3 Investigation.

Learning activity	I/D/A	Rationale for choice of learning activity
ENME 461	D	This course is about mechatronics. The investigation aspect involves the development of a dynamic model from experimental data.
ENME 479	D	This course is about the mechanics of materials. It has the investigation on material failures under various loading systems.
ENME 471	D	This course is heat transfer. It involves the lab activities to investigate the differences of counter flow and parallel heat exchangers. It requires students to interpret experimental outcomes in terms of the relevant theory.
Self-efficacy survey	A	The self-efficacy survey is an indirect measurement, designed to provide an independent viewpoint (the student's own perspective) on the program outcomes.

Indicators and Assessment tools:
Specific course learning outcomes, identified by the instructor on the official course outline as related to GA #3, were used as sub-indicators for direct assessments. Assessment tools for direct measurements mainly include deliverables from lab activities from the courses listed in Table 3.1 above. Complete details of all course learning outcomes (sub-indicators) and assessment tools used will be available on-site in the Graduate Attributes Dossier for each course assessed, as well as for the self-efficacy survey. Table 3.2 below provides illustrative examples at each level of instruction intended to allow the visiting team to assess the overall approach to assessing this graduate attribute.

Table 3.2: Examples of indicators and assessment tools for GA #3 Investigation.

Indicator	Course learning outcome (sub-indicator)	Rationale for course learning outcome	Assessment tool
3.2	**Obtain a dynamic model from experimental data. (ENME 461, D)**	The investigation aspect covers the modeling of dynamic systems and the generation of data of system behavior using simulation techniques.	*Lab #3* This lab asks students to investigate dynamic systems using Matlab and Simulink. Five questions were asked to assess the students' ability on the tasks.
3.3	**Predict component failure under complex loading systems. (ENME 479, D)**	This investigation involves physical experiments that require students to compare the performance of mechanical components based on experimental data.	*Lab #5* This lab asks students to investigate how torsional loading affects the mechanical behavior of transmission shafts with non-circular section. A lab report was requested to assess the collected data and calculations, along with discussion of results.
3.3 3.4	**Interpret experimental outcomes in terms of the relevant theory. (ENME 471, D)**	This investigation requires students to properly interpret the experimental data to verify the underlying principles. Such skill is fundamental in engineering investigation.	*Lab #1* This lab asks students to investigate the phenomena of force convective heat transfer on a cylinder. Data was collected to compare the theoretical values from the governing equations. A rubric was used to assess the lab reports.
3.2 3.3 3.4	**Self-efficacy survey questions assessing confidence in ability to perform tasks related to related to GA #3.**	Validation of the self-efficacy survey is described in "Information applicable to all graduate attributes" above.	Responses on a five-point Likert scale ranging from "No confidence" to "Total confidence". Questions relate to students personal reflection on their experiences throughout the program such as the effectiveness of the teaching and learning.

Assessment results:

The results of assessments for this graduate attribute are summarized in Chart 3.1 below. Assessments have been collected in three 400-level courses, which cover the lab activities in different areas (i.e., control, material and heat transfer). The results from direct assessments are considered quite consistent and satisfactory. While higher Unsatisfactory and Below Expectations levels are observed from ENME 471, it is considered a variation of the task difficulty rather than a systematic concern over the investigation skills of students. Based on the results to date, it does not seem appropriate to recommend specific actions.

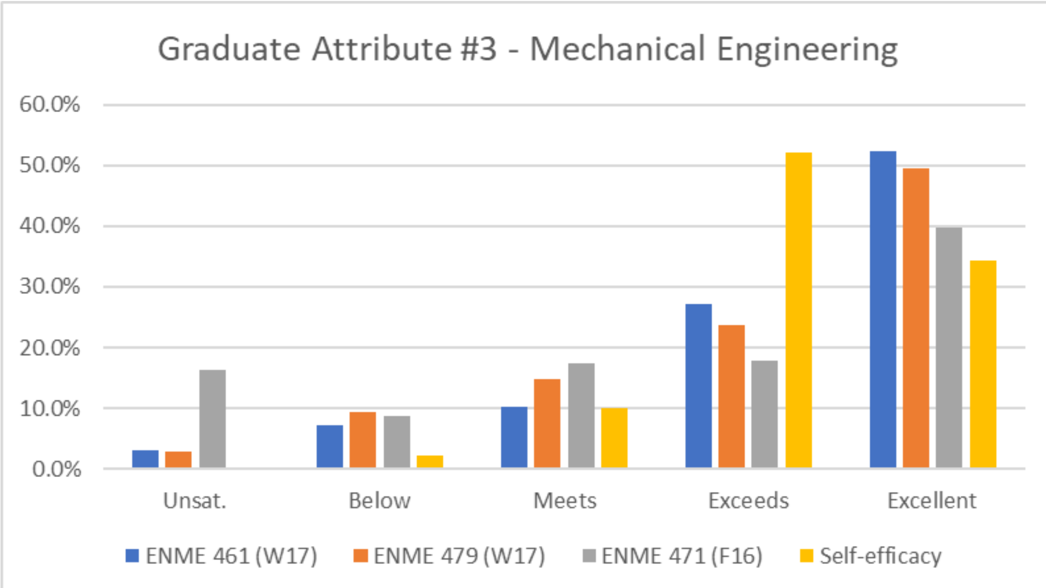

Chart 3.1: Overview of assessment results for GA #3.

Graduate attribute #4 Design

Canadian Engineering Accreditation Board definition:
An ability to design solutions for complex, open-ended engineering problems and to design systems, components or processes that meet specified needs with appropriate attention to health and safety risks, applicable standards, and economic, environmental, cultural and societal considerations.

Curriculum maps:
The learning activities selected for assessment of GA #4, as well as the rationale for selecting these learning activities, are summarized in Table 4.1 below.

Table 4.1: Summary of learning activities used to assess GA #4 Design.

Learning activity	I/D/A	Rationale for choice of learning activity
ENGG 200	D	This common core course introduces students to engineering design through development of team based design projects. Students are required to justify and defend a design solution as part of the engineering design process.
ENME 339	D	The design activities in this course include the development of working drawings and the resolution of engineering design problems.
ENME 538A	D/A	This capstone design course asks students to develop design solutions for more open-ended problems. It also covers more engineering design topics such as safety, sustainability, and robust design.
Self-efficacy survey	A	The self-efficacy survey is an indirect measurement, designed to provide an independent viewpoint (the student's own perspective) on the program outcomes.

Indicators and Assessment tools:
Specific course learning outcomes, identified by the instructor on the official course outline as related to GA #4, were used as sub-indicators for direct assessments. Assessment tools for direct measurements mainly include design project reports from the courses listed in Table 4.1 above. Complete details of all course learning outcomes (sub-indicators) and assessment tools used will be available on-site in the Graduate Attributes Dossier for each course assessed, as well as for the self-efficacy survey. Table 4.2 below provides illustrative examples at each level of instruction intended to allow the visiting team to assess the overall approach to assessing this graduate attribute.

Table 4.2: Examples of indicators and assessment tools for GA #4 Design.

Indicator	Course learning outcome (sub-indicator)	Rationale for course learning outcome	Assessment tool
4.4	**Select concepts and analyze trade-offs among and recombination of alternative concepts. (ENGG 200, D)**	The assessment of design quality is essential. It illustrates how observable and quantifiable measures (e.g., repeatability and number of human intervention) can be used to assess a design solution.	*Interim Report Project 4* In Project 4 students were required to create, build, and test Rube-Goldberg machines whose operations were restricted by a set of requirements. The report details their design ideas and how they made design choices using a formal engineering design method taught in the course; Problem statement; Discussion of alternative designs; Discussion of how the two best designs were chosen; Quality of tests; Discussion of final design.
4.5	**Define dimension and tolerances based on design and manufacturing requirements. (ENME 339, D)**	Graphical (or CAD) skill is essential in mechanical design. This activity covers the proper determination of dimensions and tolerances in the design practice.	*Project* This project asks students to design a product with multiple components. Core deliverables include 3-D modeling of parts, and assembly and 2-D drawings.
4.4	**Apply design methods to generate and select design concepts. (ENME 538A, D)**	Concept generation and selection are fundamental in engineering design. Students need to practice a more rigor procedure to carry these design tasks.	*Design Lab #2* This design lab asks students to generate design concepts based on functions and evaluate design concepts using a selection table.
4.1 4.4 4.9	**Self-efficacy survey questions assessing confidence in ability to perform tasks related to related to GA #4.**	Validation of the self-efficacy survey is described in “Information applicable to all graduate attributes” above.	Responses on a five-point Likert scale ranging from “No confidence” to “Total confidence”. Questions relate to students personal reflection on their experiences throughout the program such as the effectiveness of the teaching and learning.

Assessment results:
The results of assessments for this graduate attribute are summarized in Chart 4.1 below. Assessments have been collected in one 200-level, one 300-level, and one 500-level course, where students progress from well-defined design problem, CAD skill to open-ended capstone design problem. The results from direct assessments are considered quite consistent and satisfactory. It is acknowledged that it is not easy to assess design skills. It is expected to work on the clarity of performance expectations in design so that design skills from engineering graduates can be better articulated.

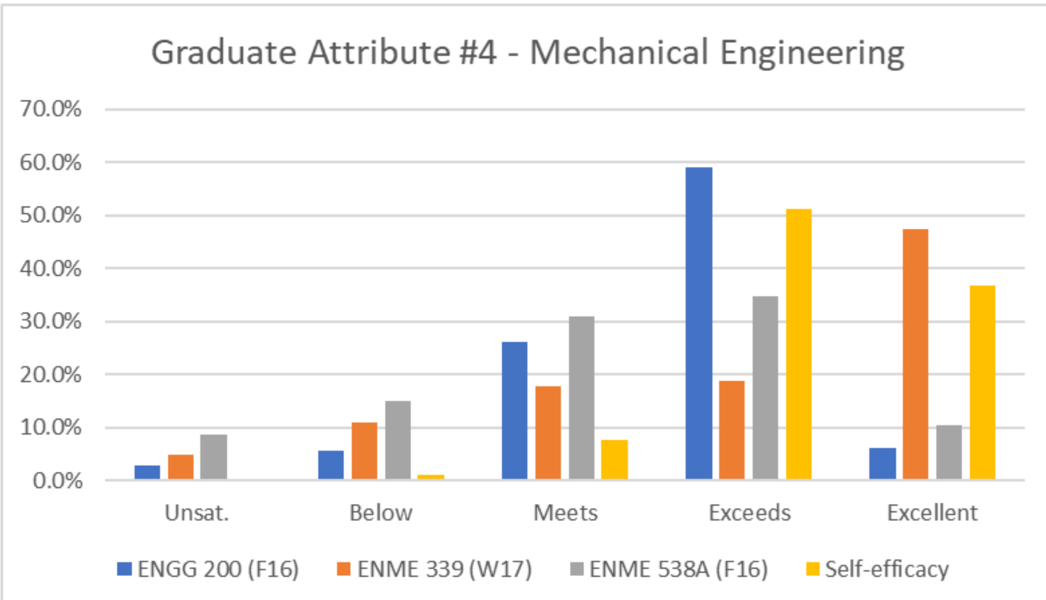

Chart 4.1: Overview of assessment results for GA #4.

