Questionnaire for Evaluation of an Engineering Program - Exhibit 1

Submitted by:

[redacted]
Name of Higher Education Institution

Mechanical Engineering
Program name

August, 2017
Date

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1 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.*

1.1 *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.

The organizational structure for those involved in the measurement of graduate attributes is shown in Figure 1, below. Ultimate responsibility falls to the Department Head, although management of the process is the responsibility of the Curriculum Committee. The Curriculum Committee is chaired by the Associate Head for Teaching, and it includes representatives from each option (Biomedical, Mechatronics, and Thermofluids) as well as several members at-large drawn from other faculty in the Department. The Department Head, in consultation with faculty and staff, appoints the Associate Head for Teaching and the Curriculum Committee members. The Department Head also appoints a faculty member as an Accreditation Advisor (who may or may not sit on the Curriculum Committee). The Accreditation Advisor is expected to have special expertise in accreditation, outcomes-based assessment, and continual program improvement, and is responsible for recommending policy for and changes to the accreditation and continual improvement processes to the Curriculum Committee. The Accreditation Advisor is also responsible for overseeing the preparation of formal accreditation documentation. One of the staff member managers in the Department (the Facilities and Technical Administration Manager for this accreditation cycle) is assigned to provide support with communication, data collection, data analysis, report writing, and other work for accreditation purposes. They report to the Department Head, but receive direction in accreditation matters from the Accreditation Advisor. An occasional worker is hired as needed to assist with accreditation tasks in the lead-up to accreditation visits; this person reports to the manager assigned to accreditation, and receives further direction from the Accreditation Advisor. As design and lab course instructors have historically been involved with the bulk of graduate attribute data collection, two standing committees—the Design Course Committee and the Lab Course Committee—have been defined. They report to the Associate Head for Teaching, and advise on matters related to graduate attribute assessment, data collection, and data interpretation in the respective course areas. Graduate attribute data are collected in courses taught by regular faculty (tenured, tenure-track, and 12-month lecturer appointments, who report to the Head), and by adjunct and sessional lecturers (who report to the Associate Head for Teaching).

Surveys of current students and alumni are developed and analyzed by the Curriculum Committee, with input from the Accreditation Advisor and administrative assistance from the manager assigned to accreditation, their assistant for accreditation, or the Mechanical Engineering Student Services office, as appropriate. The Co-operative Education office also runs surveys of students and employers, following co-op work terms. Summary data are provided directly to the Department Head, but the Accreditation Advisor also works with the Co-op Office to obtain raw data.

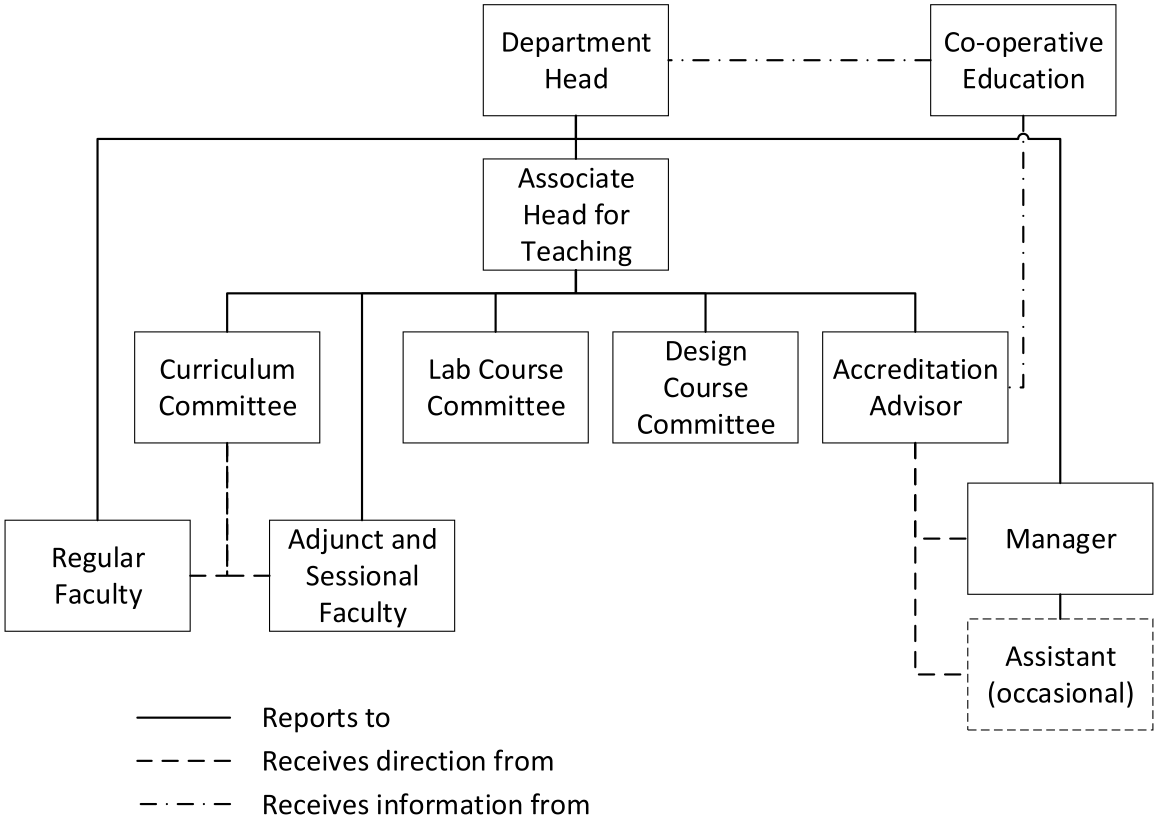


Figure 1. Graduate Attributes Organizational Chart

The above arrangement was formalized in 2017; in prior years the Department Head worked with the Accreditation Advisor (although, that role was not officially recognized at the time) and a manager assigned to work on accreditation. The Design Course Committee and Lab Course Committee (the former, in particular) worked closely with the Accreditation Advisor to pilot the majority of the existing graduate attributes data collection process. Through a series of ad hoc meetings in 2013, 2014, 2015, and 2016, these groups met to develop indicators, implement appropriate assessment tools, and give feedback on the process.

Information on the transition to the graduate attributes and continual improvement process was shared with the Department through formal and informal meetings. In 2014 and 2015, the Department reviewed and adopted proposed changes to indicators. Particular attention was given to Indicator 1.4 (Discipline-Specific Knowledge Base), since this indicator represented the bulk of credits and instruction in the curriculum. The Department discussed and formally approved a proposal to subdivide Indicator 1.4 into ten sub-disciplines in mechanical engineering, drawn from the 2014 [redacted] Mechanical Engineering Syllabus. The resulting ten sub-indicators include the topics of mechanics of materials, dynamics, vibrations, fluid mechanics, thermodynamics, heat transfer, design and manufacture of machine elements, control, electrical and electronic engineering, and materials engineering. The Department viewed the value of having graduate attributes data at the resolution of the above sub-indicators as being critical for targeted continual improvement, and worth the extra effort in data collection and analysis.

Starting in 2010, the decision was made to incorporate data measurement in attribute-rich courses as part of normal course operation. The courses were strategically selected based on the curriculum mapping, and were predominantly team-taught design project and lab courses. Evaluation in these courses has been heavily rubric based, and rubric development has been shared by multiple instructors across courses. While we are still working to refine the process, as is discussed in following sections, in principle, data are always available for review and analysis with minimal effort. In addition, by focusing on a sub-set of courses that are team-taught and interconnected, it is easier to ensure the graduate attribute assessment tools and data collection processes are preserved, especially when considering changes to teaching assignments. For Attribute 1 and several other attributes not readily captured in the above courses, call-outs to course instructors are given as needed; the most recent set of wide-spread call-outs occurred last year (2015/16) and this year (2016/17), although we are working on formalizing this data collection schedule too (as discussed in Section 2, Continual Improvement). To ensure new faculty are familiar with the process and their responsibilities for data collection, a section on graduate attributes and continuous improvement is being added to onboarding and training materials for new faculty.

Lastly, in the development of new courses or revision of existing courses (e.g. APSC 100 and 101, or MECH 30X, currently), the graduate attributes have been used to guide the development of learning objectives, and to identify learning activities and assessment tools.

1.2 *Addendum 1: Data Analysis and Presentation:*

This additional section outlines the common methods used to process and present data for all indicators in the required sections that follow.

Since our accreditation data comes form multiple sources with differing degrees of robustness and alignment to the indicators measured, a method to fairly combine the data from disparate sources was developed. To our knowledge, this innovation has not been used by other programs or institutions. This numerical measure of "assessment strength" (i.e. a "measure of trust") was computed using qualitative instructor ratings of each assessment tool. These qualitative ratings were assigned by the course instructor responsible, where possible, and otherwise by the Accreditation Advisor (see page 2). The overall assessment strength was based on four factors important in a strong assessment:

- **Validity (V)**: does the assessment align directly and completely to the indictor being assessed? An assessment that only covers part of an indicator, or that includes elements from other indicators, would have lower validity.
- **Reliability (R)**: are the assessment results believed to be repeatable? The assessment would have lower reliability if the results were not expected to be consistent under different conditions, such as if a different sample of students from the program were to repeat the assessment, if the assessment were conducted at a different time, or if different assessors were to grade the assessment, for example.
- **Authenticity (A)**: are the conditions in which the students are assessed similar to when they would use the competency in real life. For example, in terms of delivering presentations, an assessment based on asking test questions about oral presentations would have low authenticity compared to an assessment based on actually delivering a presentation.
- **Number of assessments (n)**: the assessment strength is assumed to be proportional to the number of assessments (e.g. 2 midterms have double the strength of a single midterm).

Validity, reliability, and authenticity were all qualitatively scored on a three-point scale by instructors for each assessment. In the scoring, "high" = 9, "medium" = 5, and "low" = 1 and the overall assessment strength was then computed as

$$\text{Assessment strength} = (V + R + A)/3 \times n$$

This assessment strength was used as a weighting factor for combining different assessment results (i.e. histograms) for the same indicator and year level. *For example, if indicator 3.1 were assessed through a single midterm exam (n = 1) with ratings of V = 5, R = 5, and A = 5 (assessment strength = 5) combined with three lab reports (n = 3) with ratings of V = 9, R = 5, A = 5 (assessment strength = 19), the midterm exam would contribute 21% (5/24) to the overall assessment of the indicator, and the lab reports would contribute 79% (19/24).*

In addition, the sum of the assessment strengths from all assessment tools for a given indicator and/or year level were used to determine an overall assessment strength for that indicator and/or year level. Again, assessment strength was used as a weighting factor to combine results from different indicators and/or years.

In this way, the assessment strength was used to both combine disparate data as well as to act as a "measure of trust" for the reported results.

In the required sections that follow, data for each attribute is presented using histograms arranged according to the format in Figure 2, below.

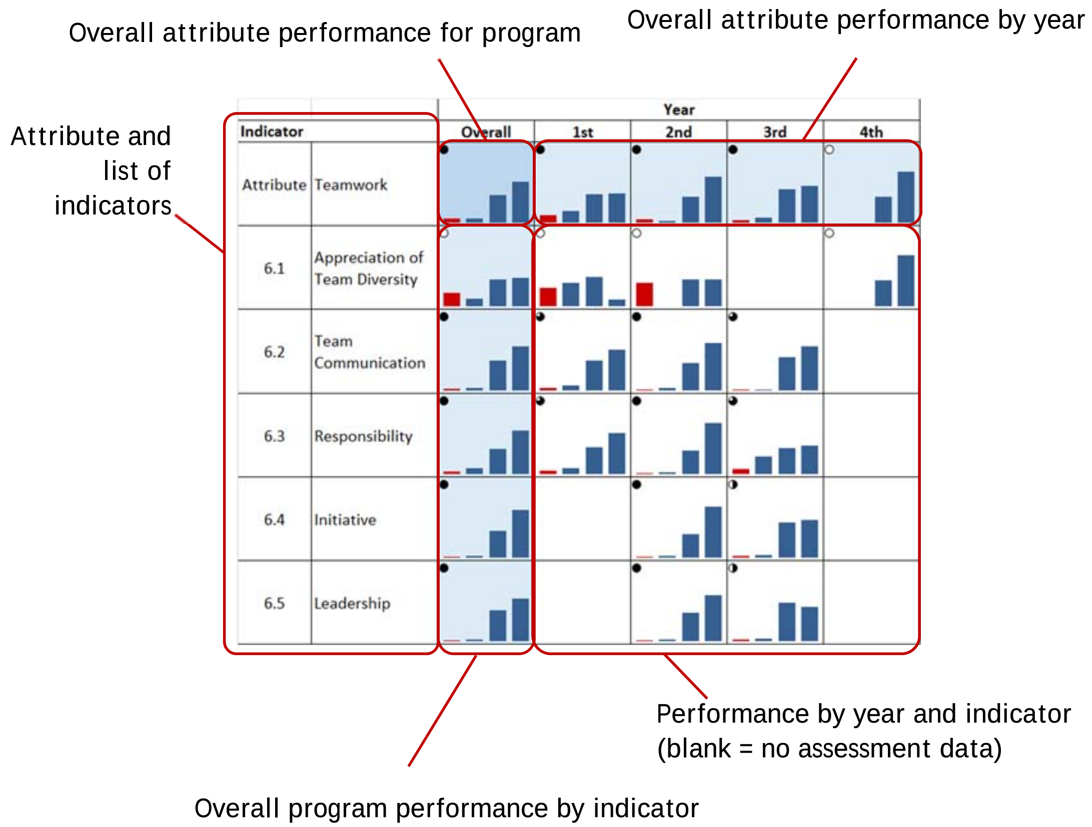


Figure 2. Legend for Graduate Attribute Data Tables

Each histogram is scaled to the range of 0 to 100%, and the four categories are, from left to right, "below expectations," "marginal," "meets expectations," and "exceeds expectations." An assessment strength icon (i.e. assessment trust measure) appears in the top left of each histogram (see Figure 3). Further details on interpreting this measure are provided in the table on the following page.

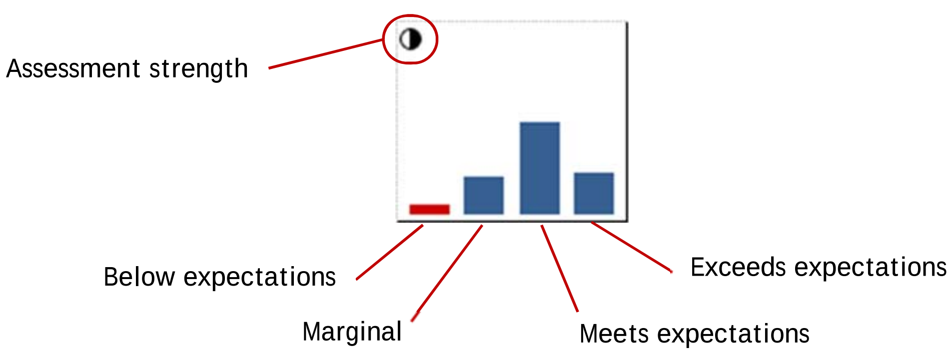


Figure 3. Histogram Interpretation

The overall assessment strength shown with the histograms is displayed using icons, according to Table 1 below. As described previously, the assessment strength for each assessment tool is based on an instructor's qualitative rating of validity, reliability, and authenticity for that tool, as well as the number of assessments in the course. The overall assessment strength for an indicator and year is the sum of the assessment strengths from all assessment tools for that indicator and/or year. Example numbers of assessments required to achieve a particular assessment strength are shown; in reality, assessments tend to not have the same rating (low, medium, high) for all three of validity, reliability, and authenticity.

Table 1. Assessment Strength Interpretation

Icon	Assessment strength	Description	Examples of number of assessments required		
			Low validity, reliability, and authenticity	Med. validity, reliability, and authenticity	High validity, reliability, and authenticity
●	>40	Very strong assessments; high confidence in results	41	9	5
◕	(20-40]	Strong assessments; confidence in results	21	5	3
◑	(10-20]	Adequate assessments; moderate confidence in results	11	3	2
◔	(5-10]	Weak assessments; low confidence in results	6	2	1
○	(0-5]	Very weak assessments; very low confidence in results	1	1	-
	[0]	No assessments			

The data derived from academic sources was also compared to end-of-work term survey data collected from co-op employers, as well as survey responses from current students and recent alumni. The overall academic data histogram is compared to histograms for the survey data from current students, alumni, and co-op employers. The percentage overlap of each survey histogram with the academic data histogram is reported in the histogram, as shown in Figure 4 below.

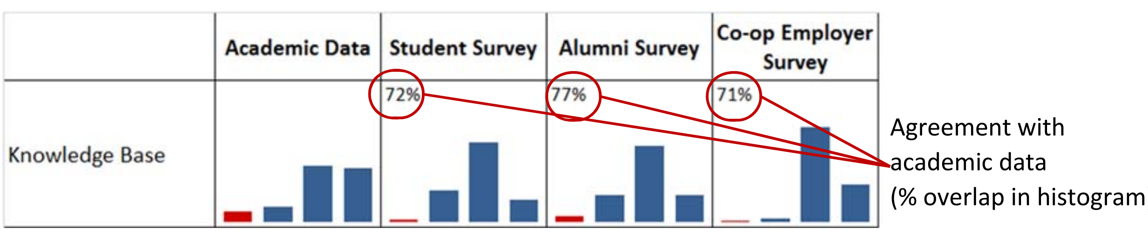


Figure 4. Histogram Comparison

The data from the four sources—courses, students, alumni, and employers—help to give a comprehensive picture of curriculum performance, but the four sources are not intended to be considered equivalent. Data from each are collected using different methods with varying degrees of rigour and are based on different sample sizes. In general, the academic data is the most complete, consistent, and objective, as it is constructed from independent and impartial indicator-level assessments from across the curriculum. The survey-based data is arguably prone to subjective judgment, as well as to differing interpretations of what the various attributes mean to someone unfamiliar with the graduate attributes process or language.

Nevertheless, by examining data from all four sources together, the most complete assessment of the curriculum is possible, with voice given to all four stakeholder groups.

Additional information on the methodology for collecting and interpreting the survey data are given below.

Co-op Employer Surveys: In total, employer surveys were received for 158 students in their first or second work terms (classified for the purpose of this analysis as students having completed second year) and 125 students in their third or higher work terms (classified as having completed third year). The employers were surveyed between December 2016 and April 2017. The surveys included the CEAB definition of each graduate attribute and asked employers to rate the student hires' performance in each one using a five-point scale (unsatisfactory, satisfactory, good, very good, and excellent), with options for a blank response or a "not applicable" response. For this analysis, the results were coded as follows:

- "Unsatisfactory" → Below expectations (BE)
- "Satisfactory" → Marginal (M)
- "Good" or "Very good" → Meets expectations (ME)
- "Excellent" → Exceeds expectations (EE)

Blank and "not applicable" responses were removed from the analyses. For each attribute, the sum of the four categories above (BE, M, ME, EE) total 100% in histograms and distributions presented.

Current Student and Alumni Surveys: Current students (years 3 and 4) and recent alumni (graduates from 2015, 2016, or 2017) were invited to participate in a survey asking them to self-rate their ability in each of the 12 graduate attributes. In total, 81 surveys were received from current students (roughly 20% response rate), and 85 responses were received from alumni (roughly 25% response rate). Responses were approximately representative of the student and alumni populations in terms of GPA, program option, and participation in Co-op, so they are believed to be fair indicators of the full populations. Respondents were asked to self-rate their competency in each attribute on a four-point scale, normalized to their level of education and mapped as follows:

- "**Not yet competent**: below the minimum proficiency I would expect for someone with my level of education" → Below expectations (BE)
- "**Marginally competent**: just meeting the minimum proficiency I would expect for someone with my level of education" → Marginal (M)
- "**Competent**: at the level of proficiency I would expect for most individuals with my level of education" → Meets expectations (ME)
- "**Highly competent**: exceeding the level of proficiency I would expect for most individuals with my level of education" → Exceeds expectations (EE)

Attribute descriptions were based on the CEAB definitions, with slight wording changes to suit a general student audience (e.g. examples of investigations and engineering tools were included, respectively, in the descriptions for Attributes 3 and 5). Blank and "Unsure" responses were removed from the analyses. For each attribute, the sum of the four categories above (BE, M, ME, EE) total 100% in histograms and distributions presented.

1.3 *Addendum 2: Graduate Attributes Data Summary*

This additional section has been added to give an overall high-level summary of the data collected and results compiled, prior to presenting data on an attribute-by-attribute basis.