Graduate attribute #5 Use of engineering tools

Canadian Engineering Accreditation Board definition:
An ability to create, select, apply, adapt, and extend appropriate techniques, resources, and modern engineering tools to a range of engineering activities, from simple to complex, with an understanding of the associated limitations.

Curriculum maps:
The learning activities selected for assessment of GA #5, as well as the rationale for selecting these learning activities, are summarized in Table 5.1 below.

Table 5.1: Summary of learning activities used to assess GA #5 Use of engineering tools.

Learning activity	I/D/A	Rationale for choice of learning activity
ENGG 233	D	Computing for engineers is taught to all engineering students in the common first year, and represents the launching point for various computing courses and languages in all degree programs in the Schulich School of Engineering. ENGG 233 is an important first step at learning the syntax of a modern object-oriented programming language and to use software development tools.
ENME 337	D/A	This course covers the programming using MATLAB and LabVIEW. Students are required to solve engineering problems by choosing the right software and applying programming skills.
ENME 461	D	This mechatronics course asks students to apply MATLAB and SimuLink to model and analyze the engineering systems.
ENME 585	A	This course asks students to apply software and programming skills to design a feedback controller to meet given performance specification.
Self-efficacy survey	A	The self-efficacy survey is an indirect measurement, designed to provide an independent viewpoint (the student's own perspective) on the program outcomes.

Indicators and Assessment tools:
Specific course learning outcomes, identified by the instructor on the official course outline as related to GA #5, were used as sub-indicators for direct assessments. Assessment tools for direct measurements include selected assignment, final exam questions and lab deliverables from the courses listed in Table 5.1 above. Complete details of all course learning outcomes (sub-indicators) and assessment tools used will be available on-site in the Graduate Attributes Dossier for each course assessed, as well as for the self-efficacy survey. Table 5.2 below provides illustrative examples at each level of instruction intended to allow the visiting team to assess the overall approach to assessing this graduate attribute.

Table 5.2: Examples of indicators and assessment tools for GA #5 Use of engineering tools.

Indicator	Course learning outcome (sub-indicator)	Rationale for course learning outcome	Assessment tool
5.2	**Solve fairly simple computer programs using the Java-based Processing language. (ENGG 233, D)**	This sub-indicator focuses on the students' ability in the basic programming with less burdens on engineering problem solving.	*Final Exam* It is used as the summative assessment on the fundamental programming skills.
5.2 5.3	**Write programs in MATLAB and LabVIEW programming environments. (ENME 337, A)**	Solving computational problems in Matlab allows students to explore basic programming techniques (e.g., for-loop, if-then logic, etc). It is fundamental to analyze and solve engineering problems using computers.	*Assignment #4* This assignment has four questions that asks for programs to evaluate income tax, approximate the integral value, and compute mathematical series.
5.2	**Determine the response of a system to step and sinusoidal inputs. (ENME 461, D)**	The application of Matlab to analyze mechatronic systems is fundamental in practical design.	*Lab #3* This lab asks students to analyze and plot the responses of different systems (as transfer functions) using Matlab.
5.3 5.4	**Design a feedback controller to meet given performance specifications. (ENME 585, A)**	It is common to design a control system using computer and simulation tools. This sub-indicator covers this type of skills in engineering tools.	*Lab #1* This lab requires students to analyze a DC motor (as a first-order system) using Matlab-Simulink.
5.1 5.2 5.3	**Self-efficacy survey questions assessing confidence in ability to perform tasks related to related to GA #5.**	Validation of the self-efficacy survey is described in "Information applicable to all graduate attributes" above.	Responses on a five-point Likert scale ranging from "No confidence" to "Total confidence". Questions relate to students personal reflection on their experiences throughout the program such as the effectiveness of the teaching and learning.

Assessment results:
The results of assessments for this graduate attribute are summarized in Chart 5.1 below. Assessments have been collected in one 200-level, one 300-level, one 400-level and one 500-level course, where students progress from general programming skills (Java-based Processing language) to the use of Matlab, LabVIEW and Simulink. The results from direct assessments show high discrepancy between junior level (ENGG 233) and upper level (ENME 337 and ENME 585). While basic programming skills remain important in general engineering training, it opens an issue whether mechanical engineering students should learn general-purpose computer languages (e.g., Java-based Processing language), which usually comprise of more difficult syntax and higher debugging skills (as compared to Matlab). Based on the results to date, it seems appropriate to review the training of programming skills at the

program level. This issue will be brought to the Departmental Undergraduate Study Committee for further discussion and actions.

In addition, relatively high Unsatisfactory and Below Expectations levels are observed from ENME 461 (Winter 2016). The results were based on the grades of three labs using Matlab and Simulink to model and analyze mechatronic systems. After the discussion with the instructor, it was noted that the situation was due to the clarity of one lab procedure. The same lab grades have been checked in Winter 2017, and the situation was improved to normal standard. Yet, we did not use ENME 461 to collect data of GA #5 in Winter 2017. We used ENME 585 (Control Systems), which shows satisfactory results on GA #5.

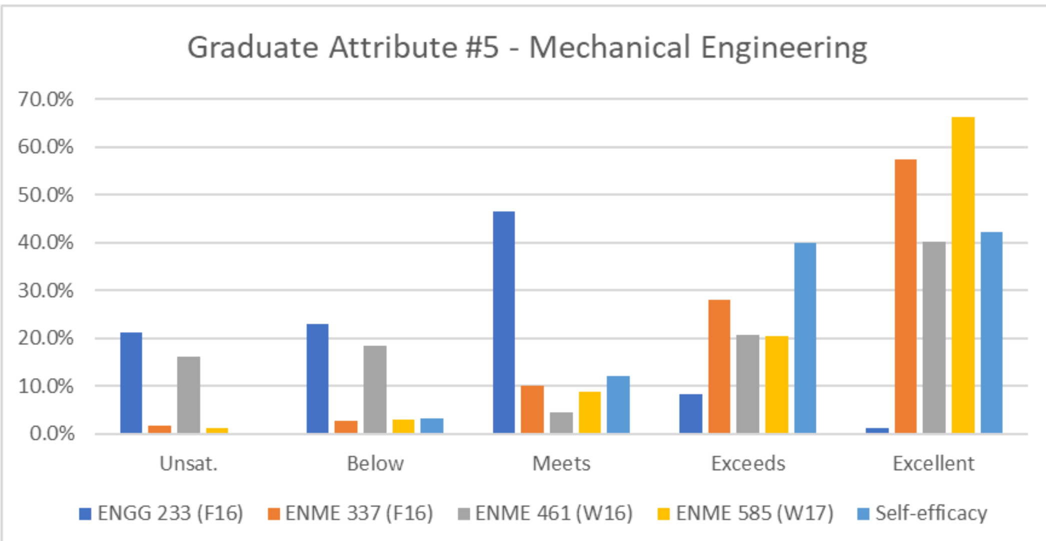

Chart 5.1: Overview of assessment results for GA #5.

Graduate attribute #6 Individual and team work

Canadian Engineering Accreditation Board definition:
An ability to work effectively as a member and leader in teams, preferably in a multi-disciplinary setting.

Curriculum maps:
The learning activities selected for assessment of GA #6, as well as the rationale for selecting these learning activities, are summarized in Table 6.1 below.

Table 6.1: Summary of learning activities used to assess GA #6 Individual and team work.

Learning activity	I/D/A	Rationale for choice of learning activity
ENGG 200	D	The first year design course requires students to work in a team to deliver design solutions.
ENME 493	D	This course is about machine component design, and it has student team projects. Student teams are asked to develop design solutions, along with reports and presentations.
ENME 538A	A	This capstone design course requires students to work in a team for two semesters to develop and test their design solutions.
Self-efficacy survey	A	The self-efficacy survey is an indirect measurement, designed to provide an independent viewpoint (the student's own perspective) on the program outcomes.
Teamwork survey	N/A	An external study on teamwork in the engineering curriculum was conducted and analyzed by the Individual and Team Performance Lab at [redacted]

Indicators and Assessment tools:
Specific course learning outcomes, identified by the instructor on the official course outline as related to GA #6, were used as sub-indicators for direct assessments. As it is not easy to assess this attribute, various assessment tools for direct measurements are included such as teamwork reflection, project presentation and peer evaluation from the courses listed in Table 6.1 above. Complete details of all course learning outcomes (sub-indicators) and assessment tools used will be available on-site in the Graduate Attributes Dossier for each course assessed, as well as for the self-efficacy survey. Table 6.2 below provides illustrative examples at each level of instruction intended to allow the visiting team to assess the overall approach to assessing this graduate attribute.

Table 6.2: Examples of indicators and assessment tools for GA #6 Individual and team work.

Indicator	**Course learning outcome (sub-indicator)**	**Rationale for course learning outcome**	**Assessment tool**
6.4 6.7	**Work effectively in a small team. (ENGG 200, D)**	Teamwork skill can be improved by reflecting on their teamwork experience, and it is a way to reduce repeated mistakes. Reflection also includes how they compare teamwork training in the actual project practice.	*Individual Teamwork Reflection Project 4* Students are asked to write a reflection report for teamwork conflicts experienced and observed in Project 4.
6.5	**Write an engineering report on analysis of mechanical performance. (ENME 493, D)**	Machine component design is classical in mechanical engineering that involves the design and analysis elements. The team project setup allows students to work for more complex problems in collaboration.	*Project Presentation and Report* Students are required to work in a team to complete a project in machine component design. Teamwork was assessed based on the overall presentation and report quality.
6.6 6.7	**Apply project management and teamwork skills including project scheduling, budgeting, and interactions with team members and stakeholders. (ENME 538A, A)**	Teamwork is assessed by their own peer as a way to understand how their individual performance is interpreted within the team. It can be a different angle from other evaluators to understand teamwork.	*Peer evaluation #1 and #2* The peer evaluation asks students to evaluate their teammates using the website tool developed by the faculty in psychology. The evaluation focuses on team competencies in five aspects such as commitment and project management.
6.1 6.2 6.4	**Self-efficacy survey questions assessing confidence in ability to perform tasks related to related to GA #6.**	Validation of the self-efficacy survey is described in "Information applicable to all graduate attributes" above.	Responses on a five-point Likert scale ranging from "No confidence" to "Total confidence". Questions relate to students personal reflection on their experiences throughout the program such as the effectiveness of the teaching and learning.
6.1 6.2 6.5	**Teamwork survey items in areas including: attitudes towards teams, perceived emphasis and support, perceived skill, and perceived importance.**	The survey items were created and validated based on teamwork literature, and specifically tailored for the CEAB attribute.	Questions were rated on a five item Likert-scale (strongly disagree to strongly agree). Student survey responses were analyzed.

Assessment results:
The results of assessments for this graduate attribute are summarized in Chart 6.1 below. Assessments have been collected in one 200-level, one 400-level, and one 500-level course to ensure that assessment points are available across most years of the program. The results from direct assessments are considered quite consistent and satisfactory. Notably, this attribute has been assessed through quite different tools (e.g., quality of overall teamwork deliverables and peer evaluations). While the program will continue providing the teamwork environment for students, we plan to investigate more critically the authentic assessment for this attribute to help students understand their individual and teamwork skills.

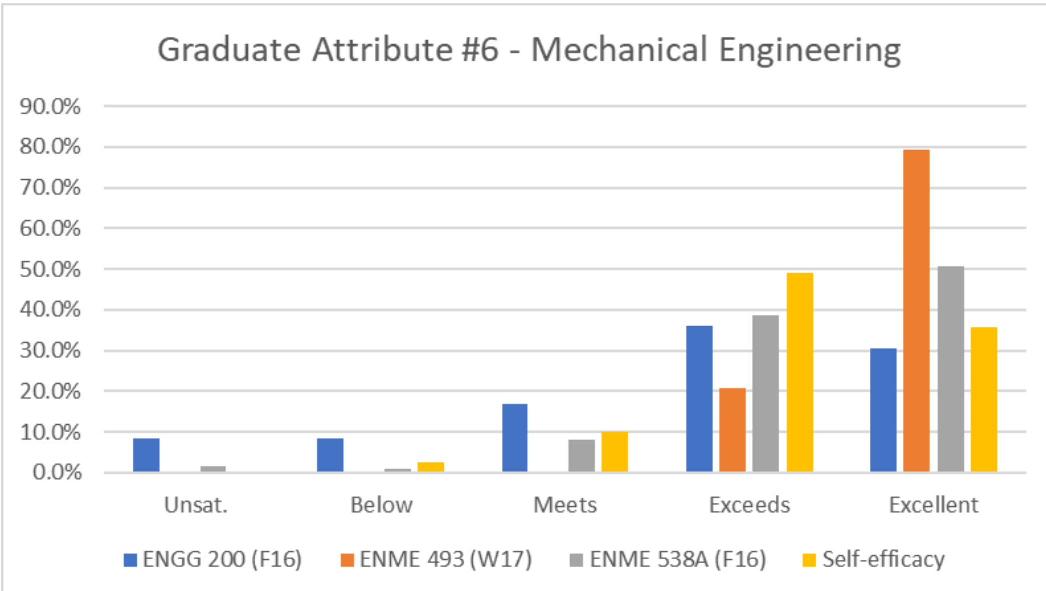

Chart 6.1: Overview of assessment results for GA #6.

Teamwork Survey: An external survey was conducted and analyzed by the [redacted]. The survey was distributed to all undergraduate students, with a participation rate of about 25%, including participants from all years and all programs. The analysts found evidence that teamwork skills are developed well in first year, but there is less emphasis upper years. This suggests a possibility for improvement to develop teamwork skills in 2nd, 3rd, 4th years.

Six teamwork competencies were presented to students in two sets of questions (listed below). In the first set of questions, participants were asked to identify the extent to which they believed they could successfully demonstrate each skill. In the second set of questions, participants were asked to identify the extent to which they believed each skill to be important for success in their future careers. Students rated their overall competence on these six skills as a 3.55 (out of 5), whereas they rated the perceived importance as a 4.36 (out of 5). The results of perceived competency and importance across the six skills are shown below in Chart 6.2. Clearly students acknowledge the importance of teamwork skills, and see potential for additional growth in this area.

Program-specific analysis was done, however no statistical difference was found between programs so the overall data from all Schulich School of Engineering programs is presented here. Details can be found in the full report which will be made available in the Graduate Attributes Dossier.

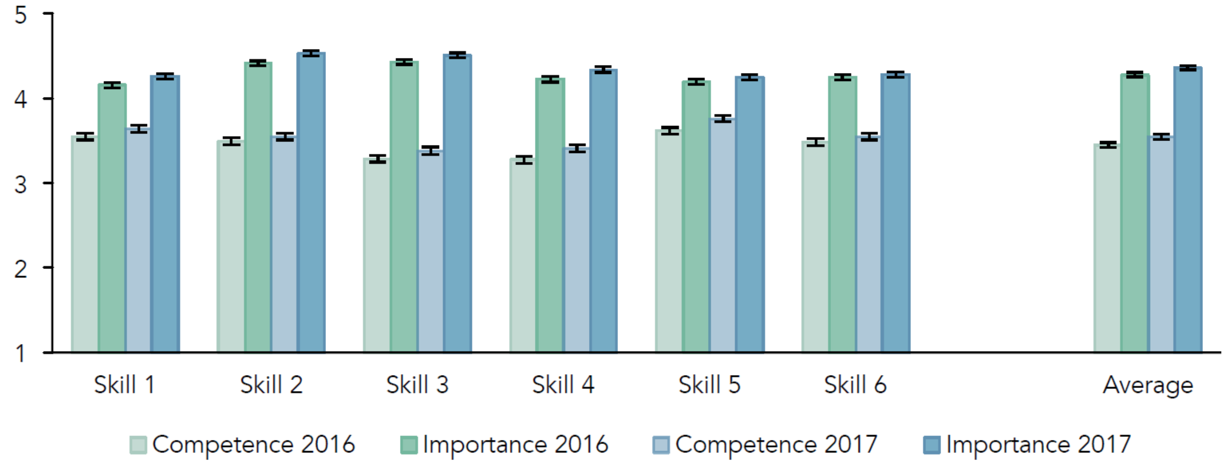

Chart 6.2: Student ratings of their perceived competence and the perceived importance across the six teamwork skills (1 = strongly disagree, 5 = strongly agree).

SKILL 1: Confront a team member who doesn't respond to group emails in a timely manner.
SKILL 2: Address a team member who is not contributing their fair share to the work.
SKILL 3: Confront a team member whose quality of work is not meeting the team's standards.
SKILL 4: Address an interpersonal conflict you have with another team member.
SKILL 5: Step in to help resolve conflict between members of your team.
SKILL 6: Help a team member raise their skill level to meet the needs of the team.

Graduate attribute #7 Communication skills

Canadian Engineering Accreditation Board definition:
An ability to communicate complex engineering concepts within the profession and with society at large. Such ability includes reading, writing, speaking and listening, and the ability to comprehend and write effective reports and design documentation, and to give and effectively respond to clear instructions.

Curriculum maps:
The learning activities selected for assessment of GA #7, as well as the rationale for selecting these learning activities, are summarized in Table 7.1 below.

Table 7.1: Summary of learning activities used to assess GA #7 Communication skills.

Learning activity	I/D/A	Rationale for choice of learning activity
ENGG 200	D	This course has the presentation component on the student design projects.
ENME 471	D	The communication component in this course is about the reporting of the experimental observations.
ENME 538B	A	In this capstone design course, the communication components involve the written report, the oral presentation and the design fair interaction for the student design projects.
Self-efficacy survey	A	The self-efficacy survey is an indirect measurement, designed to provide an independent viewpoint (the student's own perspective) on the program outcomes.

Indicators and Assessment tools:
Specific course learning outcomes, identified by the instructor on the official course outline as related to GA #7, were used as sub-indicators for direct assessments. Assessment tools for direct measurements include individual presentation, lab reports and design report / presentation from the courses listed in Table 7.1 above. Complete details of all course learning outcomes (sub-indicators) and assessment tools used will be available on-site in the Graduate Attributes Dossier for each course assessed, as well as for the self-efficacy survey. Table 7.2 below provides illustrative examples at each level of instruction intended to allow the visiting team to assess the overall approach to assessing this graduate attribute.

Table 7.2: Examples of indicators and assessment tools for GA #7 Communication skills.

Indicator	Course learning outcome (sub-indicator)	Rationale for course learning outcome	Assessment tool
7.9	**Give individual and group presentations. (ENGG 200, D)**	Giving presentations is a required fundamental communication skill of any professional engineer, and sub-indicator was taken from CDIO description of communication.	*Individual Presentation Mark Project 4* Students were required to give a presentation where no text was allowed on the electronic slides. Thus, students had to convey their ideas visually (through drawings, pictures, and video) while explanations all had to be oral. Each student in the team had to take a turn talking.
7.1 7.3	**Report experimental observations. (ENME 471, D)**	The communication skills involve the organization of collected data, graphical plots and the explanation of observed results. Such skill is essential in experiment-based reporting.	*Lab #4* This lab asks students to analyze a shell-and-tube heat exchanger via physical experiments. In data analysis, students are asked to report the performance of the heat exchanger under various conditions.
7.3 7.5 7.11	**Communicate engineering and design ideas verbally and in writing with different stakeholders. (ENME 538B, A)**	Written report is fundamental in engineering communication, and it is assessed in the final design report of the capstone project.	*Final Design Report* This report sums up the capstone design work by a student team. The required contents include project introduction, concept generation / selection, final design details, and design analysis / verification.
7.5 7.6 7.8 7.9	**Self-efficacy survey questions assessing confidence in ability to perform tasks related to related to GA #7.**	Validation of the self-efficacy survey is described in “Information applicable to all graduate attributes” above.	Responses on a five-point Likert scale ranging from “No confidence” to “Total confidence”. Questions relate to students personal reflection on their experiences throughout the program such as the effectiveness of the teaching and learning.

Assessment results:
The results of assessments for this graduate attribute are summarized in Chart 7.1 below. Assessments have been collected in one 200-level, one 400-level, and one 500-level course to ensure that assessment points are available across most years of the program. The results from direct assessments are considered quite consistent and satisfactory. Based on the results to date, it does not seem appropriate to recommend specific actions.

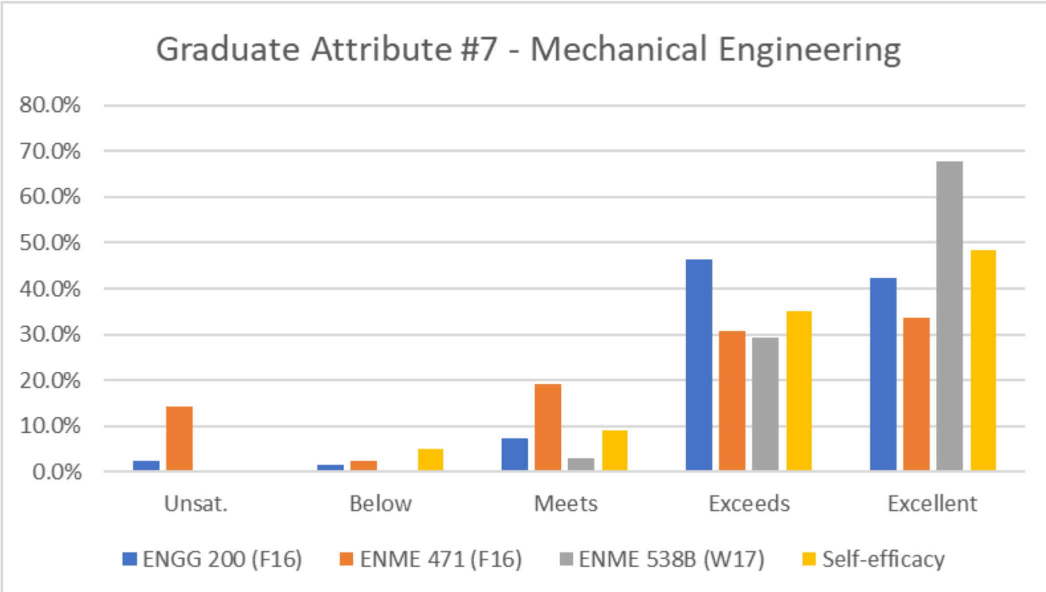

Chart 7.1: Overview of assessment results for GA #7.