Figure 5 shows a treemap diagram of the number of assessments conducted by attribute and by indicator. The area of each section represents the number of assessments compiled (direct, academic measures only) to assess that indicator/attribute. In total, this chart represents over 300 assessments in the curriculum (not including duplicate assessments of the same type within a course). In the figure, attributes are colour-coded and labelled by number and two-letter code (e.g. "3 IN" is Attribute 3, Investigation). Indicators are labelled as i1, i2, i3, etc. and follow the same order as presented later in the detailed sections that follow. For example, "i2" in attribute "3 IN" (i.e. to top-rightmost rectangle) refers to Indicator 3.2, Data Collection. Refer to the following sections for detailed descriptions of each indicator by attribute.

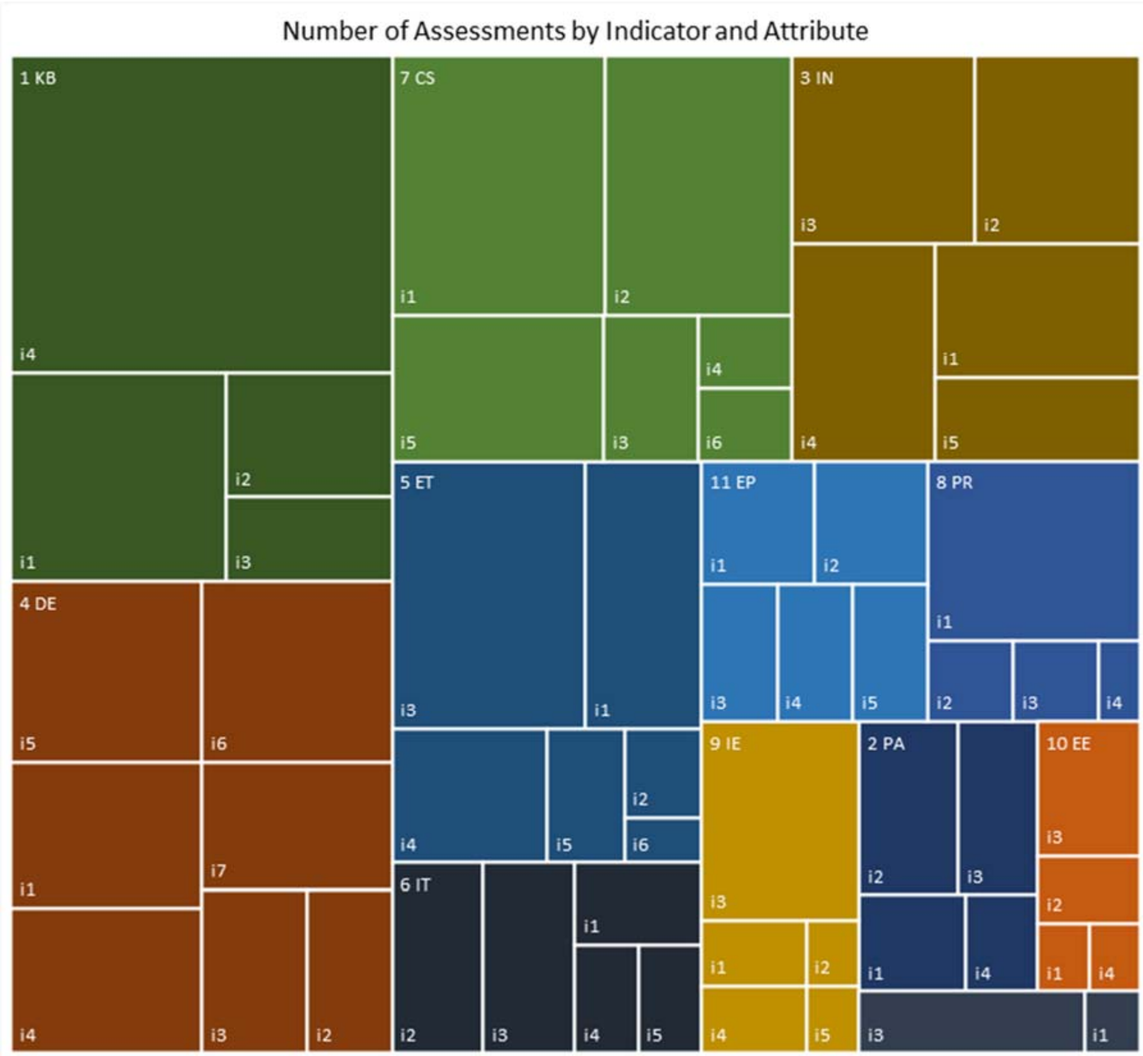


Figure 5. Number of Assessments by Indicator and Attribute

A treemap diagram was also prepared using assessment strength (see Figure 6) instead of number of assessments. As shown below, this reveals some differences in the relative weight (in other words, relative trust) of assessments across the curriculum. This will be discussed further on an attribute-by-attribute basis in the sections that follow.

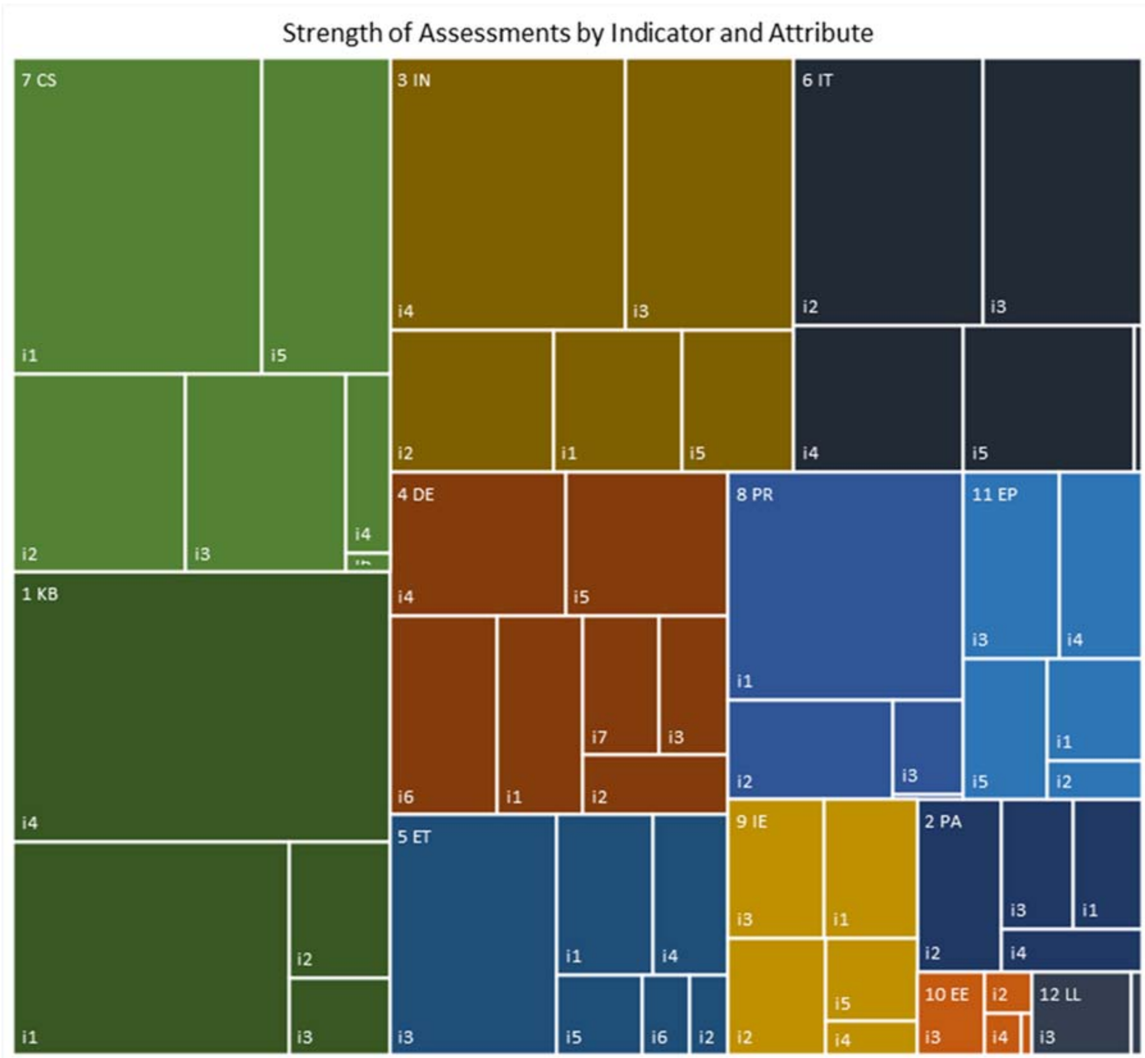


Figure 6. Strength of Assessments by Indicator and Attribute

The overall compilation of histograms from academic data and survey data (three survey sources) is presented below in Figure 7 (Attributes 1-6) and Figure 8 (Attributes 7-12) to give a convenient snapshot of the performance of the Mechanical Engineering Program. Overall, the analyses demonstrate the curriculum is generally performing well, with no obvious areas of major concern. Interpretation and discussion of the findings at a more detailed attribute-level is included in the individual sections that follow, and more holistically in Section 2 (Continual Improvement).

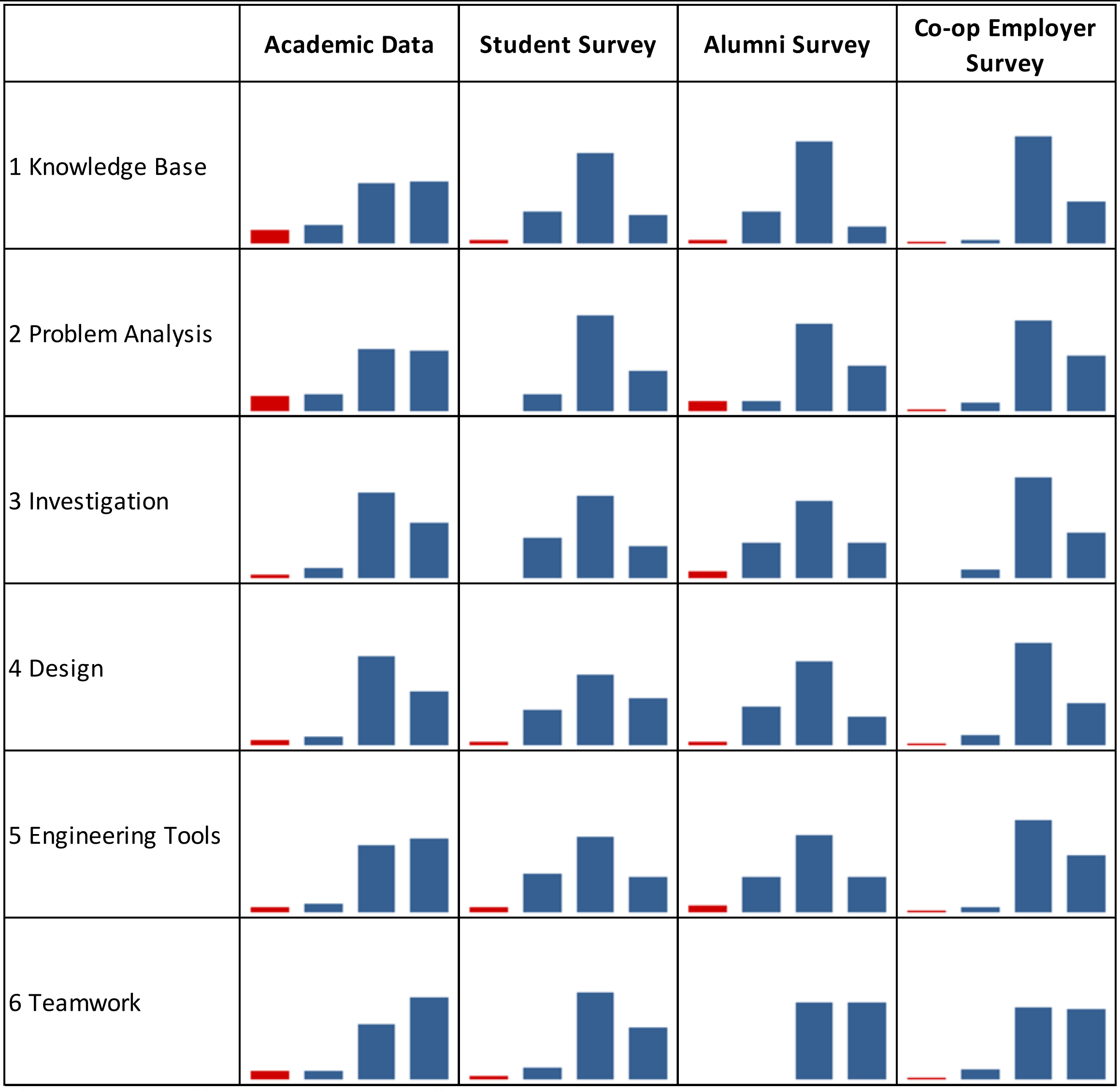


Figure 7. Overall Performance, Attributes 1-6

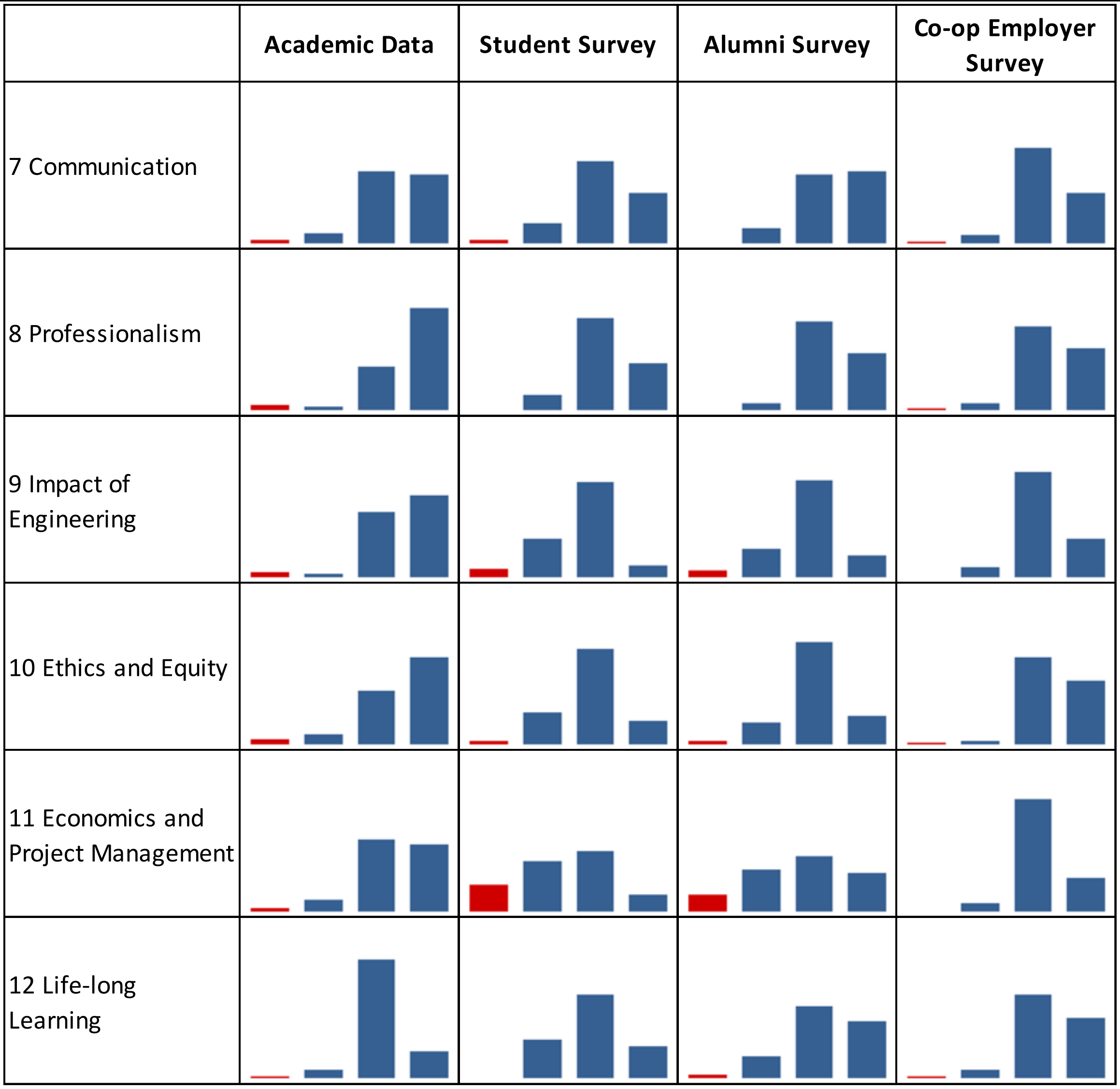


Figure 8. Overall Performance, Attributes 7-12

1.4 *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 Knowledge Base attribute is the most extensively developed in the curriculum. The bulk of first year courses focus on this attribute (including CHEM 154, MATH 100, 101, and 152, PHYS 157, 158, and 170). Some discipline-specific engineering science content is also introduced in the introduction to engineering course (APSC 101[1]). In second year, two large engineering science courses (MECH 221 and 222) introduce six topics relevant to the discipline of mechanical engineering (dynamics, solid mechanics, materials, electric circuits, thermodynamics, and fluid mechanics). In addition, MATH 253 (vector calculus) and MATH 256 (differential equations) in integrated into the MECH 221 and 222 courses, although the math courses do still appear separately on the transcript for administrative purposes. Also in second year, the MECH 223 design course introduces concepts of design and manufacture of machine components, and it requires the application of engineering science content from MECH 221 and 222 into practical design problems. In third year, the engineering knowledge base is expanded through MECH 30X (statistics and engineering laboratories), MECH 325 and 326 (design courses that include elements of design and manufacture of machine components), MECH 327 (thermodynamics), MECH 360 (mechanics of materials), MECH 375 (heat transfer), MECH 380 (fluid mechanics), and an engineering analysis course (MECH 358). The MECH 328 design project course requires students to apply the engineering science content of second and third year towards a significant design problem. In fourth year, students complete a course in vibration (MECH 463) and a course in automatic control (MECH 466). This information is summarized in Table 2 below.

Table 2. Curriculum Map for Attribute 1

Course	Title	Indicators	IDA	Details
APSC 101	Introduction to Engineering II	1.4	I	Introduction to engineering course; includes two design projects involving application of mechanics and fluid mechanics.
CHEM 154	Chemistry for Engineering	1.2	I	Fundamental chemistry course; includes properties of matter, chemical bonding, thermodynamics, electrochemistry, surface processes
MATH 100	Differential Calculus with Applications to Physical Sciences and Engineering	1.1	I	Mathematics course; includes derivatives of elementary functions; applications to modeling, graphing, optimization
MATH 101	Integral Calculus with Applications to Physical	1.1	I	Mathematics course; includes integral calculation; applications for integration techniques, modeling, infinite series

[1] Note: at the time of writing this exhibit, there was an error in the CIS for APSC 101 and the section under Attribute 1 was blank. It should appear as "I."

	Sciences and Engineering			
MATH 152	Linear Systems	1.1	I	Linear algebra course; includes techniques to evaluate multidimensional geometries, applications of eigenvalues, vibration, laboratories demonstrating computed solutions of large systems.
PHYS 157	Introductory Physics for Engineers I	1.2	I	Fundamental physics course; includes heat, thermodynamics, oscillations, waves, and sound.
PHYS 158	Introductory Physics for Engineers II	1.2	I	Fundamental physics course; includes electricity and magnetism, circuits, and optics.
PHYS 170	Mechanics I	1.3	I	Fundamental mechanics course; includes statics and dynamics.
MECH 221	Engineering Science I	1.1, 1.2, 1.3, 1.4	D	Engineering science course; focus on dynamics, solid mechanics, electric circuits, and materials engineering. Includes MATH 256, and math and physics review quizzes.
MECH 222	Engineering Science II	1.1, 1.4	D	Engineering science course; focus on thermodynamics and fluid mechanics. Includes MATH 253.
MECH 223	Introduction to the Mechanical Design Process	1.4	D	Design course; includes common mechanical components, manufacturing methods. Requires application of engineering science to projects.
MECH 305/306	Data Analysis and Mechanical Engineering Laboratories	1.1	D	Statistics and laboratory course; includes 13 laboratory experiences spanning mechanical engineering sub-disciplines integrated with a statistics course.
MECH 325	Mechanical Design I	1.4	D	Design course; emphasis on common mechanical components, mechanisms, and elements used in typical engineering design scenarios.
MECH 326	Mechanical Design II	1.4	D	Design course; emphasis on analysis, typical uses, failure modes, and other design considerations for machine elements.
MECH 327	Thermodynamics II	1.4	A	Engineering science course; focus on advanced topics in thermodynamics.
MECH 328	Mechanical Engineering Design Project	1.1, 1.2, 1.3, 1.4	D	Design course; requires application of various mathematics, natural science, engineering science, and discipline-specific knowledge.
MECH 358	Engineering Analysis	1.1	A	Applied mathematics course; advanced topics in mathematics.