Graduate attribute #8 Professionalism

Canadian Engineering Accreditation Board definition:
An understanding of the roles and responsibilities of the professional engineer in society, especially the primary role of protection of the public and the public interest.

Curriculum maps:
The learning activities selected for assessment of GA #8, as well as the rationale for selecting these learning activities, are summarized in Table 8.1 below.

Table 8.1: Summary of learning activities used to assess GA #8 Professionalism.

Learning activity	I/D/A	Rationale for choice of learning activity
ENGG 513	D	This required course provides detailed exposure to APEGA’s Code of Ethics, disciplinary process, definition of unprofessional conduct, professionalism, and regulations, as well as ethical and legal concerns regarding professional practice. Application of this knowledge is very suited for this Graduate Attribute.
ENME 583	D	This course is about mechanical systems in buildings. It delivers the contents of buildings codes, regulations and standards for designing HVAC systems.
INTE 513	A	Students take this course under the internship program. The industry supervisors are asked to provide feedback on their interns based on survey questions using the Likert scale. It is taken as the stakeholder feedback (i.e., industry) for the attribute of Professionalism.
Self-efficacy survey	A	The self-efficacy survey is an indirect measurement, designed to provide an independent viewpoint (the student’s own perspective) on the program outcomes.

Indicators and Assessment tools:
Specific course learning outcomes, identified by the instructor on the official course outline as related to GA #8, were used as sub-indicators for direct assessments. Assessment tools for direct measurements include selected quiz and final exam questions from the courses listed in Table 8.1 above. Complete details of all course learning outcomes (sub-indicators) and assessment tools used will be available on-site in the Graduate Attributes Dossier for each course assessed, as well as for the self-efficacy survey. Table 8.2 below provides illustrative examples at each level of instruction intended to allow the visiting team to assess the overall approach to assessing this graduate attribute.

Table 8.2: Examples of indicators and assessment tools for GA #8 Professionalism.

Indicator	Course learning outcome (sub-indicator)	Rationale for course learning outcome	Assessment tool
8.1 8.2	**Describe the purpose and organization of the Association of Professional Engineers, Geoscientists of Alberta (APEGA): the governing regulations and by-laws, its disciplinary powers and procedures. (ENGG 513, D)**	This sub-indicator is to relate the professionalism directly to the Code of Ethics of APEGA. This helps students to understand the roles of engineers from the professional organization.	*Questions 4 and 6 in Final Exam* Students are asked to identify a rule from the APEGA Code of Ethics to analyze a dilemma situation.
8.4	**Recognize the codes, regulations and standards for designing HVAC systems. (ENME 583, D)**	This sub-indicator is to relate HVAC design to an existing standard, and it is important for engineers to understand codes and standards in their design practice.	*Quiz #2* Students are asked to determine the ventilation flow rate per the ASHRAE 62.1 Standard.
8.2	**Industry feedback on student interns. (INTE 513, A)**	This sub-indicator shows the industry feedback on the attribute of Professionalism from the internship relation.	Three evenly spaced supervisor surveys conducted over internship with one question that probed students' performance in this attribute using a Likert scale.
8.2 8.3	**Self-efficacy survey questions assessing confidence in ability to perform tasks related to related to GA #8.**	Validation of the self-efficacy survey is described in "Information applicable to all graduate attributes" above.	Responses on a five-point Likert scale ranging from "No confidence" to "Total confidence". Questions relate to students personal reflection on their experiences throughout the program such as the effectiveness of the teaching and learning.

Assessment results:
The results of assessments for this graduate attribute are summarized in Chart 8.1 below. Assessments have been collected mainly in 500-level courses. Higher levels of Unsatisfactory and Below are observed from ENME 583, which asked students to determine the ventilation flow rate per the industrial standard (as one interpretation of Professionalism). This result may be mixed by the students' performance in flow rate calculations rather than the acknowledgement of the industrial standard. Nevertheless, improvement on the attribute's assessment will be taken to more precise measure. Notably, this attribute is defined as "An understanding of …" while other attributes are mainly defined as "An ability to …". This requires further analysis of graduate attributes to distinguish the dimension of Professionalism without seriously overlapping with other attributes (e.g., Ethics and equity). This issue will be brought to the Departmental Undergraduate Study Committee for further discussion and actions.

A faculty-wide independent external review was conducted to provide a summary of relevant coverage of GA#8 in the current curriculum and give recommendations for future improvements. Details of the report and a summary of results can be found in the continuous improvement section.

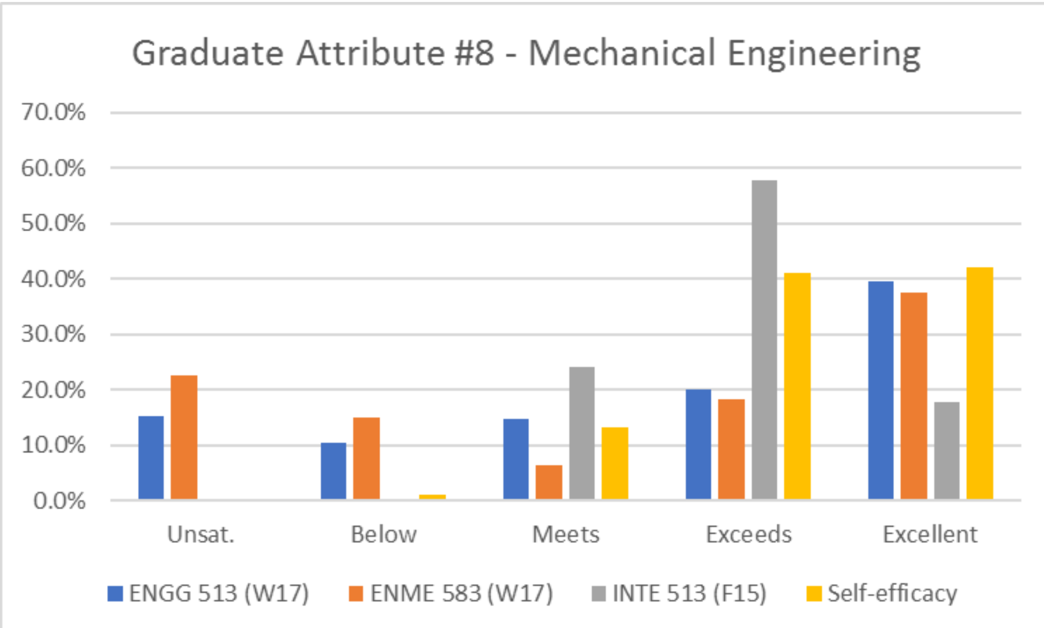

Chart 8.1: Overview of assessment results for GA #8.

Graduate attribute #9 Impact of engineering on society and the environment

Canadian Engineering Accreditation Board definition:
An ability to analyze social and environmental aspects of engineering activities. Such ability includes an understanding of the interactions that engineering has with the economic, social, health, safety, legal, and cultural aspects of society, the uncertainties in the prediction of such interactions; and the concepts of sustainable design and development and environmental stewardship.

Curriculum maps:
The learning activities selected for assessment of GA #9, as well as the rationale for selecting these learning activities, are summarized in Table 9.1 below.

Table 9.1: Summary of learning activities used to assess GA #9 Impact of engineering on society and the environment.

Learning activity	I/D/A	Rationale for choice of learning activity
ENGG 481	D	Technology and Society is a common core course. This is an interpretative course that explores the dynamic interaction between different engineering forms of technology and the impact on society (data Winter 2016).
ENGG 481	D	Additional data was collected at Winter 2017.
ENGG 513	D	This required course provides expose to both positive and negative cases of engineering activities affecting society and the environment, as well as the consequences leading to legislation to protect society and the environment from engineering activities.
Self-efficacy survey	A	The self-efficacy survey is an indirect measurement, designed to provide an independent viewpoint (the student’s own perspective) on the program outcomes.

Indicators and Assessment tools:
Specific course learning outcomes, identified by the instructor on the official course outline as related to GA #9, were used as sub-indicators for direct assessments. Assessment tools for direct measurements include selected quiz and final exam questions from the courses listed in Table 9.1 above. Complete details of all course learning outcomes (sub-indicators) and assessment tools used will be available on-site in the Graduate Attributes Dossier for each course assessed, as well as for the self-efficacy survey. Table 9.2 below provides illustrative examples at each level of instruction intended to allow the visiting team to assess the overall approach to assessing this graduate attribute.

Table 9.2: Examples of indicators and assessment tools for GA #9 Impact of engineering on society and the environment.

Indicator	Course learning outcome (sub-indicator)	Rationale for course learning outcome	Assessment tool
9.2 9.3	**Appreciate the evolution of technology and linkages to societal changes. (ENGG 481, D)**	Environmental and society changes are strongly associated technological inventions. This understanding helps students to recognize the impact of engineering in the wider scope.	*Lecture Quiz #2 and #4* Students are asked to illustrate the progress of theory in the case of waterwheel power. Also, multiple choice questions are set on the impacts of particular technologies to the environment.
9.2	**Incorporate environmental ethics and sustainability in professional engineering practice. (ENGG 513, D)**	Environmental ethics and sustainability are formally recognized in engineering practice. This indicates common standards for students to understand.	*Questions 9 and 10 in Final Exam* Students are asked to explain sustainable development in the purpose of Environmental Protection and Enhancement Act. Also, they are asked to explain the protected grounds against discrimination in Canada.
9.1 9.2	**Self-efficacy survey questions assessing confidence in ability to perform tasks related to related to GA #9.**	Validation of the self-efficacy survey is described in "Information applicable to all graduate attributes" above.	Responses on a five-point Likert scale ranging from "No confidence" to "Total confidence". Questions relate to students personal reflection on their experiences throughout the program such as the effectiveness of the teaching and learning.

Assessment results:
The results of assessments for this graduate attribute are summarized in Chart 9.1 below. Assessments have been collected in 400-level and 500-level courses. The results from direct assessments are considered quite consistent. Considering the emerging concern of sustainability in society, it should be appropriate to implement more learning activities of this attribute in technical courses (e.g., eco-attributes of materials) and in design courses (e.g., social implication from the proposed design solution). This issue will be brought to the Departmental Undergraduate Study Committee for further discussion and actions.

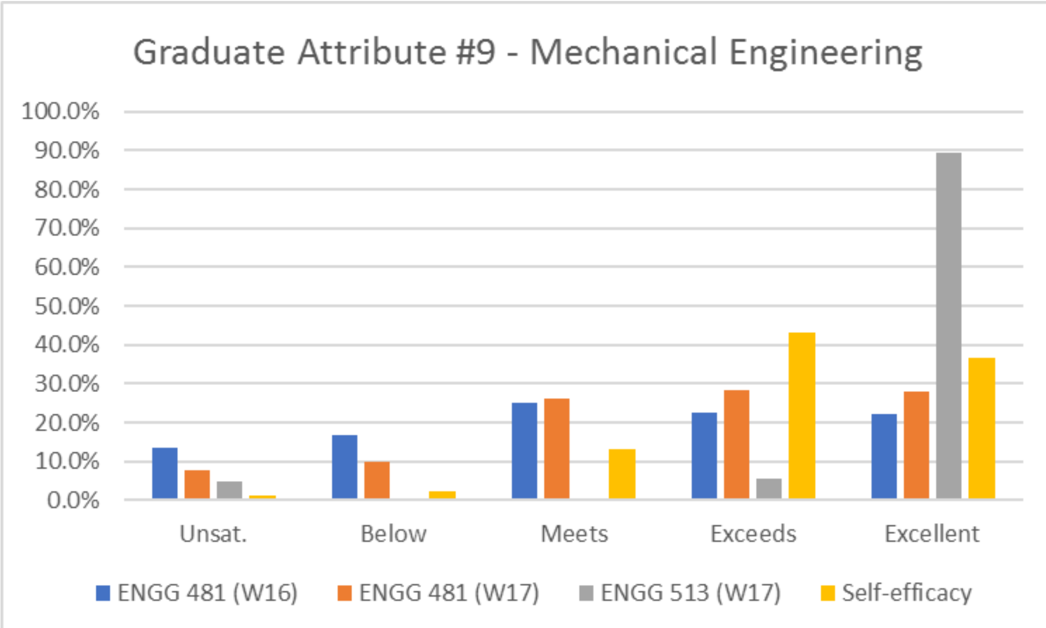

Chart 9.1: Overview of assessment results for GA #9.

Graduate attribute #10 Ethics and equity

Canadian Engineering Accreditation Board definition:
An ability to apply professional ethics, accountability, and equity.

Curriculum maps:
The learning activities selected for assessment of GA #10, as well as the rationale for selecting these learning activities, are summarized in Table 10.1 below.

Table 10.1: Summary of learning activities used to assess GA #10 Ethics and equity.

Learning activity	I/D/A	Rationale for choice of learning activity
ENGG 481	D	This course is about technology and society. It delivers the issues on how engineering can impact society and standards of living and explains the significance of ethics in engineering practice.
ENGG 513	D	This required course provides exposure to ethical theories and human rights and is appropriate for this graduate attribute
INTE 513	A	Students take this course under the internship program. The industry supervisors are asked to provide feedback on their interns based on survey questions using the Likert scale. It is taken as the stakeholder feedback (i.e., industry) for the attribute of Ethics and Equity.
Self-efficacy survey	A	The self-efficacy survey is an indirect measurement, designed to provide an independent viewpoint (the student's own perspective) on the program outcomes.

Indicators and Assessment tools:
Specific course learning outcomes, identified by the instructor on the official course outline as related to GA #10, were used as sub-indicators for direct assessments. Assessment tools for direct measurements include selected assignment and final exam questions from the courses listed in Table 10.1 above. Complete details of all course learning outcomes (sub-indicators) and assessment tools used will be available on-site in the Graduate Attributes Dossier for each course assessed, as well as for the self-efficacy survey. Table 10.2 below provides illustrative examples at each level of instruction intended to allow the visiting team to assess the overall approach to assessing this graduate attribute.

Table 10.2: Examples of indicators and assessment tools for GA #10 Ethics and equity.

Indicator	Course learning outcome (sub-indicator)	Rationale for course learning outcome	Assessment tool
10.1	**Understand how engineering work can impact society and standards of living. (ENGG 481, D)**	This sub-indicator shows the context of professional ethics in view of the impacts from engineering works.	*Seminar Assignment #2* Given a bridge building project in a developing area, students are asked to identify stakeholders and think about the potential impacts and alternate solutions.
10.2	**Practise fairness and equity in the professional workplace. (ENGG 513, D)**	This sub-indicator is appropriate because knowledge of ethics and equity issues are required to effectively practice fairness and equity.	*Questions 11 and 12 in Final Exam* Students are asked to explain the requirement of written warming to employee and the principles of natural justice.
10.1 10.4	**Industry feedback on student interns. (INTE 513, A)**	This sub-indicator shows the industry feedback on the attribute of Ethics and Equity from the internship relation.	Three evenly spaced supervisor surveys conducted over internship with three questions that probed students' performance in this attribute using a Likert scale.
10.1 10.3 10.4	**Self-efficacy survey questions assessing confidence in ability to perform tasks related to related to GA #10.**	Validation of the self-efficacy survey is described in "Information applicable to all graduate attributes" above.	Responses on a five-point Likert scale ranging from "No confidence" to "Total confidence". Questions relate to students personal reflection on their experiences throughout the program such as the effectiveness of the teaching and learning.

Assessment results:
The results of assessments for this graduate attribute are summarized in Chart 10.1 below. Assessments have been collected in 400-level and 500-level courses. The results from direct assessments are considered quite consistent. Yet, the industry-internship and self-efficacy surveys show higher confidence of this attribute than the direct assessments. In assessments, one specific challenge is how to distinguish this attribute from Professionalism and Impact of Engineering on Society and the Environment. While the original definitions are clear, it becomes challenging when they come down to student learning activities and assessments. As a result, we plan to investigate more critically the authentic assessment for this attribute to help students gain the "ability to apply professional ethics, accountability, and equity".

A faculty-wide independent external review was conducted to provide a summary of relevant coverage of GA#10 in the current curriculum and give recommendations for future improvements. Details of the report and a summary of results can be found in the continuous improvement section.

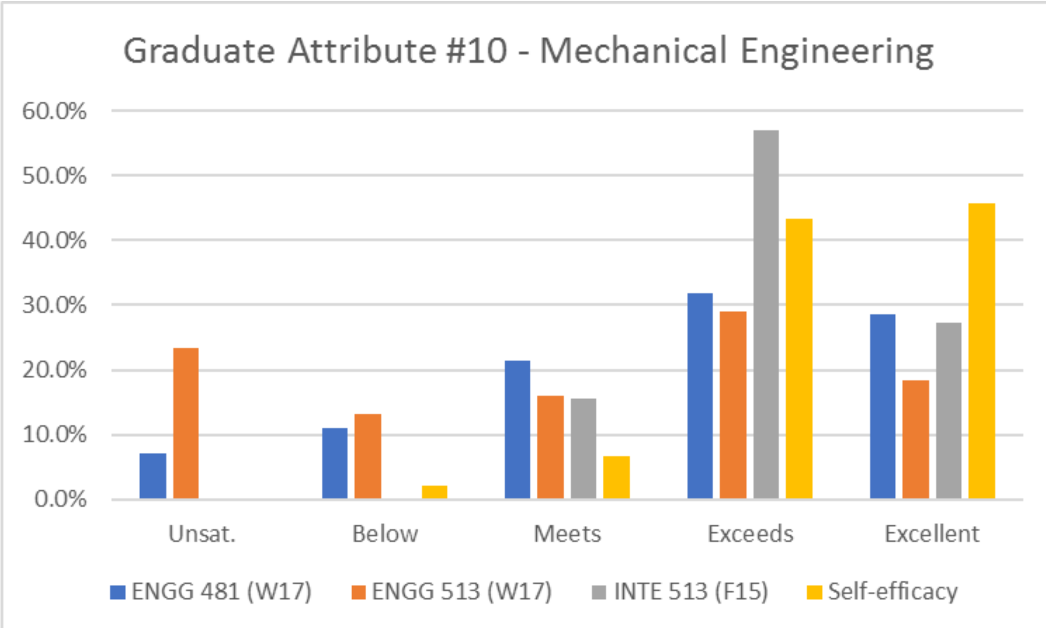

Chart 10.1: Overview of assessment results for GA #10.

Graduate attribute #11 Economics and project management

Canadian Engineering Accreditation Board definition:
An ability to appropriately incorporate economics and business practices including project, risk, and change management into the practice of engineering and to understand their limitations.

Curriculum maps:
The learning activities selected for assessment of GA #11, as well as the rationale for selecting these learning activities, are summarized in Table 11.1 below.

Table 11.1: Summary of learning activities used to assess GA #11 Economics and project management.

Learning activity	I/D/A	Rationale for choice of learning activity
ENGG 209	D	This is the first year course on engineering economics, which covers the topics of micro and macroeconomics, time value of money and replacement decisions.
ENME 538A	A	This capstone design course requires students to apply project management skills including project scheduling and budgeting to complete the design projects.
ENGG 515	I	This course is about project management for senior engineering students, and it covers more in-depth about project life cycle.
Self-efficacy survey	A	The self-efficacy survey is an indirect measurement, designed to provide an independent viewpoint (the student's own perspective) on the program outcomes.

Indicators and Assessment tools:
Specific course learning outcomes, identified by the instructor on the official course outline as related to GA #11, were used as sub-indicators for direct assessments. Assessment tools for direct measurements include assignment problem, team logbook and project advisor feedback from the courses listed in Table 11.1 above. Complete details of all course learning outcomes (sub-indicators) and assessment tools used will be available on-site in the Graduate Attributes Dossier for each course assessed, as well as for the self-efficacy survey. Table 11.2 below provides illustrative examples at each level of instruction intended to allow the visiting team to assess the overall approach to assessing this graduate attribute.

Table 11.2: Examples of indicators and assessment tools for GA #11 Economics and project management.

Indicator	Course learning outcome (sub-indicator)	Rationale for course learning outcome	Assessment tool
11.1 11.2	**Provide the necessary tools and skills to perform project evaluation. (ENGG 209, D)**	This sub-indicator directly measures the learning of the fundamental of engineering economics.	*Final grades* It is used as the summative assessment on the fundamental of engineering economics.
11.3	**Apply project management and teamwork skills including project scheduling, budgeting, and interactions with team members and stakeholders. (ENME 538A, A)**	This sub-indicator shows the application of the project management skills in their capstone design project.	*Team logbook and interaction with project advisor (PA)* In a capstone project, the student team is required to keep records of their project progress on the regular basis in the team logbook. Also, they need to meet their project advisor, who will guide and assess their project progress.
11.4	**Project Life Cycle (including project economics, budget and schedules). (ENGG 515, I)**	The understanding of the project life cycle can help students to understand the typical progress of a project. It helps to define the project's scope and relocate resources sensibly in practice.	*Assignment #1* Students are asked to develop a project budget given limited information.
11.1 11.2 11.5	**Self-efficacy survey questions assessing confidence in ability to perform tasks related to related to GA #11.**	Validation of the self-efficacy survey is described in "Information applicable to all graduate attributes" above.	Responses on a five-point Likert scale ranging from "No confidence" to "Total confidence". Questions relate to students personal reflection on their experiences throughout the program such as the effectiveness of the teaching and learning.

Assessment results:
The results of assessments for this graduate attribute are summarized in Chart 11.1 below. Assessments have been collected in 200-level and 500-level courses. The results from direct assessments are considered quite consistent and satisfactory. Based on the results to date, it does not seem appropriate to recommend specific actions.