MECH 360	Mechanics of Materials	1.4	A	Engineering science course; focus on advanced topics in solid mechanics.
MECH 375	Heat Transfer	1.4	A	Engineering science course; focus on heat transfer.
MECH 380	Fluid Dynamics	1.4	A	Engineering science course; focus on advanced topics in fluid mechanics.
MECH 463	Mechanical Vibrations	1.4	A	Engineering science course; focus on vibrating systems.
MECH 466	Automatic Control	1.4	A	Engineering science course; focus on automatic control systems.

Note that for students in one of the options (Biomedical, Mechatronics, or Thermofluids), a small subset of the above courses is different, and they may take additional courses not listed above. In future, we are planning to include the option-specific courses in our assessment, and analyze data separately for each option.

Indicators:
The Knowledge Base attribute is unique for the program in that it is the only one where we have included sub-indicators. The attribute is described using four main indicators

1.1 Mathematics Knowledge Base: Comprehend and apply mathematics relevant to the student's option in Mechanical Engineering.
1.2 Natural Science Knowledge Base: Comprehend and apply physical sciences, life sciences, and earth sciences relevant to the student's option in Mechanical Engineering.
1.3 Engineering Science Knowledge Base: Comprehend and apply the areas of engineering science that support the student's option in Mechanical Engineering.
1.4 Discipline Knowledge Base: Comprehend technical areas comprising a recognized engineering discipline, as detailed below.

These four indicators are drawn directly from the definition of the attribute: "*Demonstrated competence in university level mathematics (1.1), natural sciences (1.2), engineering fundamentals (1.3), and specialized engineering knowledge appropriate to the program (1.4).*"

Through extensive formal and informal discussion within the Department, it was agreed that increased resolution in Indicator 1.4 was necessary in order for any data collected to be of use to the Department. Specifically, since so much of the curriculum is devoted to developing Indicator 1.4, this indicator needed to be sub-divided in order to meaningfully identify strengths and weaknesses in the many topics that make up this indicator. Through a formal vote, the Department agreed to expand Indicator 1.4 to include ten sub-disciplines in mechanical engineering, drawn from the Mechanical Engineering syllabus of [redacted] (now [redacted] While it was recognized that this created more work, it was felt to be worth it in order to be able to truly assess the functioning of the curriculum. The sub-indicators in 1.4 are

1.4.1 Mechanics of Materials: Apply load and deformation analyses of engineering structures to determine appropriate strength, stiffness and safety.
1.4.2 Dynamics: Apply Newtonian mechanics, energy methods and associated physical principles to analyze the kinematics and kinetics of single and systems of particles and rigid bodies under applied loads or undergoing prescribed motions.
1.4.3 Vibrations: Apply Newtonian mechanics, energy methods and associated physical principles to analyze the kinematics and kinetics of vibrating single and multi-degree-of-freedom systems and structures.

1.4.4 Fluid Mechanics: Apply the principles of conservation of mass and momentum to problems involving laminar or turbulent internal and external flows in order to relate fluid loading to flow conditions. Apply techniques of dimensional analysis and scaling in design and interpretation of experimental studies.

1.4.5 Thermodynamics: Apply First and Second Laws of Thermodynamics to systems containing common substances such as steam, air, and metals in order to relate system property changes to heat transfer or work involved in a process.

1.4.6 Heat Transfer: Identify and describe heat transfer mechanisms by conduction, convection and radiation. Apply theoretical and empirical heat transfer calculation techniques to determine heat transfer rates, temperature distributions, or equipment sizes.

1.4.7 Design and Manufacture of Machine Elements: Identify common mechanical components, mechanisms, and manufacturing methods used in typical engineering design scenarios and describe the typical uses, failure modes, and other design considerations.

1.4.8 Control: Describe the principles of automatic control, identify common control strategies, and apply techniques to assess system response and stability.

1.4.9 Electrical and Electronic Engineering: Describe fundamental electrical concepts and apply circuit analysis methods to work effectively with electronic and electromechanical systems.

1.4.10 Materials Engineering: Describe the characteristics and variety of material physical properties. Select appropriate materials to produce safe, functional, and economical engineering components.

Unlike other attributes, performance expectations in most assessments were linked to percentage grades on assessments and overall, since those were most closely aligned to the standard grading in most courses. The below expectations, marginally meeting expectations, meeting expectations, and exceeding expectations categories were nominally binned to <50%, 50-60%, 60-80%, and >80%, respectively.

Assessment tools:

Assessment tools for the Knowledge Base attribute were primarily either grades from formal examinations, or, in the case of first year, full course grades. While the use of full course grades for outcomes-based assessment is generally discouraged, it was believed to be appropriate in this case since the topics in the first year math and science courses are very closely aligned to a specific indicator. (It is rare that a first-year course like this would assess problem analysis, investigation, design, or some other attribute beyond Attribute 1.) In the case of these courses, grades from a random sample of 60 students who went on to Mechanical Engineering were summarized (i.e. approximately 50% of the 2016/17 second year Mechanical Engineering cohort was randomly selected). The final exam is APSC 101 assessed, among other things, students' understanding of various specialized engineering topics related to mechanical engineering; however, due to the diversity of topics and since this course is part of he common first year, this was coded as Indicator 1.4 rather than attempting to divide assessments by sub-indicator. In MECH 221 and 222, performance on weekly exams (each 60 to 120 minutes in length) and final exams, was used. In addition, in MECH 221, a first-year math and physics review quiz is administered on the first day of second year (in the table below, this is listed with Year 1, since students have not received any second-year instruction by this point). A second such review quiz is administered four weeks later, and is supported with daily review lectures and homework exercises; this quiz is listed below under Year 2). Also in MECH 221, students complete 5 classes and online quizzes on statistics. In MECH 223 (second-year design) and MECH 328 (third-year design), students are required to draw from their engineering knowledge base when analyzing solutions to design problems. MECH 30X (Data Analysis and Engineering Laboratories) and MECH 358 (Engineering Analysis) provide additional assessment related to mathematics in upper years. The remaining courses (MECH 325, 326, 327, 360, 375, 380, 463, and 466) use combinations of midterm and final exams to assess the sub-categories for Indicator 1.4. This information is summarized in Table 3.

Table 3. Assessment Tools for Attribute 1

Year	Course	Assessment Tools	Indicators assessed			
			1.1	1.2	1.3	1.4
1	APSC 101	1 × Final exam				✓
	CHEM 154	Course grades		✓		
	MATH 100	Course grades	✓			
	MATH 101	Course grades	✓			
	MATH 152	Course grades	✓			
	PHYS 157	Course grades		✓		
	PHYS 158	Course grades		✓		
	PHYS 170	Course grades			✓	
	MECH 221	1 × math and physics review quiz 1	✓	✓	✓	
2	MECH 221	6 × weekly exams; 2 × final exams; 5 × statistics quizzes 1 × math and physics review quiz 2	✓	✓	✓	✓
	MECH 222	3 × weekly exam grades; 2 × final exam grades	✓			✓
	MECH 223	1 × design project report* (MECH223-Rubric-Report.pdf)				✓
3	MECH 30X	1 × midterm exam (statistics)	✓			
	MECH 325	1 × final exam				✓
	MECH 326	1 × final exam				✓
	MECH 327	1 × final exam				✓
	MECH 328	1 × final project dossier* (MECH328-Rubric-Report.xlxs)	✓	✓	✓	✓
	MECH 358	1 × final exam	✓			
	MECH 360	1 × midterm exam				✓
	MECH 375	2 × final exam				✓
	MECH 380	1 × final exam				✓
4	MECH 463	1 × final exam				✓
	MECH 466	2 × midterm exam; 1 × final exam				✓

* indicates the assessment was completed using a rubric and the name in parentheses is the associated rubric filename available for review;

Assessment results:

Assessment data were collected for the above four indicators (and 10 sub-indicators) and 22 courses spanning all four years of the program. Approximately 30 assessment tools were used, in addition to data from final course grades for 7 courses.

Data are reported below for Indicators 1.1 to 1.4, sorted by indicator and academic year. See "Addendum 1: Data Analysis and Presentation" above for a description of the histogram grid, including descriptions of the histograms and assessment strength rating scale (◯ ◔ ◑ ◕ ●).

In some instances, discipline-specific knowledge base data was attributed to Indicator 1.4, but in most cases, it was attributed to a specific sub-indicator (e.g. fluid mechanics or control). Data from the sub-indicators 1.4.1 to 1.4.10 is combined with the general data from Indicator 1.4 in Figure 9 below. As used throughout this work, the assessment strength metric was used to weight the data from the different sources in order to combine into Indicator 1.4 below.

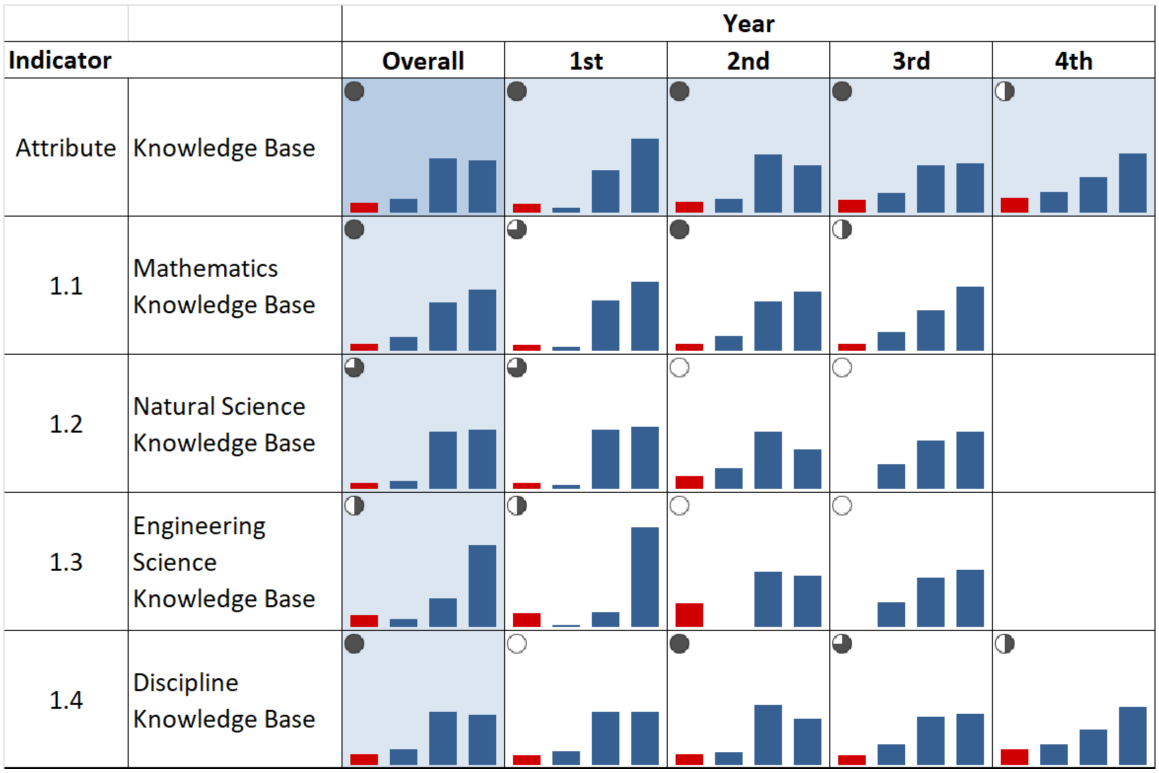


Figure 9. Assessment Data for Attribute 1

Data for the sub-indicators 1.4.1 to 1.4.10 are shown separately in Figure 10 on the following page.

(continued)

		Year				
Indicator		**Overall**	**1st**	**2nd**	**3rd**	**4th**
1.4	Discipline Knowledge Base					
1.4.1	Mechanics of Materials					
1.4.2	Dynamics					
1.4.3	Vibrations					
1.4.4	Fluid Mechanics					
1.4.5	Thermodynamics					
1.4.6	Heat Transfer					
1.4.7	Design and manufacture of machine elements					
1.4.8	Control					
1.4.9	Electrical and Electronic Engineering					
1.4.10	Materials Engineering					

Figure 10. Assessment Data for Sub-Indicators for Attribute 1

The overall academic data—all indicators and years combined, as shown in the top-left cell of Figure 9—are compared below to survey data from current students, alumni, and co-op employers in Figure 11. See “Addendum 1: Analysis and Presentation” above for more information on data collection methods and interpretation of the data.

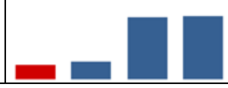
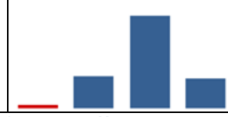
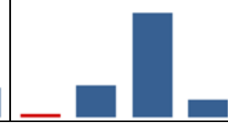
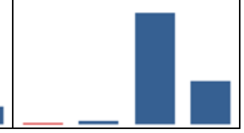
	Academic Data	Student Survey	Alumni Survey	Co-op Employer Survey
1 Knowledge Base		71% 	64% 	69% 

Figure 11. Comparison to Survey Data for Attribute 1

Comparing the overall academic data to the student, alumni, and co-op employer survey data, the academic data suggests a greater proportion of students at top (“exceeds expectations”) and bottom (“below expectations”) of the distribution. The “below expectations” data is described further below. The larger proportion of students in the “exceeds expectations” group will be discussed at an upcoming meeting of the Curriculum Committee. This difference is believed to be due, at least in part, to different interpretations of what “exceeds expectations” means. For example, the academic data is nominally classified as exceeding expectations at 80% and above (i.e. A- and above, by [redacted] grading standards). Students, alumni, and employers may view grades in the 80-84% range as meeting expectations, for example, and may view 85% (A) and above, or 90% (A+) and above, as “exceeding expectations.” The appropriate threshold for graduate attribute data analysis will be discussed at the upcoming Curriculum Committee meeting.

Looking more closely at the academic data for Indicators 1.1 to 1.4 (the first table above), performance in first year is slightly stronger compared to other years. In part, this is due to the fact that Mechanical Engineering is a competitive program to enter and in high demand; as a result, the Mechanical Engineering students represented in the table tend to have high averages relative to other students in the common first year. The “below expectations” data in first year is due to performance in the review quiz at the start of second year; even though questions are drawn from former first-year math and physics exam questions, roughly 40% of students fail the initial review quiz. (They go on to do much better in the second review quiz, with about 10% failing, after having four weeks of remedial instruction and time for review.)

In other years, performance varies, but several topic areas deserving attention include Indicator 1.4.5 (Thermodynamics, 18% below expectations), 1.4.6 (Heat Transfer, 17%), 1.4.8 (Control, 14%), 1.4.7 (Machine Elements, 13%), and 1.4.4 (Fluid Mechanics, 13%).

The Curriculum Committee will be meeting in the coming academic term to discuss these findings and determine next steps. At the very least, several years of additional data will be needed before considering curriculum changes in reaction to this data. This is in part because, for many years, these courses and the resulting grades have already been discussed during course review meetings each term, and any concerns raised regarding the functioning of these courses have been addressed. Part of the discussion within the Curriculum Committee, and to be brought to the Department, will be what a reasonable threshold for the proportion of students performing at “below expectations” in a course heavily focused on developing an engineering knowledge base.

1.5 *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.

Problem analysis is developed throughout the curriculum. In terms of assessment, data are available in the first, second, and third years, with efforts currently underway to expand assessment in third and fourth years. In a new introduction to engineering course in first year (APSC 100, level "I"), students must design a system, and in particular, outline their solution and decision-making process. In MECH 223 (level "D"), students complete two major design projects and are required to use physical and analytical prototypes; the identification of key questions to be answered with the prototypes, and the manner in which students integrate the use of prototypes in solving these questions, are assessed. (Also required in the course, but not explicitly assessed, is the process of obtaining a solution and the evaluation of the validity of that solution.) Finally, one of the main scenarios in a course final exam (i.e. 90-minute question) requires students to evaluate a complex, open-ended problem, create a model using appropriate assumptions, and develop an estimate. In MECH 326 (level "D"), teams complete several constrained design projects; these are evaluated in terms of how the problem is formulated (including the model used, and any assumptions or approximations), the solution methodology, and an assessment of the validity of results. On exams, students must also assess appropriateness of methodology for mock solutions. In MECH 328 (level "D"), teams assess a design opportunity to define the problem to be addressed, and then they must perform detailed analyses to arrive at a solution, and evaluate the validity of that solution. This information is summarized in the Table 4 below.

Table 4. Curriculum Map for Attribute 2

Course	Title	Indicators	IDA	Details
APSC 101	Introduction to Engineering II	2.2	I	Introduction to engineering course; includes a design project where teams must determine a solution.
MECH 223	Introduction to Mechanical Engineering Design	2.1, 2.2	D	Design course; includes two large design projects and a final exam where teams must identify significant unknowns and devise solution approaches .
MECH 326	Mechanical Design II	2.2, 2.3, 2.4	D	Design course; includes three design projects where teams analyze an ill-defined problem, and identify and implement a solution approach.
MECH 328	Mechanical Engineering Design Project	2.1, 2.2, 2.3, 2.4	D	Design course; focuses on one major project where students identify, analyze, and solve various problems.

While there is significant attention paid to Problem Analysis within the curriculum, the assessment data collected represents only a portion of what is readily available. In MECH 325 (Mechanical Design I) and MECH 45X (capstone design), problem analysis is utilized throughout projects; however, assessment data was not adequately collected. In MECH 223, there are additional opportunities to collect data related to Attribute 2 on the projects and in final exams. Finally, the MECH 30X course (Data Analysis and Mechanical Engineering / Mechatronics Laboratories) is currently being reviewed and revised, with the intention to focus on more open-ended laboratory experiences and design of experiments. There are opportunities in this new course to include development and assessment of problem analysis. The steps planned incorporate assessment data from these and other sources in future is discussed further below.

Indicators:

Four indicators have been used to describe the Problem Analysis attribute. The indicators examine key aspects of the attribute and allow independent assessment in each:

2.1 Problem Identification: Identify the significant issues to be considered when addressing a practical (complex) engineering question or task; Identify relevant known information, uncertainties, and biases, and key issues requiring investigation
2.2 Problem Formulation: Create an appropriate model to describe problem, articulating assumptions and approximations, and using an appropriate level of abstraction; Identify most promising solution approaches
2.3 Problem Solution: Use appropriate qualitative and quantitative techniques and analyses to generate predictions from model
2.4 Solution Evaluation: Evaluate validity and sensitivity of results; Compare predictions with available data; Check safety and potential collateral consequences; Draw substantiated conclusions

The Indicators 2.1 to 2.3 map directly to the CEAB definition of Attributes 2: "*An ability to use appropriate knowledge and skills to identify (2.1), formulate (2.2), analyze, and solve (2.3) complex engineering problems in order to reach substantiated conclusions.*" Indicator 2.4 (evaluation of the resulting solution) was felt to be a necessary step, implicit in the problem analysis process, but worth stating explicitly.

Performance expectations (below expectations, marginal, meets expectations, and exceeds expectations) in each indicator are relative to the year level. The descriptors of the detailed assessment rubrics for each course activity indicate performance expectations in each course and year.

Assessment tools:

Assessment tools for Problem Analysis are based on a mix of projects and formal examinations, as summarized in Table 5 below. The value preceding an assessment tool indicates the number of items of that type assessed in that course.

Table 5. Assessment Tools for Attribute 2

Year	Course	Assessment Tools	Indicators assessed			
			2.1	2.2	2.3	2.4
1	APSC 101	1 × oral presentation* (APSC101-M7-Rubric-Pres)		✓		
2	MECH 223	2 × prototype demonstrations* (MECH223-Rubric-Prototype); 2 × project presentations* (MECH223-Rubric-Pres-1, MECH 223-Rubric-Pres-2); 1 × design review meeting* (MECH223-Rubric-Review) 1 × final exam**	✓	✓		
3	MECH 326	3 × course projects* (MECH326-Rubric-Project.pdf); 1 × final exam		✓	✓	✓

	MECH 328	1 × comprehensive project dossier* (MECH328-Rubric-Report.xlsx)	✓	✓	✓	✓

* indicates the assessment was completed using a rubric and the name in parentheses is the associated rubric filename available for review;

** indicates a rubric was used to complete the assessment but detailed rubric data were not recorded; raw grades from the assessment tool were used to determine performance levels. (We are working to eliminate this practice by instructors and to record all rubric data directly, where possible.)