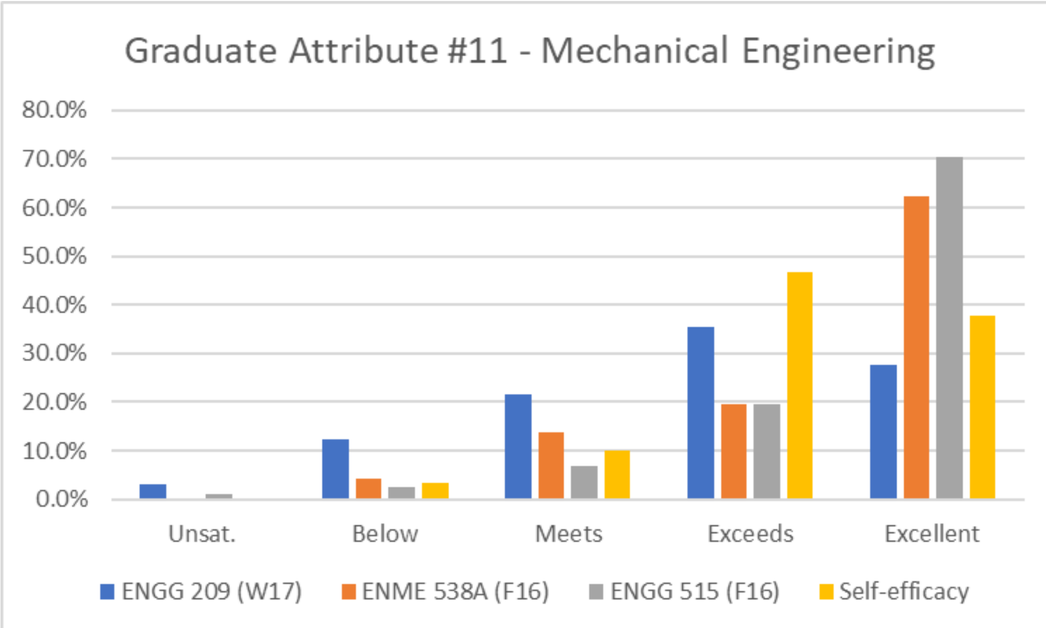

Chart 11.1: Overview of assessment results for GA #11.

Graduate attribute #12 Life-long learning

Canadian Engineering Accreditation Board definition:
An ability to identify and to address their own educational needs in a changing world in ways sufficient to maintain their competence and to allow them to contribute to the advancement of knowledge.

Curriculum maps:
The learning activities selected for assessment of GA #12, as well as the rationale for selecting these learning activities, are summarized in Table 12.1 below.

Table 12.1: Summary of learning activities used to assess GA #12 Life-long learning.

Learning activity	I/D/A	Rationale for choice of learning activity
ENGG 481	I	This course is about technology and society. The life-long learning context is to understand how engineering work can impact society and standards of living.
INTE 513	A	Students take this course under the internship program. The industry supervisors are asked to provide feedback on their interns based on survey questions using the Likert scale. It is taken as the stakeholder feedback (i.e., industry) for the attribute of Life-long Learning.
Self-efficacy survey	A	The self-efficacy survey is an indirect measurement, designed to provide an independent viewpoint (the student's own perspective) on the program outcomes.

Indicators and Assessment tools:
Specific course learning outcomes, identified by the instructor on the official course outline as related to GA #12, were used as sub-indicators for direct assessments. As it is not easy to directly assess this attribute, two surveys were used, i.e., industry feedback from internship relation (INTE 513) and the self-efficacy survey in fourth year. One direct assessment from ENGG 481, listed in Table 12.1 above, is a written question from final exam. Complete details of all course learning outcomes (sub-indicators) and assessment tools used will be available on-site in the Graduate Attributes Dossier for each course assessed, as well as for the self-efficacy survey. Table 12.2 below provides illustrative examples at each level of instruction intended to allow the visiting team to assess the overall approach to assessing this graduate attribute.

Table 12.2: Examples of indicators and assessment tools for GA #12 Life-long learning.

Indicator	Course learning outcome (sub-indicator)	Rationale for course learning outcome	Assessment tool
12.4	**Understand how engineering work can impact society and standards of living. (ENGG 481, I)**	The life-long learning aspect comes from the critical thinking process to analyze the impacts from engineering work to the society. This can motivate students to identify and learn relevant information in the future career.	*Final exam – written question* Students are asked to analyze the debate on the Kinder Morgan Trans Mountain pipeline. Students are required to demonstrate critical thinking in interpreting various debate points.
12.1 12.2	**Industry feedback on student interns. (INTE 513, A)**	This sub-indicator shows the industry feedback on the attribute of Life-long Learning from the internship relation.	Three evenly spaced supervisor surveys conducted over internship with three questions that probed students' performance in this attribute using a Likert scale.
12.1 12.2 12.5	**Self-efficacy survey questions assessing confidence in ability to perform tasks related to related to GA #12.**	Validation of the self-efficacy survey is described in "Information applicable to all graduate attributes" above.	Responses on a five-point Likert scale ranging from "No confidence" to "Total confidence". Questions relate to students personal reflection on their experiences throughout the program such as the effectiveness of the teaching and learning.

Assessment results:
The results of assessments for this graduate attribute are summarized in Chart 12.1 below. Direct assessments have been collected in one 400-level course, while more data are collected outside the course activities (e.g., surveys). The results from direct assessments and surveys are considered quite consistent and satisfactory. Based on the results to date, it does not seem appropriate to recommend specific actions. It is acknowledged that it is not easy to teach and assess life-long learning. It is expected to work on the clarity of expectations related to this attribute so that students can understand their life-long learning skills at various performance levels. As one piece of evidence towards this effort, a faculty-wide survey has been carried recently (July 2017) to gain the understanding of how the lifelong learning aspect is engaged in our programs and curriculums.

A faculty-wide independent external review was conducted to provide a summary of relevant coverage of GA#12 in the current curriculum and give recommendations for future improvements. Details of the report and a summary of results can be found in the continuous improvement section.

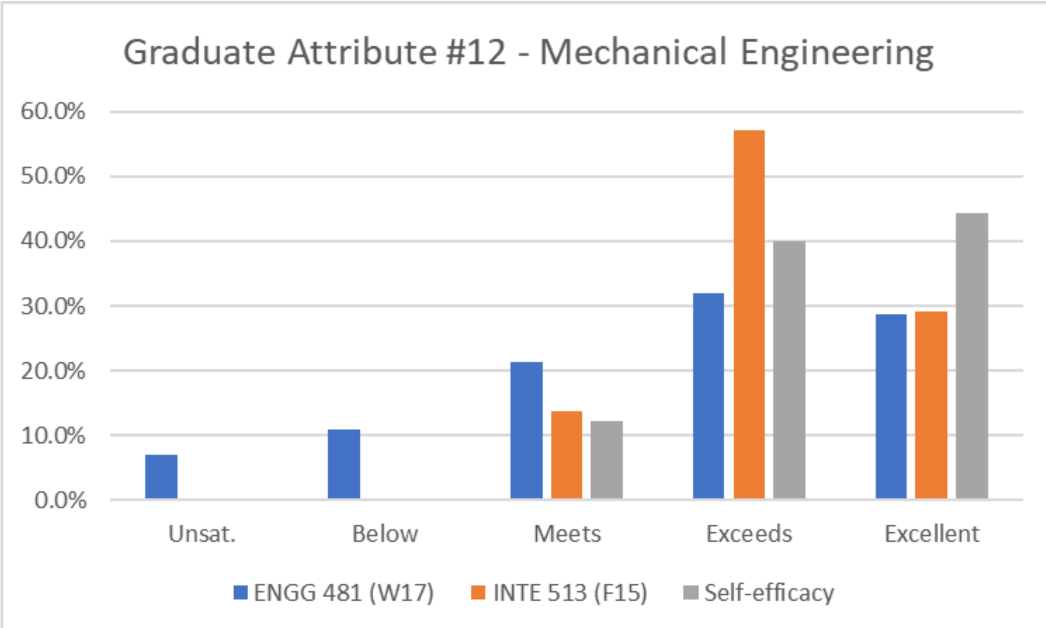

Chart 12.1: Overview of assessment results for GA #12.

Continual improvement

Engineering programs are expected to continually improve. There must be processes in place that demonstrate that program outcomes are being assessed in the context of the graduate attributes, and that the results are applied to the further development of the program.

Instructions for criterion 3.2:

Please complete the following information:

Improvement process

Please describe the continual improvement process including data review and interpretation, internal and external consultation, decision making and responsibility for actions. Provide timelines for each stage of the process:

The Schulich School of Engineering has established a Continual Improvement Process developed and approved by the Program Quality Assurance Committee (PQAC). The SSE Continual Improvement Process document is attached to this report as Appendix B. Please see the “Improvement process” section in this Appendix for details about the improvement process.

Stakeholder engagement

Please describe the composition of the stakeholder group involved in the decision-making for program improvement. Provide the rationale for the selection of the group and details of the consultation process.

The Schulich School of Engineering Continual Improvement Process (Appendix B) outlines School-wide policies related to stakeholder engagement. Please see the “Stakeholder engagement” section in this Appendix for details.

In the Mechanical Engineering program, the department organizes meetings with students and their representatives to review courses and their learning experiences through the Student Liaison Committee (twice per year). Meetings are organized by one faculty member and one administrator to collect and distribute student feedbacks confidentially with instructors. In addition, the department coordinates Industry Advisory Committee annually to collect feedbacks from industrial representatives.

Improvement actions

Please explain how the collected data is analyzed and how the decision to act (or not) is triggered based on that analysis. Discuss how the level of student performance relative to program-expectations is addressed. Describe the kinds of actions that are considered at the program level. Please list all program-level actions that have been recommended to date. In each case briefly discuss the specific rationale for change and the accountability and timelines for full implementation.

Do not describe incremental course-level actions that are routinely implemented by instructors.

Process

The process for data analysis, stakeholder engagement, formulation and approval of change recommendations is described in detail in the Schulich School of Engineering Continual Improvement Process document (Appendix B).

At the School level, the Engineering Undergraduate Studies Committee (EUSC) has held two meetings devoted to Graduate Attributes data review and consideration of potential improvement actions during the 2016/17 academic year:

March 22, 2017: Presentation of Graduate Attributes reports from Fall 2016 courses by the Program Quality Assurance Committee (PQAC) representative for each program. A standardized summary report was used for each program, providing an overview of the results obtained. Measurements for which the total of the Unsatisfactory and Below Expectations bins were greater than 30% triggered a detailed review and discussion. Based on this review, issues (Graduate Attributes) for follow-up and further consideration by the Department Undergraduate Studies Committee (D-USC) were identified for each program. In addition, issues common to all programs were also identified for follow-up by the office of the Associate Dean (Academic & Planning). Issues for follow-up were documented in meeting minutes.

June 2, 2017: "Major calendar changes meeting". In this meeting, the PQAC representative for each program reported back to the EUSC on discussion in the D-USC, stakeholder consultation, and proposed actions resulting from the review of Graduate Attributes data since the March 22 meeting. The Associate Dean (Academic & Planning) also reported on activities to address issues common to all programs. Short-term (affecting the Fall 2017 calendar submission cycle) and longer-term plans were discussed and documented in meeting minutes.

At the program level, a graduate attributes assessment planning retreat was held directly after the last accreditation visit on June 13, 2012 (a copy of the retreat notes will be available on request). In the spring of each subsequent year, the departmental representative to the PQAC (then referred to as the Assessment Coordination Team) prepared a Graduate Attribute Assessment Report in collaboration with members of the D-USC. These reports were then used by the D-USC to inform their work on curriculum review. Copies of these reports will be available on request.

The following departmental meetings were held during the 2016/17 academic year:

November 1, 2016 and March 7, 2017: Student Liaison Committee Meetings were held. In these meetings, one faculty member and one administrator met students and their representatives from Mechanical Engineering Student Society (MESS) to collect their feedback on courses and learning experiences. The collected information would be provided to relevant instructors confidentially, and this encouraged authentic inputs from students. Meeting notes will be available on request.