The above assessment tools were chosen primarily based on where we had existing assessments within the curriculum. As noted previously and outlined in detail below, there are numerous places within our curriculum where we have identified additional assessment tools to complement those above.

Assessment results:

Assessment data were collected for the above four indicators and four courses spanning the first three years of the program. This resulted in a total over 10 assessment tools each assessing roughly two indicators on average (for a total of approximately 22 assessment points).

Data are reported below in Figure 12, sorted by indicator and academic year. See "Addendum 1: Data Analysis and Presentation" above for a description of the histogram grid, including descriptions of the histograms and assessment strength rating scale (○ ◔ ◑ ◕ ●).

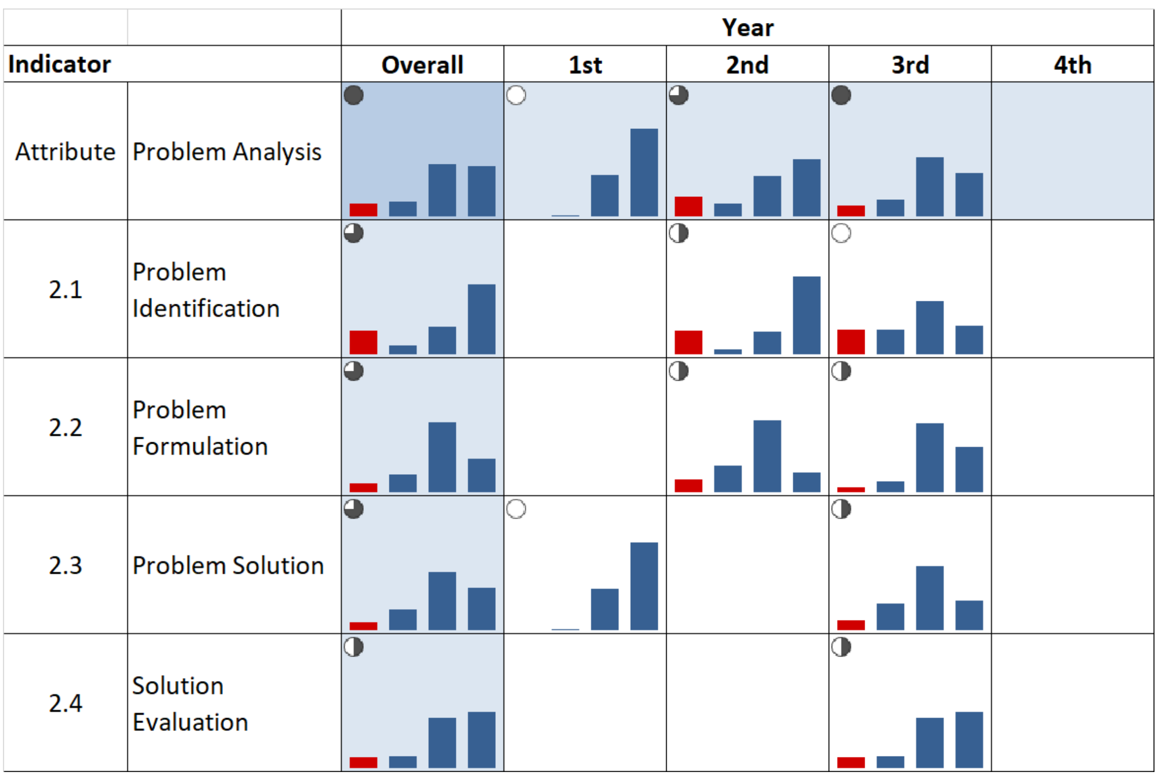


Figure 12. Assessment Data for Attribute 2

In Figure 13 the overall academic data—all indicators and years combined, as shown in the top-left cell from Figure 12 above—are compared below to survey data from current students, alumni, and co-op employers. See "Addendum 1: Analysis and Presentation" above for more information on data collection methods and interpretation of the data.

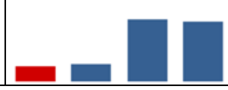
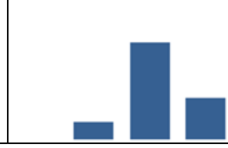
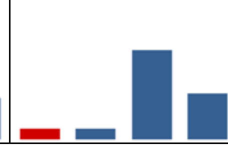
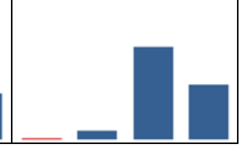
	Academic Data	Student Survey	Alumni Survey	Co-op Employer Survey
2 Problem Analysis				

Figure 13. Comparison to Survey Data for Attribute 2

The academic data—and to a similar extent, the alumni survey data—raise concerns in the Problem Analysis attribute. Most students are performing at a "meets expectations" or "exceeds expectations" level, but 10% overall are "below expectations." Similar issues are noted for all indicators at the second and third year levels, and Indicator 2.1 (Problem Identification), in particular, suggests 18% of students overall are performing at a "below expectations" level. Although it is not shown in the data above, this lower than expected performance is heavily attributable to the MECH 223 final exam (which is stressful and of an unfamiliar style to the students), but also the MECH 328 final reports (which students have substantial time to develop and refine). In other words, this issue appears to extend beyond the assessment tool used and suggests a possible curriculum deficiency.

In comparing the academic assessments with survey results reported by current students, alumni, and co-op employers, there is good agreement, with slightly more spread in the academic data than the other sources. A significant proportion of alumni in particular (7%) report a "below expectations" level of competency.

In terms of process, additional data are needed in this attribute. There appear to be adequate assessments overall, but there is only one of four indicators assessed in first year, two of four in second year, and none in fourth year (third year is the only year with all four indicators assessed). Additional data are needed before making any decisions on curriculum changes. Some specific observations and planned actions for this attribute are listed below.

1. In MECH 223, data were collected from final exams for Indicators 2.1 and 2.2. With a slight change to the question format and marking rubric, it would be possible (and appropriate for the course) to collect data for all four indicators. This will be discussed within the MECH 223 teaching team prior to the course start in January, 2018.
2. Also in MECH 223, opportunities to expand assessment of Attribute 2 in the projects is actively being considered. Specifically, as part of the projects, students currently identify a significant unknown or problem in their project and devise a way to address this using a physical prototype; one option being explored is to require development of an analytical model in addition to the physical prototype. This could be done for the same issue (allowing comparison between the analytical and physical models), or for different issues.
3. In MECH 325, (Mechanical Design I) students complete a series of constrained design projects, similar to in MECH 326 (Mechanical Design II) and a similar grading rubric is used. This data will be captured starting this coming academic term.
4. Data collection and analysis methods for MECH 45X (capstone design) are being re-developed in time for the upcoming academic year. The rubrics are being reviewed and expanded to better align with the indicators, and to add more rigour to the overall process. Attribute 2 will be included in these rubrics.

5. Finally, the MECH 30X course (Data Analysis and Mechanical Engineering / Mechatronics Laboratories) is currently being reviewed and revised. This is discussed in more detail in Section 2 (Continual Improvement), but, in short, there is a desire to include open-ended problems involving investigation and the design of experiments. This type of experience may lend itself to analytical modelling as a necessary or complementary tool, in which case, efforts will be made to include assessment of Attribute 2 in this new course.

1.6 *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:

Development and assessment of Investigation has been primarily focused on laboratory-rich courses and major design courses, since these have allowed significant opportunity for students to develop, conduct, and analyze investigations. These courses begin in first year with an introduction to the use of investigation as part of design and decision-making (in APSC 100, level "I"), continue in second year (MECH 221, 222, and 223, nominally at level "D") and third year with a deeper integration and emphasis on investigation as a tool for justified decision-making, and conclude in fourth year with an industrially-focused capstone design project (at level "A"). The flagship laboratory and statistics course in third year (MECH 305/MECH 306) emphasizes experimental techniques and investigation and is at level "A." The goal by focusing on this subset of courses and activities has been to standardized assessment protocols in these large, core courses. Additionally, there has been a goal to ensure consistent vocabulary, methods, and expectations for instructors, teaching assistants, and students. As described in the "Assessment Results" section below, to date, we have only been partially successful in harmonizing assessment approaches between these courses, but are actively working to revise courses, assessments, and data gathering to address this.

Table 6 below highlights the courses where Investigation is assessed for the purpose of graduate attributes and continual improvement.

Table 6. Curriculum Map for Attribute 3

Course	Title	Indicators	IDA	Details
APSC 101	Introduction to Engineering II	3.1, 3.2	I	Introduction to engineering course; includes two design projects involving an introduction to physical and virtual prototype development and testing.
MECH 221	Engineering Science I	3.3	D	Engineering science course; includes 8 physical laboratory experiences (covering dynamics, solid mechanics, electric circuits, and materials engineering) where data analysis is assessed.
MECH 222	Engineering Science II	3.3	D	Engineering science course; includes 5 physical laboratory experiences (covering fluid mechanics and thermodynamics) where data analysis is assessed.
MECH 223	Introduction to Mechanical Engineering Design	3.1, 3.2, 3.3, 3.4, 3.5	D	Design course; includes two major projects incorporating physical prototype development and testing used to inform design project decision-making.
MECH 305	Data Analysis and Mechanical Engineering Laboratories	3.1, 3.2, 3.3, 3.4, 3.5	A	Statistics and laboratory course; includes 13 laboratory experiences spanning mechanical engineering sub-disciplines.

MECH 328	Mechanical Engineering Design Project	3.1, 3.2, 3.3	D	Design course; one major project where teams must identify and design data collection protocols and analysis methods.
MECH 45X	Capstone Design Project	3.1, 3.2, 3.3, 3.4, 3.5	A	Design course; one major project where teams must create, test, and analyze data from multiple prototypes.

Indicators:

Five indicators have been used to describe Investigation, forming a natural progression of steps adapted from the scientific method:

3.1 Investigation Definition: Define scope and goals of investigation
3.2 Data Collection: Formulate and apply appropriate procedures, tools, and techniques to collect data
3.3 Data Analysis: Formulate and apply appropriate procedures, tools, and techniques to analyze data
3.4 Data Synthesis: Process data to reach appropriate conclusions
3.5 Assess Results: Assess the validity of conclusions given limitations of theory and measurement

Indicators 3.2 to 3.5 map directly to the CEAB definition of Attribute 3: "*An ability to conduct investigations of complex problems by methods that include appropriate experiments (3.2), analysis (3.3) and interpretation of data, and synthesis of information (3.4) in order to reach valid conclusions (3.5).*" Indicator 3.1 was added to assess the high-level ability to define investigations.

Performance expectations (below expectations, marginal, meets expectations, and exceeds expectations) in each indicator are relative to the year level assessed. The descriptors in the detailed assessment rubrics in each course activity describe performance expectations by course and year (see next section for the rubrics used).

Assessment tools:

Assessment tools for Investigation are primarily deliverables from courses, as summarized in Table 7 below. The value preceding an assessment tool indicates the number of items of that type assessed in that course. These assessment tools were chosen due to the opportunity for authentic assessment (i.e. where students demonstrate the competency in a more real-world application), and the assessment tools (rubrics) were chosen due to their good reliability and validity compared to other assessment instruments. For non-rubric-based assessments of lab and project deliverables (e.g. some lab reports, project presentations, etc.), as discussed below, expectations are to transition to full adoption of rubrics over the coming academic years.

Table 7. Assessment Tools for Attribute 3

Year	Course	Assessment Tools	Indicators assessed				
			3.1	3.2	3.3	3.4	3.5
1	APSC 101	1 × poster presentation* (APSC101-M5-Rubric-Poster); 1 × oral presentation* (APSC101-M7-Rubric-Pres)	✓	✓			

2	MECH 221	8 × lab reports* (MECH221-222-Rubric-Lab)			✓		
	MECH 222	5 × lab reports* (MECH221-222-Rubric-Lab)			✓		
	MECH 223	2 × prototype demonstrations* (MECH223-Rubric-Prototype); 1 × project report* (MECH223-Rubric-Report); 2 × project presentation* (MECH223-Rubric-Pres-1, MECH 223-Rubric-Pres-2); 1 × design review meeting* (MECH223-Rubric-Review)	✓	✓	✓	✓	✓
3	MECH 305	13 × lab reports; 1 × final exam	✓	✓	✓	✓	✓
	MECH 328	1 × concept selection review* (MECH328-Rubric-Concept.xlsx); 1 × comprehensive project dossier* (MECH328-Rubric-Report.xlsx)	✓	✓	✓		
4	MECH 45X	3 × prototype presentations** (MECH45X-Rubric-CFP.pdf, MECH45X-Rubric-Prototype-A.pdf, MECH45X-Rubric-Prototype-B.pdf); 1 × comprehensive project dossier** (MECH45X-Rubric-Dossier.pdf)	✓	✓	✓	✓	✓

* indicates the assessment was completed using a rubric and the name in parentheses is the associated rubric filename available for review;

** indicates a rubric was used to complete the assessment but detailed rubric data were not recorded; raw grades from the assessment tool were used to determine performance levels. (We are working to eliminate this practice by instructors and to record all rubric data directly, where possible.)

As shown above, in each of Years 2, 3, and 4, all indicators covering the attribute are assessed.

Assessment results:

Assessment data were collected for the above five indicators and seven courses spanning the program. This resulted in a total of over 120 assessment points (approximately 40 assessment tools each assessing approximately 3 indicators, on average). Although this is a large number of individual assessments, the assessment data were collected as part of normal course operation, and it was a small, incremental step to process and collate data to assess Investigation.

Data are reported in Figure 14 below, sorted by indicator and academic year. See "Addendum 1: Data Analysis and Presentation" above for a description of the histogram grid, including descriptions of the histograms and assessment strength rating scale (○ ◔ ◑ ◕ ●).

Figure 14. Assessment Data for Attribute 3

The overall academic data from above—all indicators and years combined, as shown in the top-left cell of Figure 14—are compared below to survey data from current students, alumni, and co-op employers in Figure 15. See "Addendum 1: Data Analysis and Presentation" above for more information on data collection methods and interpretation of the data.

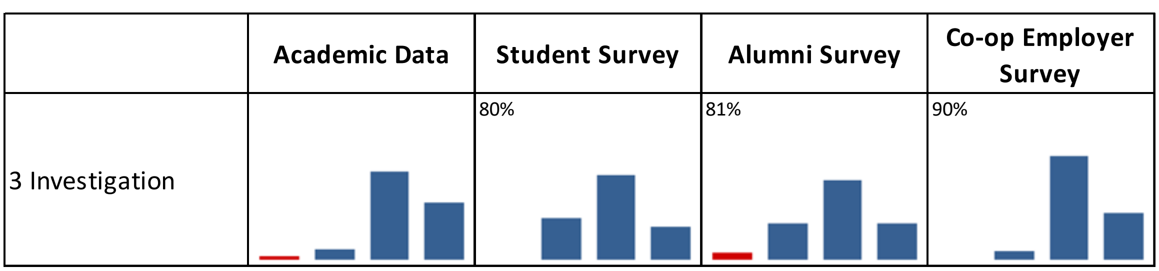


Figure 15. Comparison to Survey Data for Attribute 3

As shown, there is good agreement across all assessments. Histograms from current students and alumni agree to approximately 80% with the histogram from our academic data, and the histogram from co-op employers agrees to 90%. Moreover, the general distributions look similar, although current students and alumni tend to have more “Marginal” ratings than either our ratings or the co-op employer findings show.

Overall, the data suggests program performance in terms of Investigation is satisfactory. At all year levels, and in all indicators, the majority of students are meeting or exceeding expectations. The data suggest curriculum changes to improve program performance in Investigation are not needed at this point. In terms of data collection, there appears to be sufficient data overall. Assessment strength for Indicators 3.1 to 3.4 are “very strong” and “strong” for Indicator 3.5. Assessment strength by year is “adequate” for first and fourth year, and “very strong” for years 2 and 3; this is reasonable given the bulk of coursework related to investigation occurs in the middle two years.

Still, there are five concerns raised by the data above to be addressed in terms of data collection processes:

1. Data collection and analysis methods for fourth year (specifically MECH 45X) are under development, and, to date, lack the rigour of the other design-oriented courses at earlier years. Therefore, the strength of these assessments has been rated as “very weak” in most cases, as shown above. The concern is not in the quality of the course or in the abilities of the students, but rather in the way assessment data are collected and recorded. In most cases, the assessments are done using rubrics, but the rubrics lack well-defined descriptors at each level of mastery. In addition, different instructors use the rubrics in different ways (leading to low validity and low reliability in the accreditation data). Overall grades for each deliverable (i.e. total grades resulting from the rubrics) were collected in the course and used in place of detailed data at the indicator level; as a result, multiple indicators assessed in one deliverable contaminated data (further reducing validity). These issues are easily addressed by bringing rigor to the MECH 45X course assessments, similar to the assessments in the design courses in years 1, 2, and 3. This process to review and revise the rubrics and their use in grading in the course is currently underway in time for the 2017/18 academic year.
2. The report rubric used in the MECH 328 (Mechanical Engineering Design Project) course was very detailed and produced histograms with a very pronounced peak in the “Meets Expectations” level; due to the increased assessment strength compared to MECH 30X (see next point), this peak dominates the results above for third year. While this does not necessary call the MECH 328 results into question, it is an unusual result and is being investigated.
3. The MECH 30X (Data Analysis and Mechanical Engineering Laboratories) course assessments vary by teaching assistant despite efforts to adopt a standard lab report evaluation rubric, similar to that used in MECH 221 and MECH 222. The MECH 30X course has been undergoing a review process, and is currently being redeveloped in time for January 2018. Consultations with the instructors responsible for the redevelopment have taken place, with an emphasis on adopting well-formed rubrics aligned to the graduate attribute indicators for investigation, similar to those in the second year labs.
4. The first year introduction to engineering course (APSC 101) currently assesses only Indicators 3.1 and 3.2. There may be natural opportunities within the course to expand assessment of deliverables to include Indicators 3.3 (Data Analysis), 3.4 (Data Synthesis), and/or 3.5 (Assess Results). This is being discussed with the APSC 100 and 101 teaching team.
5. The current student and alumni surveys indicate slightly higher proportions of self-ratings in the “marginal” category compared to the co-op employer survey data and our academic assessments. This may indicate that students and alumni do not feel confident in this attribute, even though instructors and employers view them as competent. This will be observed for the next continual improvement cycle to determine if this is a significant issue and/or if further action is needed.

1.7 *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:

Development and assessment of Design is focused on the major design courses in each year, although there are some design experiences in other courses. Design is introduced in the common first year (at level "I") through two new introduction to engineering courses (APSC 100 and 101), which include multiple open-ended design experiences. Through these courses, students are introduced to a generic design process, suitable for all engineering disciplines. The major design courses from second year to fourth year a share common design philosophy and nomenclature, and use many of the same design tools and references. In second year, through a large 7-credit design course (MECH 223, level "D"), the design process is further developed and tailored to mechanical engineering; in addition, the majority of design fundamentals to be used in third and fourth year courses are developed in this course. This course includes two major open-ended project experiences that begin with well-defined design specifications. Third year refines and expands the material from second year, with a focus on developing skill and fluency in analysis and embodiment (MECH 325 and 326, level "D"), and another major project (MECH 328, level "A"). The MECH 328 project is a paper design (due to time constraints), but delves deeply into the early stages of design, including identifying needs and setting target design specifications. In fourth year, the capstone design course (MECH 45X, level "A") provides the most complete design experience, with an opportunity for students to work through the entire design cycle from identifying needs through to producing a comprehensive physical prototype.

Table 8 below highlights the courses where Design is assessed for the purpose of graduate attributes and continual improvement.

Table 8. Curriculum Map for Attribute 4

Course	Title	Indicators	IDA	Details
APSC 100	Introduction to Engineering I	4.1, 4.3, 4.4, 4.5	I	Design course; includes two projects involving application of the design process to an open-ended problem.
APSC 101	Introduction to Engineering II	4.1, 4.4, 4.5, 4.7	I	Design course; includes three projects involving application of the design process to an open-ended problem.
MECH 223	Introduction to Mechanical Engineering Design	4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7	D	Design course; includes two major projects incorporating physical prototype development and testing used to inform design project decision making.
MECH 325	Mechanical Design I	4.6	D	Design course; focuses on detailed design and component selection, and includes three design projects where teams must select, size, and analyze mechanical components.
MECH 326	Mechanical Design II	4.6, 4.7	D	Design course; focuses on detailed design and analysis, and includes three design

				projects where teams must design various structures and components while considering fracture, fatigue, deflection, and use considerations.
MECH 328	Mechanical Engineering Design Project	4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7	A	Design course; focuses on one major project that covers the design process from needs identification to detailed design (but not build).
MECH 45X	Capstone Design Project	4.2, 4.3, 4.5, 4,6	A	Design course; focuses on one major project that covers the design process from needs identification to final prototype construction and testing.

Indicators:

A total of seven indicators were used to describe the design attribute; six of the indicators map directly to the design process model that we have adopted in Mechanical Engineering at [redacted] and one additional indicator (4.1) is used to describe the overall application of the process. Through a multi-year process, the indicators used for the design attribute were developed and refined by instructors teaching the above courses.

While seven indicators is a larger than usual number for one attribute, after extensive consultation amongst the design instruction team, it was felt this higher degree of resolution in the assessment data was warranted and valuable as part of the continual improvement process of our design courses. The indicators are

4.1 Use of Process: Adapt and apply a general iterative design process to develop devices, systems, or processes to address open-ended complex problems
4.2 Need and Constraint Identification: Identify and articulate stakeholder needs, and applicable constraints, including appropriate attention to health and safety risks, applicable standards, and economic, environmental, cultural and societal considerations
4.3 Problem Specification: Specify design requirements based on needs and constraints
4.4 Concept Generation: Produce a variety of potential design solutions suited to meet functional specifications
4.5 Concept Evaluation: Perform systematic evaluations of the degree to which several design concept options meet project criteria
4.6 Embodiment: Apply appropriate engineering knowledge, judgement, and tools in creating and implementing design solutions
4.7 Solution Assessment: Assess design performance based on requirements, needs, and constraints including appropriate attention to health and safety risks, applicable standards, and economic, environmental, cultural and societal considerations.

Indicators 4.1, 4.2, 4.3, and 4.7 are drawn directly from Attribute 4, while indicators 4.4, 4.5, and 4.6 are felt to be implicit in the attribute: "*An ability to design solutions (4.4, 4.5, 4.6) for complex, open-ended engineering problems and to design systems, components or processes (4.1) that meet specified needs (4.2, 4.3, 4.7) with appropriate attention to health and safety risks, applicable standards, and economic, environmental, cultural and societal considerations (4.2, 4.7).*" Indicators 4.4, 4.5, and 4.6 represent the divergent, convergent, and embodiment stages of design, respectively, and are felt to be implicit in the "ability to design solutions" aspect of the attribute.

Performance expectations (below expectations, marginal, meets expectations, and exceeds expectations) in each indicator are relative to the year level assessed. The descriptors in the detailed assessment rubrics in each course activity describe performance expectations by course and year (see next section for the rubrics used).

Assessment tools:

Assessment tools for Design are primarily deliverables from courses, as summarized in Table 9 below. The value preceding an assessment tool indicates the number of items of that type assessed in that course. These assessment tools were chosen due to the opportunity for authentic assessment (i.e. where students demonstrate the competency in a more real-world application), and the assessment tools (rubrics) were chosen due to their good reliability and validity compared to other assessment instruments. Through a multi-year (and still ongoing) process, rubrics and other assessment tools have been shared. However, as described in the "Assessment Results" section below, work is still progressing in harmonizing the assessment tools and data collection approaches. For non-rubric-based assessments of project deliverables, as discussed below, expectations are to transition to full adoption of rubrics over the coming academic years.

Table 9. Assessment Tools for Attribute 4

Year	Course	Assessment Tools	Indicators assessed						
			4.1	4.2	4.3	4.4	4.5	4.6	4.7
1	APSC 100	1 × poster presentation* (APSC100-M1-Rubric-Poster); 1 × final exam	✓		✓	✓	✓		
	APSC 101	1 × poster presentation* (APSC101-M5-Rubric-Poster); 2 × oral presentation* (APSC101-M6-Rubric-Pres, APSC101-M7-Rubric-Pres);	✓			✓	✓		✓
2	MECH 223	1 × project report* (MECH223-Rubric-Report.pdf); 2 × oral presentations* (MECH223-Rubric-Pres-1.pdf, MECH223-Rubric-Pres-2.pdf); 1 × design review meeting* (MECH223-Rubric-Review.pdf); 2 × midterm exams; 1 × final exam	✓	✓	✓	✓	✓	✓	✓
3	MECH 325	3 × course projects**; 1 × final exam						✓	
	MECH 326	3 × course projects* (MECH326-Rubric-Project.pdf); 1 × final exam						✓	✓
	MECH 328	1 × concept selection review* (MECH328-Rubric-Concept.xlxs); 1 × oral presentation* (MECH328-Rubric-Pres.pdf);	✓	✓	✓	✓	✓	✓	✓

		1 × final report* (MECH328-Rubric-Report.xlxs)							
4	MECH 45X	1 × project dossier** (MECH45X-Rubric-Dossier.pdf)		✓	✓		✓	✓	

* indicates the assessment was completed using a rubric and the name in parentheses is the associated rubric filename available for review;

** indicates a rubric was used to complete the assessment but detailed rubric data were not recorded; raw grades from the assessment tool were used to determine performance levels. (We are working to eliminate this practice by instructors and to record all rubric data directly, where possible.)

As shown above, all indicators describing the attribute are assessed; in Years 2 and 3 in particular, all indicators are assessed within the year. Assessment of all indicators also occurs in fourth year in MECH 45X, but data has not been properly captured from those assessments. Work is currently underway to improve assessment and data capture rigour in MECH 45X.

Assessment results:

Assessment data were collected for the above seven indicators and seven courses spanning the program. This resulted in a total of over 60 assessment points (24 assessment tools, each assessing one or more indicators). Although a large number of individual assessments, the assessment data were collected as part of normal course operation, and it was a small, incremental step to process and collate data to assess the attribute of Design.

(Continued)

Data are reported in Figure 16 below, sorted by indicator and academic year. See "Addendum 1: Data Analysis and Presentation" above for a description of the histogram grid, including descriptions of the histograms and assessment strength rating scale (○ ◔ ◑ ◕ ●).

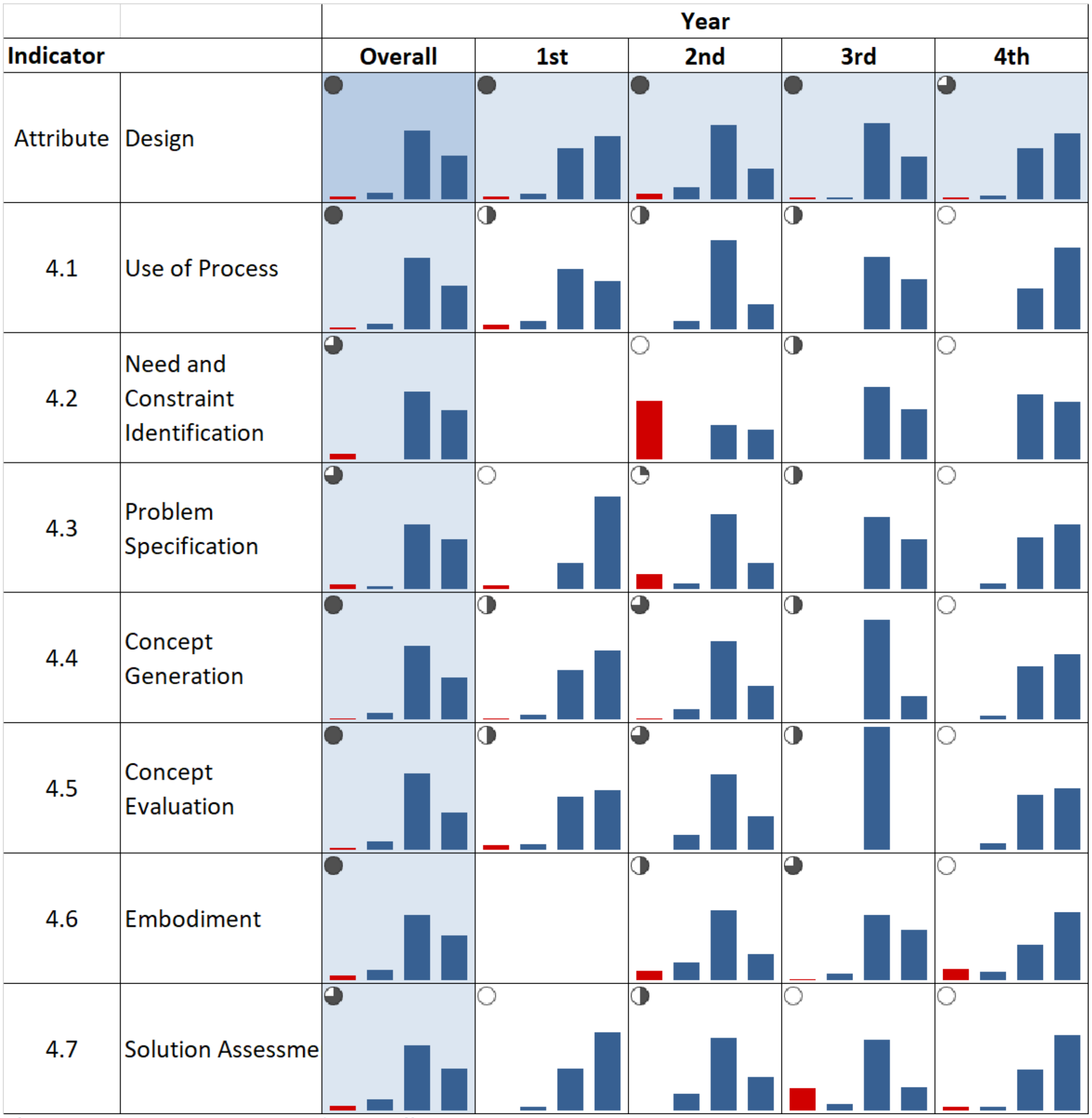


Figure 16. Assessment Data for Attribute 4

In Figure 17, the overall academic data—all indicators and years combined, as shown in the top-left cell from Figure 16 above—are compared below to survey data from current students, alumni, and co-op employers. See "Addendum 1: Analysis and Presentation" above for more information on data collection methods and interpretation of the data.

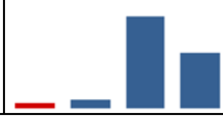
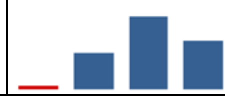
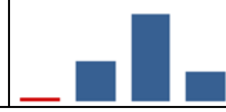
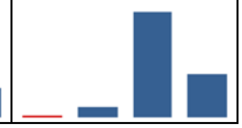
	Academic Data	Student Survey	Alumni Survey	Co-op Employer Survey
4 Design		82% 	80% 	89% 

Figure 17. Comparison to Survey Data for Attribute 4

As shown, there is good agreement across all assessments. Histograms from current students and alumni agree to approximately 80% with the histogram from our academic data, and the histogram from co-op employers agrees to almost 90%. Moreover, the general distributions look similar, although current students and alumni tend to have more “Marginal” ratings than either our ratings or the co-op employer findings show.

Overall, the data suggests program performance in terms of Design is satisfactory. At all year levels, and in all indicators, the majority of students are meeting or exceeding expectations. However, one second-year finding stands out: Indictor 4.2 (Need and Constraint Identification) of Year 2 shows a significant number of students appear to be performing below expectations. These data were collected through challenging midterm and final exam questions (not design experiences), and therefore the authenticity was low. In addition, students were time-pressured during the exams, so the reliability was also low. In contrast, assessments of this indicator in Years 3 and 4 based on authentic design project work do not show the same concern. Taken together, these circumstances suggest that the anomalies in second year data for Indicator 4.2 is due to the assessment tools used and not due to program performance or student ability. Overall, the data suggest curriculum changes to improve program performance in Design are not needed at this point.

In terms of data collection, there appears to be sufficient data overall. Assessment strength for all indicators and across all years is “strong” or “very strong.” Still, there are four concerns raised by the data above to be addressed in terms of data collection processes:

1. Data collection and analysis methods for fourth year (specifically MECH 45X) are under development, and, to date, lack the rigour of the other design-oriented courses at earlier years. Therefore, the strength of these assessments has been rated as “very weak” in most cases, as shown above. The concern is not in the quality of the course or in the abilities of the students, but rather in the way assessment data are collected and recorded. In most cases, the assessments are done using rubrics, but the rubrics lack well-defined descriptors at each level of mastery. In addition, different instructors use the rubrics in different ways (leading to low validity and low reliability in the accreditation data). In past years, overall grades for each deliverable (i.e. total grades resulting from the rubrics) were collected in the course and used in place of detailed data at the indicator level; as a result, multiple indicators assessed in one deliverable contaminated data (further reducing validity). These issues are easily addressed by bringing rigour to the MECH 45X course assessments, similar to the assessments in the design courses in years 1, 2, and 3. This process to review and revise the rubrics and their use in grading in the course is currently underway in time for the 2017/18 academic year.
2. The first year (APSC 100 and 101) and fourth year (MECH 45X) data show many students in the “exceeds expectations” category. In the first year courses, it is suspected this may be partly due to graders “marking generously,” even though they are working from rubrics with well-defined descriptors. In response, we are generating exemplar documents and providing additional marking guidelines in an attempt to improve the validity of measurements. If this does not address the issue, we will investigate further changes to

the rubric descriptor wording. For MECH 45X, this issue is believed to be due to the lack of rigour in the design and use of the rubrics; this issue is expected to be addressed through Item 1, above. If not, further steps will be taken to examine grading practices in MECH 45X (a course with historically high grades).

3. The report rubric used in the MECH 328 (Mechanical Engineering Design Project) course was very detailed and produced histograms with a very pronounced peak in the "Meets Expectations" level; this is particularly evident for Indicators 4.4 and 4.5. While this does not necessary call the MECH 328 results into question, it is an unusual result and is being investigated.
4. The current student and alumni surveys indicate slightly higher proportions of self-ratings in the "Marginal" category compared to the co-op employer survey data and our academic assessments. This may indicate that students and alumni do not feel confident in this attribute, even though instructors and employers view them as competent. This will be observed for the next continual improvement cycle to determine if this is a significant issue and/or if further action is needed.

1.8 *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:

Development and assessment of the Use of Engineering Tools attribute has been primarily focused on courses with major projects, since these have allowed significant opportunity for students to use various engineering tools. In two new introduction to engineering courses in first year (APSC 100 and 101, level "I"), students are exposed to CAD, digital fabrication, engineering graphics and microcontrollers. When they start second year in Mechanical Engineering, students work full time for four weeks in an intensive technical skills practicum course (MECH 220, level "D"), which rotates through four, 4-day modules on machining and fabrication, electronics and instrumentation, software (CAD and MATLAB), and engineering graphics. Students continue to use MATLAB to complete weekly computer labs in MECH 224 and 225 (both level "D" and, respectively, associated directly with the MECH 221 and 222 engineering science courses). Also in second year, students complete two major design projects in the 7-credit MECH 223 design course (level "I"); as part of this course they use software tools for simulation, optimization, CAD, and material selection. In third year, in MECH 326, students are introduced to finite element analysis as part of a two-week module in that course; they get FEA theory in the classroom, and complete one tutorial exercise and one project using ANSYS (level "D"). In their major third year design course project (MECH 328, level "D"), students complete a full paper design (i.e. no physical prototype), and, in the process, they generate engineering drawings and other visualizations, they specify and locate relevant components and materials for their design, they use simulation, analysis, and modelling to complete their detailed design, and they complete a prototype production, testing, and analysis forecast. In MECH 45X (level "A"), students complete a full design project in which they conduct patent searches and other research, conduct analyses and simulations, construct multiple functioning prototypes, and produce engineering drawings. This information is summarized in Table 10 below.

Table 10. Curriculum Map for Attribute 5

Course	Title	Indicators	IDA	Details
APSC 100	Introduction to Engineering I	5.3, 5.4	I	Design course; includes project on the use of CAD and digital fabrication technologies (3D printing, laser cutting, waterjet, cutting).
APSC 101	Introduction to Engineering II	5.1, 5.3	I	Design course; includes module on engineering graphics and microcontrollers.
MECH 220	Technical Skills Practicum	5.1, 5.3, 5.4, 5.5	D	Technical skills practicum course; uses four, full-time, four-day modules (drafting, CAD and software, instrumentation, and machining). As part of the course, students fabricate and assemble a functioning electromechanical device.

MECH 223	Integration of Engineering Concepts II	5.1, 5.3	I	Design course; includes two major projects requiring production of engineering drawings and the use of simulation, as well as computer labs in simulation and optimization.
MECH 224	Integration of Engineering Concepts I	5.3	D	Engineering science course; includes weekly computer labs done in MATLAB.
MECH 225	Integration of Engineering Concepts II	5.3	D	Engineering science course; includes weekly computer labs done in MATLAB.
MECH 326	Mechanical Design II	5.3	D	Design course; includes module on finite element analysis (FEA), with assignment and project completed on ANSYS.
MECH 328	Mechanical Engineering Design Project	5.1, 5.2, 5.3, 5.4, 5.5, 5.6	D	Design course; focuses on one major project that covers the design process and requires consideration and specification of all engineering tool indicators; teams do not construct prototypes but they outline prototype construction.
MECH 45X	Capstone Design Project	5.1, 5.2, 5.3, 5.4	A	Design course; focuses on one major project and requires patent searches and other research, modelling, creating engineering drawings, and construction of multiple functional prototypes.

In addition, there are many courses in third and fourth year which require the use software tools, but are not mentioned above. For example, MATLAB is used as an analysis tool in MECH 327, MECH 478, MECH 489, and more, to complete course objectives. As we continue to develop the graduate attributes data collection process, we will bring in data from these additional courses as appropriate.

Indicators:

Six indicators have been used to describe the Use of Engineering Tools attribute. The indicators were developed as part of a multi-year discussion between instructors responsible for the major design courses. The indicators are

5.1 Visual Representations: Produce clear sketches, diagrams, drawings, and visualizations, appropriate to the activity, in both physical and electronic form, using appropriate engineering tools
5.2 Information Retrieval: Locate, catalogue, and utilize relevant information, including patents and standards.
5.3 Modelling, Analysis, and Simulation: Select and use current tools for modelling, analysis, simulation, and synthesis
5.4 Fabrication and Prototyping: Select and use current tools for mechanical and electrical fabrication and prototyping
5.5 Testing and Evaluation: Select and use appropriate instrumentation and data acquisition systems, and analyzing and interpreting the resulting data

5.6 Appropriateness and Limitations of Tool Use: Appreciate the accuracy and limitations of such tools and the assumptions inherent in their use; verify the credibility of results achieved

Indicators 5.1 through 5.6 map directly to the CEAB definition of use of Engineering Tools: "*An ability to create, select, apply, adapt, and extend appropriate techniques (5.3, 5.4, 5.5), resources (5.2), and modern engineering tools (5.1, 5.3, 5.4, 5.5) to a range of engineering activities, from simple to complex, with an understanding of the associated limitations (5.6).*" Since the attribute does not specify what "modern engineering tools" are expected, Indicators 5.1 to 5.5 were developed through discussion and deliberation amongst the design course instructors based on engineering tools needed to complete typical engineering projects, as described above. Indicator 5.6 was seen to be an important element of the attribute not captured directly in the other indicators, and so it was added.

It is worth elaborating the thinking behind Indicator 5.1 (Visual Representations) due to the similarity with Indicator 7.5 from the Communication attribute. Indicator 5.1 is meant to capture competency in the *production* of visualizations—for example with hand drawings, CAD, flowcharts, and other electronic visualizations—and is distinct from Indicator 7.5 (Visual and Multi-modal Communication) which is meant to capture the *effectiveness* of communication through visualizations. To illustrate, a diagram could require effective and proficient use of a software tool and be technically well-produced (Indicator 5.1), but not be relevant or impactful for the communication at hand (Indicator 7.5). For these reasons, the two related aspects to visual communication have been treated as separate indicators.

Performance expectations (below expectations, marginal, meets expectations, and exceeds expectations) in each indicator are relative to the year level assessed. The descriptors in the detailed assessment rubrics in each course activity relate to performance expectations by course and year (see next section for the rubrics used).

Assessment tools:

Assessment tools for the Use of Engineering Tools are primarily deliverables from courses, as summarized in Table 11 below. The value preceding an assessment tool indicates the number of items of that type assessed in that course. These assessment tools were chosen due to the opportunity for authentic assessment (i.e. where students demonstrate competency in a more real-world application), and the assessment tools (rubrics) were chosen due to their good reliability and validity compared to other assessment instruments. For non-rubric-based assessments of design project deliverables, as discussed below, expectations are to transition to full adoption of rubrics over the coming academic years.