May 23, 2017: Industry Advisory Committee (Mechanical and Manufacturing Engineering) were met. This meeting had industry representatives from energy, building, and manufacturing sectors. In this meeting, we reviewed the status of the University Curriculum Review and the Report on Graduate Attributes. Then, we had guideline questions to collect their opinions on the training of engineering students. Meeting notes will be available on request.

Issues and actions affecting all programs

During the March 22, 2017 EUSC meeting, similar issues arose in the discussion of the data for all or most of the programs for three of the Graduate Attributes (#8, #10, #12). While the measurements available for these Graduate Attributes generally indicated satisfactory (or better) outcomes, observations were often limited to one or two courses, typically in the final year. The EUSC therefore felt that the School should investigate ways to strengthen our ability to assess student performance on these attributes. As a first step, the office of the Associate Dean (Academic & Planning) has initiated independent reviews of the curriculum and assessment relative to these Graduate Attributes. Deliverables from these reviews are specified in terms of reference, and include 1) a summary of relevant coverage in the current curriculum, 2) recommendations for opportunities and methodology for assessment in the current curriculum, and 3) recommendations for future curriculum modifications to enhance delivery of relevant material. The recommendations resulting from these independent reviews will be considered for further action during the 2017/18 Continual Improvement cycle. Summaries of the findings from the two reports are given below, and the full reports will be available in the Graduate Attributes Dossier.

The external review of GA8 (Professionalism) and GA10 (Ethics and Equity) was conducted by a Professional Engineer with over a dozen years' experience in the engineering industry, [redacted]. The review took a high level review of the curriculum, and conducted interviews with instructors from relevant courses. The main findings indicate that GA8 and GA10 are primarily taught in one course mandatory for all engineering students (ENGG 513). In order to provide additional opportunities to develop these attributes in students, the report recommends: collaboration with external organizations, collaboration within engineering departments to identify topics of relevance, and collaboration between departments to identify topics of common interest.

The external review of Lifelong Learning (LLL) was completed by researchers in the Faculty of Arts with expertise in LLL. The review took a thorough look at the curriculum to determine where LLL was observed, including a detailed analysis of course materials. The review also conducted interviews and surveys to better understand perspectives of faculty, students and alumni. Overall, the results from the report indicate that graduates of the Schulich School of Engineering are able to fulfill the CEAB definition of LLL, including identifying and addressing their own education needs in a changing world and maintaining their competence to allow them to contribute to the advancement of knowledge. Recommendations from this report include: design courses with intentionality, promote more peer-to-peer learning to relieve resource limitations, provide greater LLL resources to instructors, and develop best practice guidelines for assessment.

Table 13: Summary of actions pertaining to all Schulich School of Engineering programs.

Graduate Attribute issue	Action taken/considered	Timeline	Accountable
GA #8 – Professionalism: Limited opportunities for assessment	Independent review of curriculum related to GA #8 by [redacted]	Report by August 2017	[redacted]
GA #10 – Ethics/equity: Limited opportunities for assessment	Independent review of curriculum related to GA #10 by [redacted]	Report by August 2017	[redacted]
GA #12 –Life-long learning: Limited opportunities for assessment	Independent review of curriculum related to GA #12 by [redacted] (Faculty of Arts, [redacted]), a [redacted] faculty member with research expertise in the area.	Report by August 2017	[redacted]

<u>Issues and actions specific to the program in Mechanical Engineering</u>

Resulting from the data analysis of graduate attributes, we plan to carry two specific actions, which are discussed below and summarized in Table 27.

- GA #5: Use of engineering tools. While mechanical engineering students are required to take various courses with computer programming, we should align the overall expectations of programming skills from our students. This issue will be brought to the Engineering Undergraduate Study Committee, with specific concerns of ENGG 233, and its alignment with ENME 337.
- GA #8: Professionalism. Depending on the industries, mechanical design often involves different codes and standards. In addition to the general recognition of codes and standards, it is suggested to practice relevant information in mechanical (ENME) courses (in addition to the ENGG courses). Currently, it is applied in a technical elective, ENME 583, on the design of a ventilation system.

Table 14: Summary of actions specific to the program in Mechanical Engineering

Graduate Attribute issue	Action taken/considered	Timeline	Accountable
GA #5 – Use of engineering tools: Alignment of programming training	Discussion with the Departmental Undergraduate Study Committee for further actions	Starting in Fall 2017	[redacted]
GA #8 – Professionalism: Weak training on Codes and Standards	Discussion with the Departmental Undergraduate Study Committee for further actions	Starting in Fall 2017	[redacted]

On the aspect of process improvement, we plan to carry the following actions to improve our current practice of collecting, analyzing and interpreting the data of graduate attributes.

- We admit that some graduate attributes are more difficult to assess (thus influencing the quality of relevant data). In particular, we plan to refine the assessments of GA #4 (Design), GA #6 (Individual and team work), GA #8 (Professionalism), GA #10 (Ethics and equity), and GA #12 (Life-long learning). The actions include helping the instructors to set up refined sub-indicators for measurements and develop clearer expectation levels to better inform students on their performance in each attribute. The departmental representative of the Program Quality Assurance Committee will take charge of this suggestion.

- The current data about GA #9 (Impact of engineering on society and the environment) is based on ENGG courses, which certainly address this attribute. Yet, it should be appropriate to deliver relevant contents specific to mechanical (ENME) courses. Potential topics include eco-attributes of engineering materials and analysis of social implications of mechanical design. This issue will be brought to the Departmental Undergraduate Study Committee for their suggestions of implementing advanced environmental and social analyses (as learning modules) in ENME technical and design courses.

- To utilize Integrated Course Design Tool (ICDT) for better data reliability, we plan to standardize the mapping of graduate attributes and learning outcomes as the information of the course outlines. While instructors retain their freedom of their teaching styles (e.g., how they grade the students), we have some closer control on the links between graduate attributes and course contents (which are already regulated under the course descriptions of the Calendar). The departmental representative of the Program Quality Assurance Committee will work with the Department Head on this suggestion.

- As the current process of data collection is quite standardized, we plan to recruit and train teaching assistants (or graduate students) to carry the data collection (mainly involve extracting and compiling spreadsheet data). Along with the support from the office administrator, we should be able to effectively streamline the data collection process. Then, faculty members and instructors can spend more effort on the data analysis and the continual improvement.

Appendix A: SSE Graduate Attribute Indicators

"Graduate Attribute"

Generic characteristics, specified by the Accreditation Board, expected to be exhibited by graduates of accredited Canadian engineering programs at the time of graduation.

"Indicator"

Descriptors of what students must do to be considered competent in the attribute; the measurable and pre-determined standards used to evaluate learning (i.e. measureable characteristics of attributes or components of attributes).

3.1.1 A knowledge base for engineering

Demonstrated competence in university level mathematics, natural sciences, engineering fundamentals, and specialized engineering knowledge appropriate to the program.

1. Standardized test(s): e.g., Force Concept Inventory, Mechanics Baseline Test.
2. Use mathematics to describe and solve engineering problems.
3. Use technical knowledge to inform engineering activities.
4. Describe a well-known experiment that proved an important scientific law.

3.1.2 Problem analysis

An ability to use appropriate knowledge and skills to identify, formulate, analyze, and solve complex engineering problems in order to reach substantiated conclusions.

1. Apply engineering knowledge and skills to solve real world problems.
2. Make assumptions that successfully simplify a complex problem.
3. Evaluate initial assumptions used to formulate a solution to a problem.
4. Elicit incomplete and ambiguous information.
5. Synthesize problem solutions and formulate summary recommendations.
6. Formulate a strategy for solving an engineering problem.

3.1.3 Investigation

An ability to conduct investigations of complex problems by methods that include appropriate experiments, analysis and interpretation of data, and synthesis of information in order to reach valid conclusions.

1. Formulate an experimental concept and strategy to solve an engineering problem.
2. Generate a working hypothesis and strategy to test it.
3. Analyze and interpret experimental data.
4. Synthesize information to reach conclusions that are supported by data and needs.

3.1.4 Design

An ability to design solutions for complex, open-ended engineering problems and to design systems, components or processes that meet specified needs with appropriate attention to health and safety risks, applicable standards, and economic, environmental, cultural and societal considerations.

1. Elicit and interpret customer needs.
2. Interpret ethical, social, environmental, legal and regulatory influences.
3. Identify and explain system performance metrics.
4. Select concepts and analyze the trade-offs among and recombination of alternative concepts
5. Decompose and assign function to elements, and define interfaces.
6. Use prototypes and test articles in design development.
7. Demonstrate iteration until convergence and synthesize the final design.
8. Demonstrate accommodation of changing requirements.
9. Design systems, components or processes that meet specific needs.

3.1.5 Use of engineering tools

An ability to create, select, apply, adapt, and extend appropriate techniques, resources, and modern engineering tools to a range of engineering activities, from simple to complex, with an understanding of the associated limitations.

1. Select the most appropriate engineering tool to accomplish at task from various alternatives.
2. Apply appropriate engineering techniques or tools to accomplish a task.
3. Adapt or extend an engineering technique to accomplish a task.
4. Evaluate the appropriateness of results from different engineering techniques and tools.

3.1.6 Individual and team work

An ability to work effectively as a member and leader in teams, preferably in a multi-disciplinary setting.

1. Identify the stages of team formation and lifecycle as well as the roles and responsibilities of team members
2. Evaluate team effectiveness and plan for improvements.
3. Execute the planning and facilitation of effective meetings.
4. Practice conflict negotiation and resolution.
5. Assume responsibility for own work and participate equitably.
6. Exercise initiative and contribute to team goal setting.
7. Demonstrate capacity for initiative and technical or team leadership while respecting other’s roles.

3.1.7 Communication skills

An ability to communicate complex engineering concepts within the profession and with society at large. Such ability includes reading, writing, speaking and listening, and the ability to comprehend and write effective reports and design documentation, and to give and effectively respond to clear instructions.

1. Construct logical and persuasive arguments.
2. Practice conciseness, crispness, precision and clarity of language.
3. Demonstrate writing with coherence and flow.
4. Practice writing with correct spelling, punctuation and grammar
5. Apply various written styles (informal, formal, memos, reports, etc.)
6. Demonstrate sketching and drawing.
7. Demonstrate construction of tables, graphs, and charts.
8. Interpret formal technical drawings and renderings.
9. Deliver clear and organized formal presentation following established guidelines.
10. Use appropriate referencing to cite previous work.
11. Adapt format, content, organization, and tone for various audiences.

3.1.8 Professionalism

An understanding of the roles and responsibilities of the professional engineer in society, especially the primary role of protection of the public and the public interest.

1. Recognize and accept the goals and roles of the engineering profession.
2. Recognize and accept the responsibilities of engineers to society.
3. Recognize the way in which legal and political systems regulate and influence engineering.
4. Describe how professional societies license and set standards.

3.1.9 Impact of engineering on society and environment

An ability to analyze social and environmental aspects of engineering activities. Such ability includes an understanding of the interactions that engineering has with the economic, social, health, safety, legal, and cultural aspects of society, the uncertainties in the prediction of such interactions; and the concepts of sustainable design and development and environmental stewardship.