Table 11. Assessment Tools for Attribute 5

Year	Course	Assessment Tools	Indicators assessed					
			5.1	5.2	5.3	5.4	5.5	5.6
1	APSC 100	1 × final exam			✓	✓		
	APSC 101	1 × midterm exam; 1 × final exam	✓		✓			
2	MECH 220	1 × practicum Assignments; 1 × course project; 1 × final exam	✓		✓	✓	✓	
	MECH 223	2 × oral presentation* (MECH223-Rubric-Pres-1.pdf, MECH223-Rubric-Pres-2.pdf)	✓		✓			

		1 × project report* (MECH223-Rubric-Report.pdf); 1 × final exam						
	MECH 224	7 × computer labs			✓			
	MECH 225	6 × computer labs			✓			
3	MECH 326	1 × final exam			✓			
	MECH 328	1 × final report* (MECH328-Rubric-Report.xlxs)	✓	✓	✓	✓	✓	✓
4	MECH 45X	1 × project dossier** (MECH45X-Rubric-Dossier.pdf)	✓	✓	✓	✓		

* indicates the assessment was completed using a rubric and the name in parentheses is the associated rubric filename available for review;

** indicates a rubric was used to complete the assessment but detailed rubric data were not recorded; raw grades from the assessment tool were used to determine performance levels. (We are working to eliminate this practice by instructors and to record all rubric data directly, where possible.)

As shown above, all indicators describing the attribute are assessed in the program; however, there is limited assessment of Indicators 5.2 (Information Retrieval) and 5.6 (Appropriateness and Limitations in Tool Use). Development and use of all indicators for Attribute 5 occur in fourth year in MECH 45X, but not all indicators are currently assessed, and data have not been properly captured from all of the indicators that are assessed. Work is currently underway to improve assessment and data capture rigour in MECH 45X (see below).

(continued)

Assessment results:

Assessment data were collected for the above six indicators and nine courses spanning the program. This resulted in a total of 26 assessment tools each assessing approximately 2 indicators on average for a total of approximately 50 assessment points.

Data are reported below in Figure 18, sorted by indicator and academic year. See “Addendum 1: Data Analysis and Presentation” above for a description of the histogram grid, including descriptions of the histograms and assessment strength rating scale (○ ◔ ◑ ◕ ●).

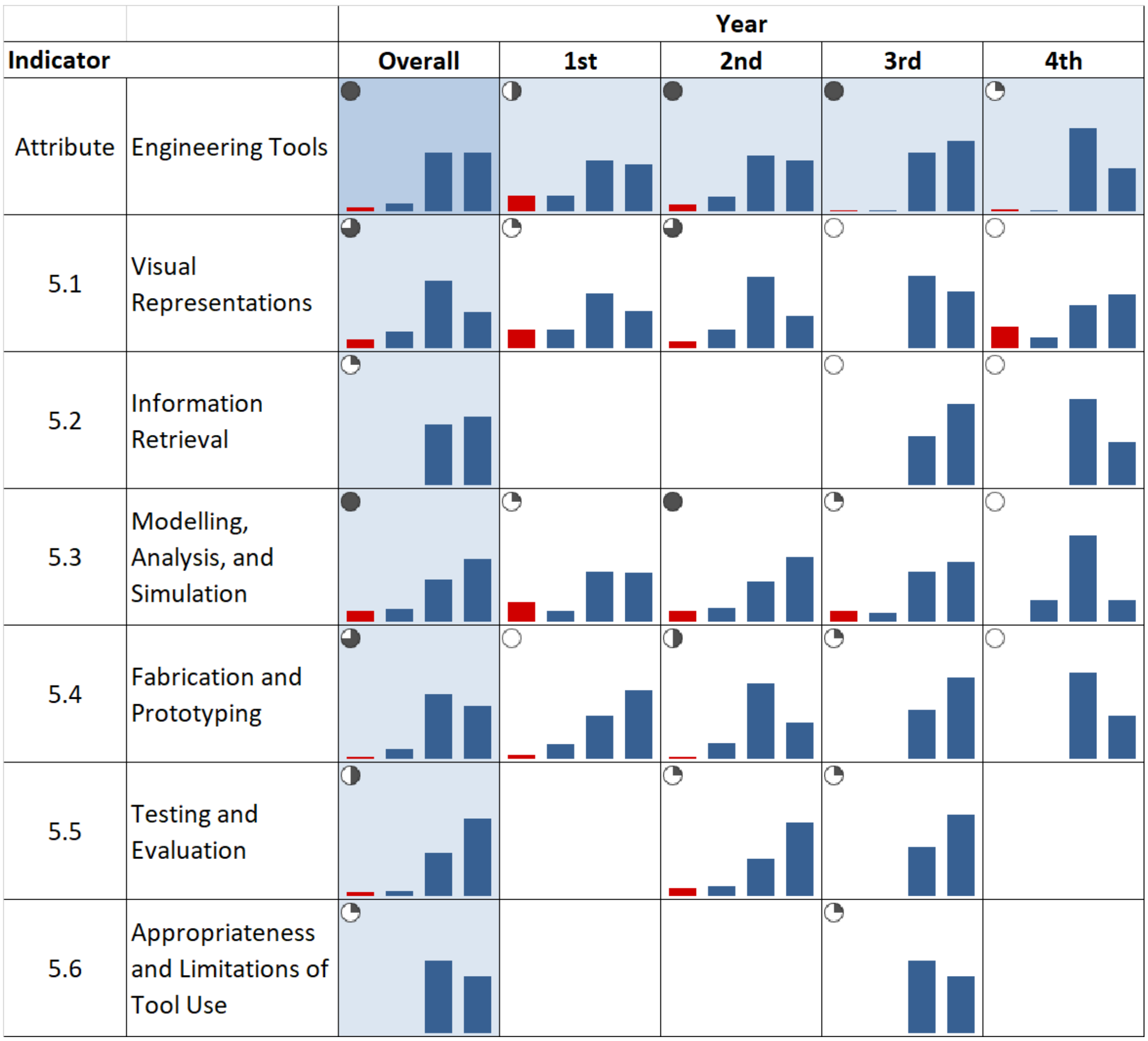


Figure 18. Assessment Data for Attribute 5

The overall academic data—all indicators and years combined, as shown in the top-left cell from Figure 18 above—are compared below to survey data from current students, alumni, and co-op employers in Figure 19. See “Addendum 1: Analysis and Presentation” above for more information on data collection methods and interpretation of the data.

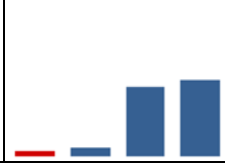
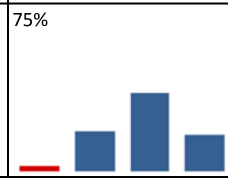
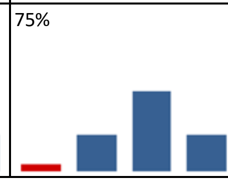
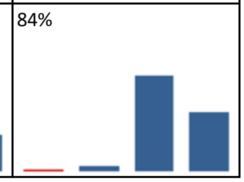
	Academic Data	Student Survey	Alumni Survey	Co-op Employer Survey
5 Engineering Tools				

Figure 19. Comparison to Survey Data for Attribute 5

Overall, the data does not raise major concerns in terms of program performance or student ability in the Use of Engineering Tools attribute. At all year levels and in all indicators, the majority of students are meeting or exceeding expectations. There appears to be a small sub-set of students who struggle with the ability to produce visual representations (Indicator 5.1) and to model, analyze, and simulate systems (Indicator 5.3). In both cases, these issues appear to span multiple courses and multiple years (Years 1, 2, and 4 in the case of Indicator 5.1, and Years 1, 2, and 3 in the case of 5.3). While these do not appear to be critical issues to the program at present, through this analysis they have both been identified to observed and investigate further over the next several years (as described further in Section 2 of this exhibit). In other respects, program performance appears to be satisfactory.

In terms of data collection, there appears to be sufficient data overall; however, there are several concerns raised above:

1. Assessment strength in Indicators 5.2 (Information Retrieval) and 5.6 (Appropriateness and Limitations of Tool Use) are "weak." Information retrieval is integral in all major project courses (MECH 223, MECH 328, and MECH 45X) but is not currently adequately assessed. Grading rubrics are currently under review in all three courses for the coming academic year, and efforts will be made to enhance the assessment of Indicator 5.2. Similarly, Indicator 5.6 is currently only assessed in MECH 328. Opportunities are being explored to include assessment in MECH 223, MECH 326, and MECH 45X for the coming academic year.
2. Assessment strength in Indicator 5.5 (Testing and Evaluation) is "adequate" and will be addressed in part in coming revisions to rubrics and data collection in MECH 45X. The MECH 30X lab course (not part of the assessment data above) is currently being redeveloped and will likely include experimental design and data acquisition components, both of which contribute to Indicator 5.5. There is active dialogue between the faculty members redeveloping MECH 30X and members working on accreditation to ensure rigorous integration of graduate attributes assessment in that course.
3. Considering fourth year more generally, data collection and analysis methods for MECH 45X are under development. The strength of these assessments has been rated as "very weak" in most cases, as shown above. The concern is not in the quality of the course or in the abilities of the students, but rather in the way assessment data are collected and recorded. In most cases, the assessments are done using rubrics, but the rubrics lack well-defined descriptors at each level of mastery. In addition, different instructors use the rubrics in different ways (leading to low validity and low reliability in the accreditation data). Overall grades for each deliverable (i.e. total grades resulting from the rubrics) were collected in the course and used in place of detailed data at the indicator level; as a result, multiple indicators assessed in one deliverable contaminated data (further reducing validity). These issues are easily addressed by bringing rigor to the MECH 45X course assessments, similar to the assessments in the design courses in years 1, 2, and 3. This process to review and revise the rubrics and their use in grading in the course is currently underway in time for the coming academic year.
4. The current student and alumni surveys indicate slightly higher proportions of self-ratings in the "Marginal" category compared to the co-op employer survey data and our academic assessments. A common student complaint for many years in focus group meetings held by

the Department is that students do not feel they are adequately trained in the specific software tools they use in co-op and in employment. This often turns to a philosophical discussion about what is the role of a university, and what is the responsibility of a student or an employer when it comes to detailed training of specific software tools. Our position has been that it is our role to develop ways of thinking and to train general understanding of software tools that can be transferred to different software packages. It is possible that this common student sentiment that there should be detailed training on specific software tools has influenced the survey results. Related to this, students often cite a need for proficiency in SolidWorks or AutoCAD as part of their co-op work placements. Until 2016/17, due to our involvement with the Partners for Advancement of Collaborative Engineering Education (PACE) Program, we used Siemens Unigraphics NX as our CAD package taught in MECH 220. In 2016/17, we transitioned to SolidWorks for this course, which also follows a change in first year engineering (APSC 100) which introduced training in CAD, and specifically SolidWorks. This may influence student perception of this attribute moving forward. In general, the above noted differences between student perception and academic assessment will continue to be observed, and it will be discussed at upcoming student focus group meetings.

1.9 *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:

Assessment of the Individual and Team Work attribute occurs in team-based courses with major design projects, since these have allowed significant opportunity for students to work together as well as being natural places to discuss team dynamics and individual working styles. In two new introduction to engineering courses in first year (APSC 100 and 101, level "I"), students work in class ("lecture") and studio time in teams, and they are responsible to complete six large projects together. Both courses draw heavily from the Team-Based Learning (TBL) pedagogical approach, and incorporate team quizzes as well as regular peer evaluation. The APSC 101 course also includes an introduction to team development theory, as well as a workshop-like session on implicit bias and stereotype threat. The MECH 223 and MECH 326 courses (both level "D"), are taught completely in the TBL approach, and also include team quizzes, team projects, and peer evaluation. The MECH 223 course includes two 2-hour workshops on team dynamics; the first focuses on personality type preferences and how those impact individual behaviour and team performance, and the second focuses on common team dysfunctions and how to address them. MECH 328 (level "D") is the major design project course in third year, and teams work closely with an assigned teaching assistant and instructor as they complete their project. Finally, MECH 45X (level "A") is the capstone design course, and is done in teams with peer evaluation as well as regular team debriefing sessions and reflections. This information is summarized in Table 12 below.

Table 12. Curriculum Map for Attribute 6

Course	Title	Indicators	IDA	Details
APSC 100	Introduction to Engineering I	6.2, 6.3	I	Design course; includes two team-based projects, reflections and peer-assessments of teammates, team quizzes.
APSC 101	Introduction to Engineering II	6.1, 6.2, 6.3	I	Design course; includes two team-based projects, reflections and peer-assessments of teammates, team quizzes; course topics include team development, implicit bias, stereotype threat.
MECH 223	Introduction to the Mechanical Design Process	6.1, 6.2, 6.3, 6.4, 6.5	D	Design course; includes two team-based projects, peer-assessments of teammates and opportunities to reflect and incorporate individual feedback from teammates, team quizzes; includes workshops on team dynamics.
MECH 326	Mechanical Design II	6.2, 6.3, 6.4, 6.5	D	Engineering science course; includes peer-assessments of teammates and opportunities to reflect and incorporate individual feedback from teammates
MECH 328	Mechanical Engineering Design Project	6.2, 6.3	D	Design course; includes one team-based project, peer-assessments of teammates and opportunities to reflect and

				incorporate individual feedback from teammates
MECH 45X	Capstone Design Project	6.1	A	Design course; includes one team-based project report, peer-assessments of teammates and opportunities to reflect and incorporate individual feedback from teammates

Indicators:

Five indicators have been used to describe the Individual and Team Work attribute. The indicators span core components of performance and engagement in team environments:

6.1 Appreciation of Team Diversity: Recognize a variety of working and learning preferences; appreciate the value of diversity on a team and strategically use team members' differing abilities
6.2 Team Communication: Communicate effectively and constructively with other team members, clients, supervisors, and other stakeholders; Reflect on team performance and provide appropriate feedback to all stakeholders
6.3 Responsibility: Assume responsibility for own work, participate equitably, and respond appropriately to feedback
6.4 Initiative: Exercise initiative and contribute to team goal-setting and goal-achieving
6.5 Leadership: Demonstrate team leadership while respecting others' roles; accept leadership roles of others

Indicator 6.5 maps explicitly to part of the CEAB definition of Individual and Team Work: *"An <u>ability to work effectively as a member and leader in teams</u> (6.5), preferably in a multi-disciplinary setting."* Indicators 6.1 through 6.4 represent key components of teamwork, and are felt to be implicit in the "[working] effectively as a member and leader in teams" aspect of the attribute.

Performance expectations (below expectations, marginal, meets expectations, and exceeds expectations) in each indicator are relative to the year level assessed. The descriptors in the detailed assessment rubrics in each course activity describe performance expectations by course and year (see next section for the rubrics used).

Assessment tools:

Assessment tools for the Individual and Teamwork attribute are heavily based on peer evaluations in team-based courses. Peer evaluation data are readily available and easy to collect and process, but the primary reason for using it is because it is more authentic than having an outside observer judge student performance in these indicators. An exception is in MECH 328, where a teaching assistant and instructor work closely with a few teams on a weekly basis and are able to observe and measure aspects such as communication and responsibility. In APSC 101 and MECH 223, individual and team work are part of the course content and aspects of this topic are assessed on exams. The assessment tools used are summarized in Table 13 below.

Table 13. Assessment Tools for Attribute 6

Year	Course	Assessment Tools	Indicators assessed				
			6.1	6.2	6.3	6.4	6.5
1	APSC 100	3 × Peer Evaluation* (APSC100-101-Rubric-PeerEval.pdf)		✓	✓		

	APSC 101	3 × Peer Evaluation* (APSC100-101-Rubric-PeerEval.pdf); 1 × final exam	✓	✓	✓		
2	MECH 223	7 × Peer Evaluation* (MECH223-Rubric-PeerEval.pdf); 1 × final exam	✓	✓	✓	✓	✓
3	MECH 326	3 × Peer Evaluation* (MECH326-Rubric-PeerEval.pdf)		✓	✓	✓	✓
	MECH 328	3 × weekly report* (MECH328-Rubric-Weekly.xlxs); 1 × concept review* (MECH328-Rubric-Concept.xlxs; 1 × final report* (MECH328-Rubric-Report.xlxs)		✓	✓		
4	MECH 45X	1 × project dossier** (MECH45X-Rubric-Dossier.pdf)	✓				

* indicates the assessment was completed using a rubric and the name in parentheses is the associated rubric filename available for review;

** indicates a rubric was used to complete the assessment but detailed rubric data were not recorded; raw grades from the assessment tool were used to determine performance levels. (We are working to eliminate this practice by instructors and to record all rubric data directly, where possible.)

In MECH 328 and 45X (as well as MECH 325, not listed), students complete peer evaluations using the same tool as in the other courses listed; however, the method of evaluation used in this case did not lend itself to usable graduate attributes data. This issue will be addressed for this coming academic year by shifting MECH 325, 328, and 45X to the same peer evaluation rubric as the other courses.

Assessment results:

Assessment data were collected for the above five indicators and six courses spanning the program. This resulted in a total of over 24 assessment tools each assessing roughly two indicators on average (for a total of approximately 60 assessment points).

(continued)

Data are reported below in Figure 20, sorted by indicator and academic year. See "Addendum 1: Data Analysis and Presentation" above for a description of the histogram grid, including descriptions of the histograms and assessment strength rating scale (○ ◔ ◑ ◕ ●).

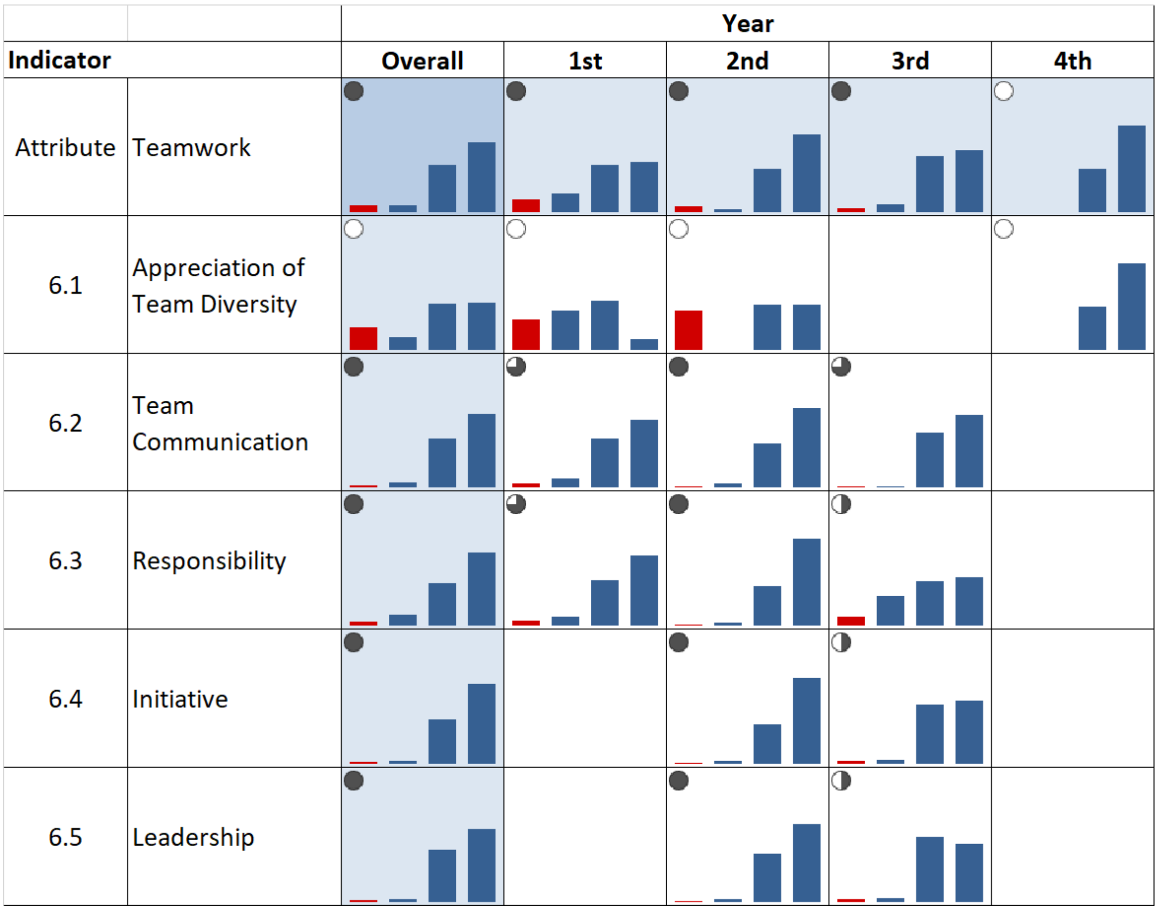


Figure 20. Assessment Data for Attribute 6

The overall academic data—all indicators and years combined, as shown in the top-left cell from Figure 20 above—are compared below to survey data from current students, alumni, and co-op employers in Figure 21. See "Addendum 1: Analysis and Presentation" above for more information on data collection methods and interpretation of the data.

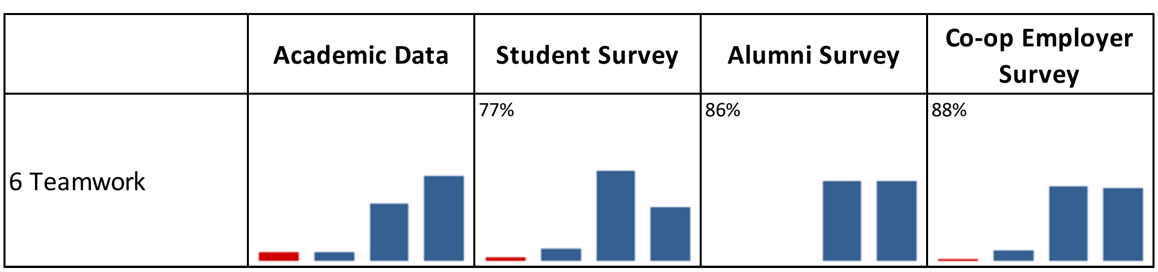


Figure 21. Comparison to Survey Data for Attribute 6

The data for Indicators 6.2 through 6.5 look favourable, and appear relatively consistent from year to year. The data for Indicator 6.1 (Appreciation of Team Diversity) is concerning, at least in Years 1 and 2; however, this data was collected from embedded questions on final exams in

APSC 101 and MECH 223, meaning the assessments lacked authenticity. In addition, the indicator is most strongly aligned with development in the affective domain (appreciation), yet the exam questions were better suited to assessing the cognitive domain (comprehension). This reduces the validity of the results. In short, the observed data for Indicator 6.1 is of concern but there are also significant questions in terms of how trustworthy the data are. As an outcome from this analysis, this finding will go back to the Curriculum Committee (i.e. our graduate attributes committee) this year for further discussion. In addition, there is a mildly concerning result in 3rd year for Indicator 6.3 (Responsibility) as a larger number of students scored in the "marginal" category compared to other years and indicators. We will continue to monitor this finding.

There is generally strong agreement between our academic assessments and with survey results reported by current students, alumni, and co-op employers. Our academic assessments tend to have more students in the "exceeds expectations" category, as well as more students in the "below expectations" category. This will be something we will continue to observe in the coming years.

In terms of data collection, there appears to be sufficient data overall for Indicators 6.2 to 6.5, and for Year 1 to Year 3. The concerns with the data collection are as follows:

1. As mentioned previously for other attributes, the data collection and analysis methods for MECH 45X were inadequate. Students use and develop all indicators shown in the MECH 45X course, but only the first is assessed, and even that is rated as a "very weak" assessment. The concern is not in the quality of the course or in the abilities of the students, but rather in the way assessment data are collected and recorded. The rubrics in MECH 45X are currently being reviewed and redeveloped in time for the coming academic year.
2. The MECH 325, 328, and 45X courses did not use the rubric-based peer evaluation system that was used in APSC 100, APSC 101, MECH 223, and MECH 326 to generate the data shown from those courses. Discussions have already occurred to ensure the rubric-based peer evaluation system is put in place in MECH 325, 328, and 45X in time for this coming academic year.

1.10 *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:

Assessment of Communication has been primarily focused on courses with significant communications deliverables as part of laboratory or project work (e.g. reports, presentations, posters, etc.). The reason for selecting these courses has been to engage, as much as possible, in authentic assessments where the communication material produced is part of a larger engineering activity. These include assessment of written materials, posters, oral presentations, and visualizations in the first year introduction to engineering courses (APSC 100 and 101, both level "I"), the second year design course (MECH 223, level "D"), the third year design course (MECH 328, level "D"), and the forth year design course (MECH 45X, level "A"). In addition, there is the assessment of written lab reports in second year lab courses (MECH 224 and 225, both level "I"), and the third year lab course (MECH 30X, level "D"). Reading ability is assessed through reading quizzes as part of Team-Based Learning courses (MECH 223, 325, and 326, all level "D").

Table 14 below highlights the courses where Communication is assessed for the purpose of graduate attributes and continual improvement.

Table 14. Curriculum Map for Attribute 7

Course	Title	Indicators	IDA	Details
APSC 100	Introduction to Engineering I	7.1, 7.2, 7.5	I	Design course; includes project with a poster presentation, project with oral presentation, project with a technical memo, personal letter, and instruction on communication frameworks.
APSC 101	Introduction to Engineering II	7.1, 7.2, 7.5	I	Design course; includes project with poster, two projects with oral presentations, business letter, and project proposal.
MECH 221	Engineering Science I	7.1, 7.5	I	Engineering science course; includes 8 physical laboratory experiences prepared in a semi-formal lab report format
MECH 222	Engineering Science II	7.1, 7.5	I	Engineering science course; includes 5 physical laboratory experiences prepared in a semi-formal lab report format
MECH 223	Introduction to the Mechanical Design Process	7.1, 7.2, 7.3, 7.4, 7.5	D	Design course; includes two major projects incorporating two oral presentations, two poster presentations, and one technical report; reading ability assessed through six reading quizzes
MECH 226	Technical Communication	7.1, 7.2,	D	Communications course integrated with MECH 221-225; includes various written documents and presentations

	for Mechanical Engineers			
MECH 30X	Data Analysis and Mechanical Engineering Laboratories	7.1	D	Statistics and laboratory course; includes 13 laboratory experiences requiring formal lab reports
MECH 325	Mechanical Design I	7.3	D	Design course; reading ability assessed through five reading comprehension quizzes
MECH 326	Mechanical Design II	7.1, 7.3	D	Design course; three design reports; reading ability assessed through five reading comprehension quizzes
MECH 328	Mechanical Engineering Design Project	7.1, 7.2, 7.3, 7.4, 7.5	D	Design course; focuses on one major project including weekly reports, oral presentations, background research, and weekly meetings.
MECH 45X	Capstone design Project	7.1, 7.2	A	Design course; focuses on one major project where teams communicate with stakeholders, faculty members, and peers through written and oral forms.

Indicators:

Five indicators have been used to describe the Communications attribute. The indicators were developed through extensive consultation between design and communications faculty members, and were based on the different forms of communication expected of our graduates.

7.1 Writing: Produce clear and well-constructed documents in a variety of professional genres
7.2 Presenting: Construct and deliver effective multi-modal presentations to technical and non-technical audiences, including society at large, in a variety of scenarios and genres
7.3 Reading: Read, understand, interpret, and synthesize technical and non-technical information
7.4 Speaking and listening: Participate effectively in oral exchanges with technical and non-technical personnel; understand, evaluate, synthesize, and share information
7.5 Visual and multi-modal communication: Produce effective visual and multi-modal representations of complex engineering concepts

Indicators 7.1, 7.3, and 7.4 map directly to the CEAB definition of Attribute 7: "*An ability to communicate complex engineering concepts within the profession and with society at large. Such ability includes <u>reading</u> (7.3), <u>writing</u> (7.1), <u>speaking and listening</u> (7.4), and the ability to comprehend and <u>write effective reports and design documentation</u> (7.1) and to <u>give and effectively respond to clear instructions</u> (7.4)." Indicator 7.2 was added as a specialized communication skill that goes beyond simply speaking and also integrates body language, audio and visual elements, and so on into a formal delivery (such as in oral presentations, poster presentations, pitches, and such). Indicator 7.5 was added to capture the emerging need for visual and multi-modal forms of communication (e.g. graphics, animations, video, websites, etc.).*

It is worth elaborating the thinking behind Indicator 7.5 (Visual and Multi-Modal Communication) due to the similarity with Indicator 5.1 (Visual Representations) in the Use of Engineering Tools attribute. Indicator 7.5 (Visual and Multi-modal Communication) is meant to capture the *effectiveness* of communication through visualizations, and is distinct from Indicator 5.1, which is meant to capture competency in the *production* of visualizations using engineering tools—for example with CAD or other software packages. To illustrate, a diagram could require effective and proficient use of a software tool and be technically well-produced (Indicator 5.1), but not be relevant or impactful for the communication at hand (Indicator 7.5). For these reasons, the two related aspects to visual communication have been treated as separate indicators.

Performance expectations (below expectations, marginal, meets expectations, and exceeds expectations) in each indicator are relative to the year level. The descriptors of the detailed assessment rubrics for each course activity indicate performance expectations in each course and year.

Assessment tools:

Assessment tools for Communication are primarily deliverables from courses, as summarized in Table 15 below. The value preceding an assessment tool indicates the number of items of that type assessed in that course.

Table 15. Assessment Tools for Attribute 7

Year	Course	Assessment Tools	Indicators assessed				
			7.1	7.2	7.3	7.4	7.5
1	APSC 100	1 × poster* (APSC100-M1-Rubric-Poster.pdf); 2 × personal letters; 1 × technical memorandum; 1 × final exam	✓	✓			✓
	APSC 101	1 × poster* (APSC101-M5-Rubric-Poster.pdf); 1 × business letter; 2 × oral presentations (APSC101-M6-Rubric-Pres.pdf, APSC101-M7-Rubric-Pres.pdf)	✓	✓			✓
2	MECH 221	8 × lab reports* (MECH221-222-Rubric-Lab)	✓				✓
	MECH 222	5 × lab reports* (MECH221-222-Rubric-Lab)	✓				✓
	MECH 223	1 × project report* (MECH223-Rubric-Report.pdf); 2 × oral presentations* (MECH223-Rubric-Pres-1.pdf, MECH223-Rubric-Pres-2.pdf); 6 × readiness assurance (i.e. reading) quizzes; 2 × poster presentations* (MECH223-Rubric-Poster.pdf)	✓	✓	✓	✓	✓
	MECH 226	1 × technical description**; 1 × project report**; 1 × process description**; 1 × informal report**;	✓	✓			

		1 × oral presentation**; 1 × poster presentation**					
3	MECH 30X	13 × lab report	✓				
	MECH 325	5 × readiness assurance (i.e. reading) quiz			✓		
	MECH 326	3 × technical report* (MECH326-Rubric-Project.pdf) 5 × readiness assurance (i.e. reading) quiz	✓		✓		
	MECH 328	4 × weekly report* (MECH328-Rubric-Weekly.xlxs); 1 × final report* (MECH328-Rubric-Report.xlxs); 1 × concept selection review* (MECH328-Rubric-Concept.xlxs); 1 × oral presentation (MECH328-Rubric-Pres.pdf)	✓	✓	✓	✓	✓
4	MECH 45X	1 × project dossier** (MECH45X-Rubric-Dossier.pdf)	✓	✓			

* indicates the assessment was completed using a rubric and the name in parentheses is the associated rubric filename available for review;

** indicates a rubric was used to complete the assessment but detailed rubric data were not recorded; raw grades from the assessment tool were used to determine performance levels. (We are working to eliminate this practice by instructors and to record all rubric data directly, where possible.)

The above assessment tools were chosen due to the opportunity for authentic assessment (i.e. where students demonstrate the competency in a more real-world application), and the assessment tools (rubrics) were chosen due to their good reliability and validity compared to other assessment instruments. For non-rubric-based assessments of lab and project deliverables (e.g. lab reports, project presentations, etc.), as discussed below, expectations are to transition to full adoption of rubrics over the coming academic years.

Assessment results:

Assessment data were collected for the above five indicators and 11 courses spanning the program. This resulted in a total of over 70 assessment tools each assessing between one and two indicators on average (for a total of approximately 120 assessment points). Although this is a large number of individual assessments, the assessment data were collected as part of normal course operation, and it was a small, incremental step to process and collate data to assess the Communication attribute.

(continued)

Data are reported below in Figure 22, sorted by indicator and academic year. See "Addendum 1: Data Analysis and Presentation" above for a description of the histogram grid, including descriptions of the histograms and assessment strength rating scale (○ ◔ ◑ ◕ ●).

Indicator		Year				
		Overall	1st	2nd	3rd	4th
Attribute	Communication	●	●	●	●	◔
7.1	Writing	●	◕	●	●	○
7.2	Presenting	●	◕	◕	◑	○
7.3	Reading	●		◕	●	
7.4	Speaking and listening	◑		◔	◑	
7.5	Visual and multi-modal communication	●	◑	●	○	

Figure 22. Assessment Data for Attribute 7

In Figure 23, overall academic data—all indicators and years combined, as shown in the top-left cell from Figure 22 above—are compared below to survey data from current students, alumni, and co-op employers. See "Addendum 1: Analysis and Presentation" above for more information on data collection methods and interpretation of the data.

	Academic Data	Student Survey	Alumni Survey	Co-op Employer Survey
7 Communication		87%	95%	85%

Figure 23. Comparison to Survey Data for Attribute 7

Overall, the data does not raise major concerns in terms of program performance or student ability in the Communication attribute. At all year levels and in all indicators, the majority of students are meeting or exceeding expectations. Furthermore, at no year level does an individual indicator reach a point of concern in terms of proportions of students in the “below expectations” or “marginal” categories. There is generally very strong agreement between our academic assessments and with survey results reported by current students, alumni, and co-op employers.

In terms of data collection, there appears to be sufficient data overall and with each indicator; however, there are three main concerns raised above:

1. Considering fourth year, and MECH 45X specifically, as mentioned previously, data collection and analysis methods were inadequate but are currently being reviewed and revised. The strength of these assessments has been rated as “very weak” in the two indicators assessed, as shown above. The concern is not in the quality of the course or in the abilities of the students, but rather in the way assessment data are collected and recorded. In most cases, the assessments are done using rubrics, but the rubrics lack well-defined descriptors at each level of mastery. In addition, different instructors use the rubrics in different ways (leading to low validity and low reliability in the accreditation data). Overall grades for each deliverable (i.e. total grades resulting from the rubrics) were collected in the course and used in place of detailed data at the indicator level; as a result, multiple indicators assessed in one deliverable contaminated data (further reducing validity). These issues are easily addressed by bringing rigor to the MECH 45X course assessments, similar to the assessments in the design courses in years 1, 2, and 3. This process to review and revise the rubrics and their use in grading in the course is currently underway in time for the coming academic year.
2. Related to the previous point, work is underway in MECH 45X to expand the indicators assessed to include most, in not all, of the indicators for the Communication attribute.
3. Additional data from the MECH 226/7 (technical communications) course will be available starting in the coming academic year for a written proposal, an oral presentation, a poster presentation, and a written report. This will add data from assessments of individuals to complement (or replace) the team-based assessments already used.
4. The assessments from third year for Indicators 7.1 (Writing), 7.2 (Presentation), and 7.5 (Visual and Multimodal Communication) show pronounced peaks at the “meets expectations” category and little differentiation in performance. In part, this appears to be a result of the detailed report rubric used in the MECH 328 (Mechanical Engineering Design Project) course, but it may also be due to the grading practices in MECH 30X (Data Analysis and Engineering Laboratories). The MECH 328 rubrics are currently being reviewed, and the MECH 30X course is being redeveloped for this coming academic year. As part of this work, steps will be taken to investigate possible causes for the results shown, and, if necessary, corrective action will be taken. To emphasize, the data seem unusual and will be investigated, but they do not suggest any concerns regarding the quality of the program or the abilities of the students.

1.11 *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:

Assessment of Professionalism has been primarily focused on courses with significant team project components, since these have allowed significant opportunity for students to work together and take on tasks most similar to those of practicing engineers. In two new introduction to engineering courses in first year (APSC 100 and 101, level "I"), students are introduced to the engineering profession, including Codes of Ethics (both for [redacted] and [redacted] Engineering), as well as the role of engineers in society. These courses have a significant team project component which allows regular peer evaluation of professional behaviour within the team setting, and professional behaviour is also assessed in formal oral presentations. The MECH 223 and MECH 326 courses (both level "D"), are taught completely in the TBL approach, and include peer evaluation of professional behaviour within the team. The MECH 223 course also includes components of professional practice and intellectual property, as well as assessments of professional behaviour during oral and poster presentations, meetings, and design reviews. MECH 328 (level "D") is the major design project course in third year, and teams work closely with an assigned teaching assistant and instructor as they complete their project. It includes a module on regulations, codes, and standards. Finally, MECH 45X (level "A") is the capstone design course, and is done in teams. Teams participate in regular meetings and must consider regulations, codes, and standards in their projects. This information is summarized in Table 16 below.

Table 16. Curriculum Map for Attribute 8

Course	Title	Indicators	IDA	Details
APSC 100	Introduction to Engineering I	8.1, 8.2	I	Design course; includes introduction to the engineering profession, engineering codes of ethics, and assessment of professional behaviour within teams.
APSC 101	Introduction to Engineering II	8.2	I	Design course; includes assessment of professional behaviour within teams.
MECH 223	Introduction to Mechanical Engineering Design	8.2, 8.3, 8.5	D	Design course; module on intellectual property and assessment of professional behaviour within teams.
MECH 326	Mechanical Design II	8.2	D	Design course; includes assessment of professional behaviour within teams.
MECH 328	Mechanical Engineering Design Project	8.2, 8.4	D	Design course; includes module on codes, standards, and regulations, as well as assessment of professional behaviour at regular meetings.
MECH 45X	Capstone Design Project	8.3, 8.4	A	Design course; includes assessment of treatment of codes, standards, and regulations in project as well as professional behaviour within teams.

Indicators:

A total of five indicators were chosen to describe Professionalism:

8.1 Role of Engineering: Describe and value the role of protection of the public and public interest in decision making
8.2 Professional Behaviour: Demonstrate punctuality, responsibility and appropriate communication etiquette
8.3 Meeting Participation: Prepare material for meetings; lead and participate actively in meetings; help to generate ideas
8.4 Integration of Regulations, Codes, and Standards: Integrate standards, codes of practice, and legal and regulatory factors into engineering work
8.5 Intellectual Property: Demonstrate awareness of intellectual property and confidentiality matters in engineering practice and act appropriately

The indicators for Attribute 8 were developed through a multi-year consultation process between instructors responsible for the major design courses. Indicator 8.1 is drawn directly from the attribute description: "*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 (8.1).*" Indicators 8.2 to 8.5 we added to represent more specific qualities and expectations felt to be implicit in "the roles and responsibilities of the professional engineer" aspect of the attribute.

A proposal to revise these indicators for the 2017/18 academic year is currently under review. The proposed change is to drop Indicator 8.3 (Meeting Participation) since it extensively overlaps indicators from the Individual and Team Work attribute. This is described further below and in Section 2, Continual Improvement.

Performance expectations (below expectations, marginal, meets expectations, and exceeds expectations) in each indicator are relative to the year level. The descriptors of the detailed assessment rubrics for each course activity indicate performance expectations in each course and year.

Assessment tools:

Assessment tools for Professionalism are primarily peer evaluations, assessments of instructors and TAs sitting in on team meetings, and some exam-based assessments. All have been drawn from major project-based courses, and include the following. These are summarized in Table 17. The value preceding an assessment tool indicates the number of items of that type assessed in that course.

Table 17. Assessment Tools for Attribute 8

Year	Course	IDA	Assessment Tools	Indicators assessed				
				8.1	8.2	8.3	8.4	8.5
1	APSC 100	I	1 × quiz questions; 3 × peer evaluations* (APSC100-101-Rubric-PeerEval.pdf)	✓	✓			
	APSC 101	I	3 × peer evaluations* (APSC100-101-Rubric-PeerEval.pdf); 2 × oral presentations* (APSC101-M6-Rubric-		✓			

			Pres.pdf; APSC101-M7-Rubric-Pres.pdf);					
2	MECH 223	D	2 × oral presentation* (MECH223-Rubric-Pres-1.pdf; MECH223-Rubric-Pres-2.pdf); 2 × poster presentation* (MECH223-Rubric-Poster.pdf); 1 × design review* (MECH223-Rubric-Review.pdf); 7 × peer evaluations (MECH223-Rubric-PeerEval.pdf); 5 × weekly design meetings* (MECH223-Rubric-Logbook.pdf); 1 × Final exam		✓	✓		✓
3	MECH 326	D	3 × peer evaluation* (MECH326-Rubric-PeerEval.pdf)		✓			
	MECH 328	D	1 × oral presentation* (MECH328-Rubric-Pres.xlxs); 1× concept review presentation* (MECH328-Rubric-Concept.xlxs)		✓		✓	
4	MECH 45X	A	1 × project dossier** (MECH45X-Rubric-Dossier.pdf)			✓	✓	

* indicates the assessment was completed using a rubric and the name in parentheses is the associated rubric filename available for review;

** indicates a rubric was used to complete the assessment but detailed rubric data were not recorded; raw grades from the assessment tool were used to determine performance levels. (We are working to eliminate this practice by instructors and to record all rubric data directly, where possible.)