1. Analyze the impact of engineering on the environment, social, knowledge and economic systems in modern culture.
2. Describe the important contemporary political, social, legal and environmental issues and values.
3. Define the process by which contemporary values are set, and one's role in these processes
4. Analyse the environmental risk using different data sets.

3.1.10 Ethics and equity

An ability to apply professional ethics, accountability, and equity.

1. Demonstrate an ability to make informed ethical choices.
2. Demonstrate knowledge of a professional code of ethics.
3. Evaluate the ethical dimensions of professional and scientific practice.
4. Demonstrate ethical practice.

3.1.11 Economics and project management

An ability to appropriately incorporate economics and business practices including project, risk, and change management into the practice of engineering and to understand their limitations.

1. Apply the concept of the time value of money to engineering projects.
2. Recognize the role of financial planning and capital budgeting in engineering projects.
3. Describe project control for cost, performance, and schedule.
4. Discuss the estimation and allocation of resources in engineering projects.
5. Identify risks and alternatives in engineering projects.

3.1.12 Life-long learning

An ability to identify and to address their own educational needs in a changing world in ways sufficient to maintain their competence and to allow them to contribute to the advancement of knowledge.

1. Reflect on one’s skills, interests, strengths, and weaknesses.
2. Describe one’s own learning style.
3. Describe the importance of developing relationships with mentors.
4. Identify and critically evaluate sources for continued learning including but not limited to technical research literature, and professional and technical societies.
5. Apply self-directed learning to address knowledge and skill gaps.

Appendix B: Schulich School of Engineering Continual Improvement Process

Approved by PQAC February 2, 2017

Criterion 3.2.1 in the Accreditation Criteria and Procedures 2016 document states: *Engineering programs are expected to continually improve. There must be processes in place that demonstrate that program outcomes are being assessed in the context of the graduate attributes, and that the results are applied to the further development of the program.*

This document outlines the annual process for Continual Improvement, as required by section 3.2.1 in the 2016 Canadian Engineering Accreditation Board Accreditation Criteria and Procedures, of the Schulich School of Engineering. It is acknowledged that additional continual improvement activities exist, and are encouraged, in the SSE programs and departments.

Improvement process

The improvement process in the SSE consists of the following main steps:

1. <u>Data collection</u> takes place on an annual cycle. Within the four-year programs, data collection takes place primarily during the Fall and Winter terms. Due to the extensive use of Spring and Summer term courses in the Energy Engineering program, the data collection for Energy Engineering continues over the summer months. Data collection is coordinated by the Program Quality Assurance Committee (PQAC) to ensure that consistent best practices are developed and maintained across the SSE. PQAC coordination also ensures that data collection is coordinated for courses that are shared across multiple programs, and that the resulting data are shared across programs.

   Data consists of direct assessments, carried out by sampling the assessment activities that are part of courses and other formal learning activities, such as internship, as well as indirect assessments, carried out , e.g., through surveys of students, employers, and faculty members. Direct assessments in courses are planned by the Program Quality Assessment Committee (PQAC) representative for each program in consultation with the Department Heads and individual course instructors. Indirect assessments, in particular those involving surveys across the entire faculty, are planned and coordinated by the PQAC. Surveys involving significant resources to administer and analyze (e.g., the involvement of external experts to design and administer surveys) will be planned on multi-year (typically three-year) cycles, such that different graduate attributes are assessed in different years.

2. <u>Data analysis</u> of the data collected over the preceding academic year is carried out over the summer and/or early in the Fall term[3]. Routine tasks, such as compiling data into an initial overview for each program is supported by administrative staff in the Department offices, as well as the office of the Associate Dean, Academic & Planning. This process is facilitated by a standardized format for data collection and reporting. The PQAC representative for each program, in collaboration with the department-level curriculum committee, is responsible for reviewing the data and identifying issues requiring action or additional monitoring/data collection for possible future action. Importantly, this involves consultation with the instructors for the courses where an issue was identified to obtain their interpretation of the data and any

[3] Some analysis at the course level may take place earlier, as soon as the data is available, and guide instructor-initiated changes to individual courses.

recommendations they may have for addressing the issue. A report from each program outlining issues requiring action at the program level or above is presented to the Engineering Undergraduate Studies Committee (EUSC) by the end of the Fall term to help identify any issues that are common across multiple programs and thus may require a faculty-wide approach to address.

3. Change recommendations at the program-level[4] are developed by department-level curriculum committees over the Winter term, and endorsed by department councils, as appropriate. Draft change recommendations are presented to stakeholder groups (below), along with a summary of the observations (data) that prompted the action. Feedback from the stakeholder groups are incorporated into the final versions of the change recommendations. Change recommendations at the faculty-level are developed by the EUSC over the Winter term, following a similar process, including stakeholder engagement.

   Finalized change recommendations are submitted to the EUSC for approval at the EUSC Major Calendar Changes meeting typically scheduled in late May or early June. Any resulting calendar changes that go beyond the EUSC's delegated authority are referred to the Engineering Faculty Council (EFC) for approval. All calendar changes are made available to all EFC members for a one week review and comment period prior to EUSC approval, typically in September. Calendar changes approved at the faculty level are forwarded to the university level for final approval (Calendar & Curriculum Subcommittee or Academic Planning & Priorities Committee, as appropriate) and take effect for the following academic year.

   Change recommendations that require a multi-year timeline for implementation, e.g., because further study is needed, extensive program changes are involved, etc., are submitted to the EUSC for approval (or recommendation to EFC, as appropriate) on the same timeline as above to ensure that the recommendations are approved and accountabilities and timelines for implementation are established.

4. Change implementation at the program level is the responsibility of the Department Head responsible for the program, with assistance from the Associate Head/Program Director. In the case of the Energy Engineering program, this responsibility falls on the Heads of Mechanical & Manufacturing Engineering and Chemical & Petroleum Engineering, with assistance from the Program Director, Energy Engineering. The EUSC will maintain a list of approved change recommendations and the associate timelines, and review the status of each recommendation annually until completed.

Stakeholder engagement

The following stakeholder groups are consulted by the SSE on a regular basis. As we go through the continual improvement cycle for each program, we will seek and document feedback on potential areas for improvement and proposed improvement actions from each of these groups to ensure that various stakeholder perspectives are considered.

Students

A Student Liaison Committee or other mechanism for collecting student feedback is required for each program and serves as the formal mechanism for student feedback to program leadership. Membership

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[4] It is acknowledged that, in some cases, the discussion of change recommendations may result in recommendations for improvement that can be implemented at the course level without program-level action.

on this committee is selected to ensure broad representation from a variety of program options. Student representatives are asked to gather feedback from their peers in advance of meetings. Meetings are held 1-2 times per term and documented through meeting notes, which form part of the input to the continual improvement process. The Student Liaison Committee is chaired by the Head, Associate Head (Undergraduate), or Program Director at the Head's discretion.

Faculty

Faculty members are engaged in the academic governance processes and are thus well represented as stakeholders in the continual improvement process. The department-level Undergraduate Studies Committee (for Energy Engineering, the Energy Engineering Program Committee) and the department councils are the primary mechanisms for engaging faculty members in the program governance and continual improvement process.

Industry

SSE departments have generally established an Industry Advisory Committee. The SSE also benefits from a strong faculty-level advisory committee, the Schulich Industry Advisory Committee (SIAC). The Industry Advisory Committees are the primary mechanisms for engaging industry representatives in the continual improvement process.

Example of improvement actions

The process for data analysis, stakeholder engagement, formulation and approval of change recommendations is described under "Improvement process" above. The following hypothetical scenario (where *"year"* refers to the academic year, i.e., July to June) is intended as an illustration of the planned process and timelines (see also Table 1 below). The role of SSE committees in this process is illustrated by Figure 1.

Data analysis carried out in the *summer or early Fall of year 1* by the D-USC, based on data collected over the past year (and trends from previous years), identifies an issue with students not improving their teamwork skills over the program. Assessments of team effectiveness in the capstone design courses ENGG 501/502 produce lower scores than corresponding assessments in ENER 200, the design course taken by students in their first Spring term. Scores on the self-efficacy survey indicate that final year students feel less confident in their abilities to lead and participate in a team than when they entered the program. Feedback from internship supervisors in industry also raise some concerns about students' teamwork and conflict resolution skills. The department-level Undergraduate Studies Committee (D-USC) summarizes this data in its report presented to the EUSC in *November of year 1*. The EUSC supports the D-USC recommendation that the issue be addressed through a curriculum change.

During *January and February of year 1*, the D-USC meets to discuss possible change recommendations. The D-USC consults with students, faculty with expertise in team-based learning (inside and outside the SSE), and teaching & learning experts in the Taylor Institute for Teaching & Learning. A draft proposal involving the introduction of a third-year team project course, merging the theoretical components of two existing courses, is developed by the D-USC members in consultation with potential instructors for the new course. The draft proposal is presented to the Student Liaison Committee and the Industry Advisory Committee during *March of year 1*. After revising the proposal based on the feedback received, the finalized proposal is brought to the EUSC major calendar changes meeting in *late May of year 1*. The proposal moves through EUSC and university level approvals during the *Fall term of year 2*, and will appear in the calendar in *February of year 2* to take effect the following July, i.e., at the *beginning of year 3*.

Change implementation begins as soon as the proposal is approved in the *Fall term of year 2*. By *January of year 2*, the Head of the department selected to deliver the course assigns an instructor, who starts to plan and develop the course. The new course is offered for the first time in the *Fall of year 3*. In its report to the EUSC in *November of year 3*, the D-USC reports that the change implementation is completed.

Data collection during *year 3* (and subsequent years) is planned to collect data that can be compared to past trends to assess the impact of the new course on students' teamwork skills through both direct assessments in courses and through surveys of students and internship supervisors.

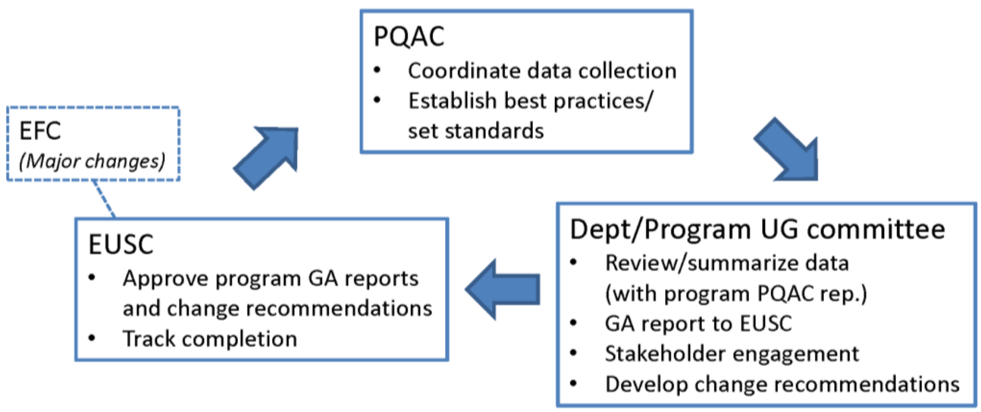

Figure 1: Overview of committee responsibilities in the SSE Continual Improvement Process.

Table 1: Overview of timelines for Continual Improvement process