The above assessment tools were chosen due to the opportunity for authentic assessment (i.e. where students demonstrate the competency in a more real-world application), and the assessment tools (rubrics) were chosen due to their good reliability and validity compared to other assessment instruments. For non-rubric-based assessments of some project deliverables (e.g. dossiers, etc.), as discussed below, expectations are to transition to full adoption of rubrics over the coming continuous improvement cycles.

Assessment results:

Assessment data were collected for the above five indicators and six courses spanning all years of the program. This resulted in a total of over 33 assessment tools each assessing roughly one indicator on average (for a total of approximately 38 assessment points). The assessment data were collected as part of normal course operation, and it was a small, incremental step to process and collate data to assess the Professionalism attribute.

Data are reported in Figure 24 below, sorted by indicator and academic year. See "Addendum 1: Data Analysis and Presentation" above for a description of the histogram grid, including descriptions of the histograms and assessment strength rating scale (◯ ◔ ◑ ◕ ●).

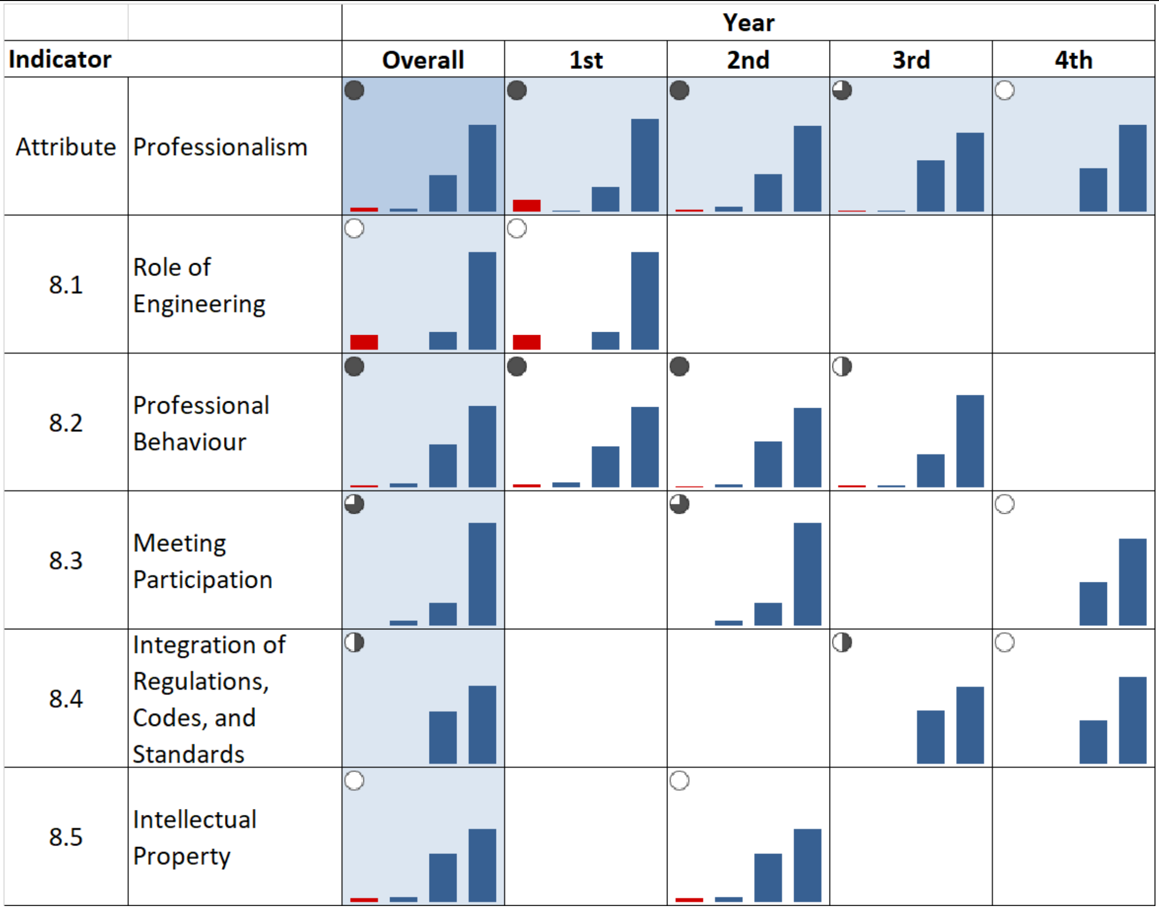


Figure 24. Assessment Data for Attribute 8

The overall academic data—all indicators and years combined, as shown in the top-left cell from Figure 24 above—are compared below to survey data from current students, alumni, and co-op employers in Figure 25. See "Addendum 1: Analysis and Presentation" above for more information on data collection methods and interpretation of the data.

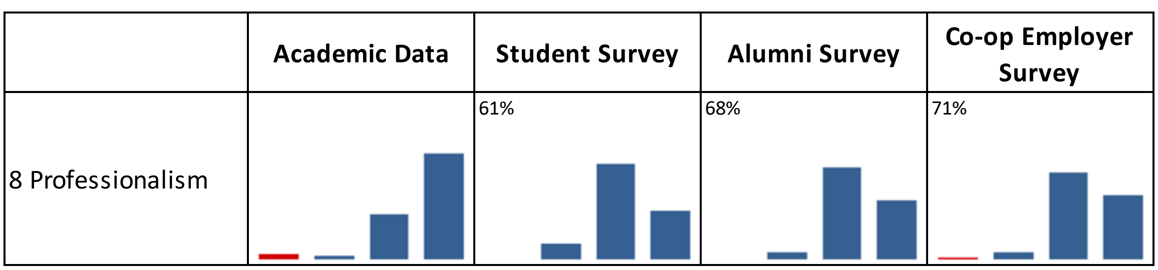


Figure 25. Comparison to Survey Data for Attribute 8

Overall, the data does not raise major concerns in terms of program performance or student ability in the Professionalism attribute. At all year levels and in all indicators, the majority of students are meeting or exceeding expectations. The first year assessment of the role of engineering does show a larger than usual group of students at the "below expectations" level, but this data was collected through quizzes and exams (i.e. neither authentic or highly reliable assessment). In comparing the academic assessments with survey results reported by current students, alumni, and co-op employers, there is fair agreement. Our academic assessments suggest we see the students performing better in this attribute than students, alumni, or employers report. Both of these issues—the larger than usual number of students at the "below expectations" category of Indicator 8.1 in Year 1 and the lack of strong agreement between academic and survey data—may be due to a lack of data, and are addressed further below.

In terms of data collection, there is significantly less data overall than for most other attributes, as witnessed by the larger than usual number of empty cells in the assessment results table. This lack of data may be a contributing factor to the two issues noted above; regardless, more data are needed before making any decisions on curriculum changes. Some specific observations and planned actions for this attribute are listed below.

1. Having now collected and analyzed extensive data for this attribute, it has become clear that Indicator 8.3 (Meeting Participation) includes elements of Indicators 6.2 (Communication), 6.3 (Responsibility), 6.4 (Initiative), and 6.5 (Leadership). Through a recent joint meeting between the Curriculum Committee and Design Course Committee, it has been decided that Indicator 8.3 is redundant and will be dropped in future. This is discussed further in Section 2, Continual Improvement.
2. The academic data for all indicators and years show similar performance, with the majority of students at the "exceeds expectations" performance level. This is in contrast to the student, alumni, and employer survey data. This suggests that, in addition to reviewing the quality of assessment data, we may need to examine our expectations and/or grading practices for this attribute. This topic will be discussed at an upcoming meeting of the Curriculum Committee, as well as with students at the next student focus group meeting.
3. Considering fourth year, and MECH 45X specifically, as mentioned previously, data collection and analysis methods were inadequate but are currently being reviewed and revised. The strength of these assessments has been rated as "very weak" in the two indicators assessed, as shown above. The concern is not in the quality of the course or in the abilities of the students, but rather in the way assessment data are collected and recorded. In most cases, the assessments are done using rubrics, but the rubrics lack well-defined descriptors at each level of mastery. In addition, different instructors use the rubrics in different ways (leading to low validity and low reliability in the accreditation data). Overall grades for each deliverable (i.e. total grades resulting from the rubrics) were collected in the course and used in place of detailed data at the indicator level; as a result, multiple indicators assessed in one deliverable contaminated data (further reducing validity). These issues are easily addressed by bringing rigor to the MECH 45X course assessments, similar to the assessments in the design courses in years 1, 2, and 3. This process to review and revise the rubrics and their use in grading in the course is currently underway in time for the coming academic year.
4. Related to the previous point, work is underway in MECH 45X to expand the indicators assessed to include Indicators 8.2 (Professional Behaviour) and 8.5 (Intellectual Property)
5. Efforts are underway to collect data from the faculty-wide APSC 450 (Professional Engineering Practice). Some data was collected in this course, but was not processed in time for this exhibit.

1.12 *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:

Assessment of the Impact of Engineering has been primarily focused on courses where there is instruction on the topic, and on senior design project courses where considerations of impact are expected of the student teams. In two new introduction to engineering courses in first year (APSC 100 and 101, level "I"), students are introduced to sustainability principles and management techniques. The MECH 223 design course in second year directly scored sustainability performance in two major projects, but this was done in the way that made it difficult to gather any meaningful data for assessment of this attribute, and therefore no data was collected (i.e. teams could have chosen to favour functionality, reliability, personal workload or other factors over sustainability scoring elements, which does not mean they do not have ability in this attribute). Even though it is not a compulsory course, CIVL 200 (level "A") was added since it is taken by a large percentage of Mechanical Engineering students (56/112, 50%, in the 2017 graduating class selected this specific elective course to fulfil their Impact of Technology on Society complementary studies requirement; the next most popular course had 10 students, 9%). MECH 328 (level "D") is the major design project course in third year, and teams must consider many elements related to the impact of engineering (including legal requirements, impacts of people, sustainability, and management techniques). MECH 431 (level "D") is an engineering economics course with a large project that requires treatment of sustainability. Finally, MECH 45X (level "D") is the capstone design course that requires considerations of sustainability in the projects. This information is summarized in Table 18 below.

Table 18. Curriculum Map for Attribute 9

Course	Title	Indicators	IDA	Details
APSC 100	Introduction to Engineering I	9.3	I	Design course; includes one module on engineering decision-making based on sustainability; stakeholder engagement included throughout the course.
APSC 101	Introduction to Engineering II	9.3, 9.4	I	Design course; includes module on sustainability, including management tools, and a second module implementing sustainability considerations into detailed design.
CIVL 200	Engineering and Sustainable Development	9.3, 9.4	A	Impact of technology on society approved elective course; 50% of MECH students take this course; includes self-regulated learning project related to sustainable development.
MECH 328	Mechanical Engineering Design Project	9.1, 9.2, 9.3, 9.5	D	Design course; focuses on one major project where teams incorporate engineering impacts into decision-making and design.

MECH 431	Engineering Economics	9.3	D	Economics course; includes large course project that requires consideration of sustainability as part of proposal.
MECH 45X	Capstone design Project	9.3	D	Design course; focuses on one major project where teams must create, test, and analyze data from multiple prototypes.

Indicators:

Five indicators have been used to describe the Impact of Engineering attribute. The indicators examine key aspects of the attribute and allow independent assessment in each:

9.1 Legal Requirements: Describe relevant legal requirements governing engineering activities
9.2 Impact of Human Activity: Describe impact of human activity on health, safety, and environmental systems
9.3 Sustainability: Incorporate sustainability considerations (societal, ecological, and economic) in decision making
9.4 Management Techniques: Apply management techniques for sustainable development
9.5 Intercultural Sensitivity: Demonstrate understanding and respect of different cultural values and communication preferences

Indicators 9.1 to 9.5 map directly to the CEAB definition of Attribute 9: "*An ability to <u>analyze social and environmental</u> (9.2) aspects of engineering activities. Such ability includes an understanding of the interactions that engineering has with the economic, social, health, safety, <u>legal</u> (9.1), and <u>cultural</u> (9.5) aspects of society, the uncertainties in the prediction of such interactions; and the <u>concepts of sustainable design and development and environmental stewardship</u> (9.3, 9.4).*"

Performance expectations (below expectations, marginal, meets expectations, and exceeds expectations) in each indicator are relative to the year level. The descriptors of the detailed assessment rubrics for each course activity indicate performance expectations in each course and year.

Assessment tools:

Assessment tools for Impact of Engineering are based on a mix of projects and formal examinations, as summarized below in Table 19. The value preceding an assessment tool indicates the number of items of that type assessed in that course.

Table 19. Assessment Tools for Attribute 9

Year	Course	Assessment Tools	Indicators assessed				
			9.1	9.2	9.3	9.4	9.5
1	APSC 100	1 × final exam			✓		
	APSC 101	1 × project proposal* (APSC101-M6-Rubri-EOI.pdf); 1 × oral presentation* (APSC101-M6-Rubric-Pres.pdf); 1 × final exam			✓	✓	

3	CIVL 200	1 × self-regulated learning project poster* (CIVL200-Rubric-Poster.pdf)			✓	✓	
	MECH 328	1 × concept selection review* (MECH328-Rubric-Concept.xlxs); 1 × oral presentation* (MECH328-Rubric-Pres.xlxs); 1 × final report* (MECH328-Rubric-Report.xlxs)	✓	✓	✓		✓
4	MECH 431	1 × final project report* (MECH431-Rubric-Report.pdf)			✓		
	MECH 45X	1 × project dossier** (MECH45X-Rubric-Dossier.pdf)			✓		

* indicates the assessment was completed using a rubric and the name in parentheses is the associated rubric filename available for review;

** indicates a rubric was used to complete the assessment but detailed rubric data were not recorded; raw grades from the assessment tool were used to determine performance levels. (We are working to eliminate this practice by instructors and to record all rubric data directly, where possible.)

The above assessment tools were chosen primarily based on where we had existing assessments within the curriculum. For non-rubric-based assessments of some project deliverables (e.g. dossiers, etc.), as discussed below, expectations are to transition to full adoption of rubrics over the coming continuous improvement cycles.

Assessment results:

Assessment data were collected for the above five indicators and five courses spanning all years of the program, except Year 2. This resulted in a total over 9 assessment tools each assessing roughly two indicators on average (for a total of approximately 17 assessment points).

Data are reported below in Figure 26, sorted by indicator and academic year. See "Addendum 1: Data Analysis and Presentation" above for a description of the histogram grid, including descriptions of the histograms and assessment strength rating scale (○ ◔ ◑ ◕ ●).

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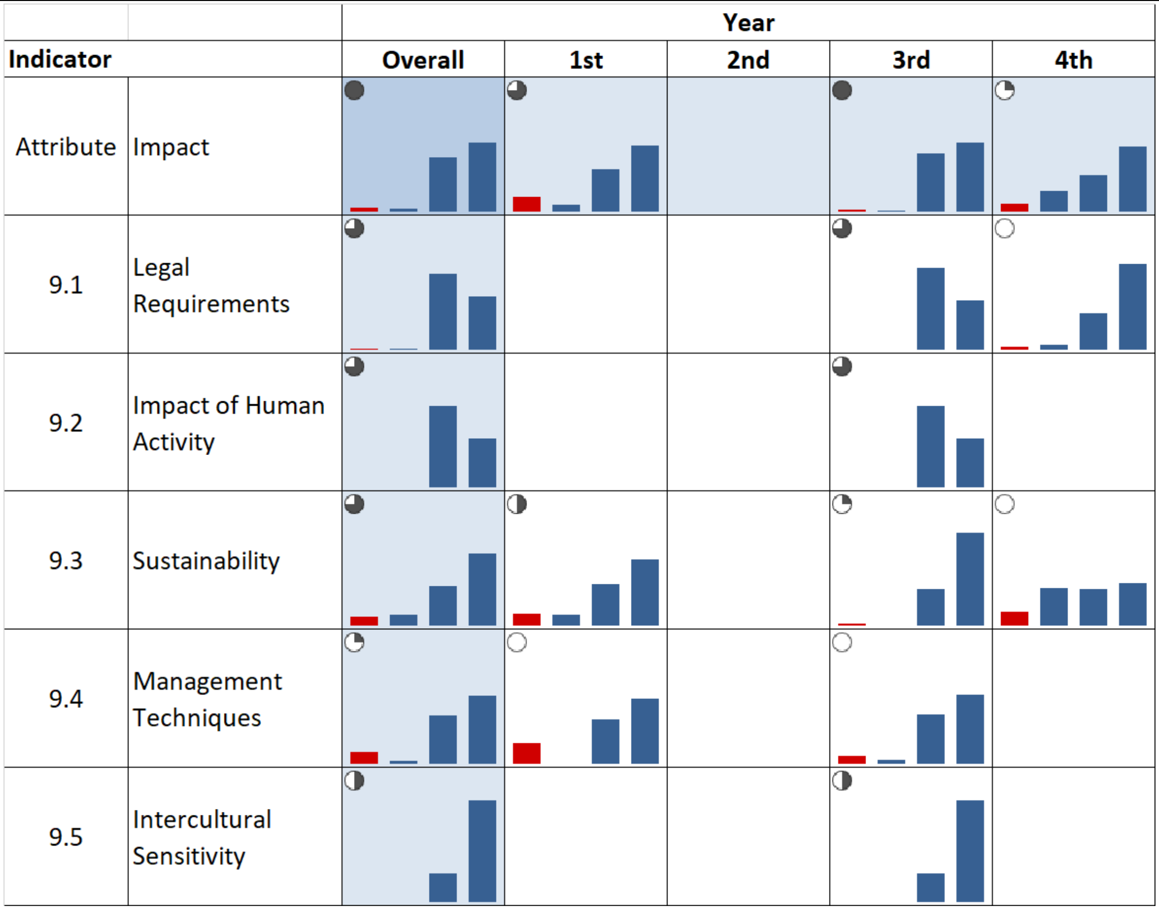

Figure 26. Assessment Data for Attribute 9

In Figure 27, overall academic data—all indicators and years combined, as shown in the top-left cell from Figure 26 above—are compared below to survey data from current students, alumni, and co-op employers. See "Addendum 1: Analysis and Presentation" above for more information on data collection methods and interpretation of the data.

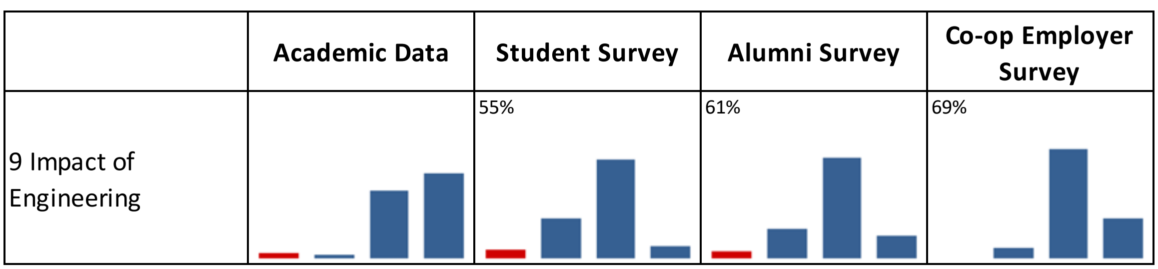

Figure 27. Comparison to Survey Data for Attribute 9

There are some concerns raised by the data above, but, overall, most students are performing at a "meets expectations" or "exceeds expectations" level. In terms of understanding and being able to apply concepts of sustainability (Indicator 9.3), there is a significant number of students (approximately 10%) in first and fourth year who are performing "below expectations." Also in first year, almost 15% of students are performing at a "below expectations" level in applying management techniques for sustainable development (Indicator 9.4). In comparing the academic assessments with survey results reported by current students, alumni, and co-op employers, there is adequate agreement; however, our academic assessments suggest we see the students performing better in this attribute than students, alumni, or employers report. Both of these issues—the larger than usual number of students at the "below expectations" category of Indicators 9.3 and 9.4, and the lack of strong agreement between academic and survey data—may be due to a lack of data, and are addressed further below.

In terms of data collection, there is significantly less data overall than for most other attributes, as witnessed by the larger than usual number of empty cells in the assessment results table. This lack of data may be a contributing factor to the two issues noted above; regardless, more data are needed before making any decisions on curriculum changes. Some specific observations and planned actions for this attribute are listed below.

1. As mentioned above, students apply concepts of sustainability in their MECH 223 design courses; however, assessment of their competency is not currently possible due to the project deliverable structure. The opportunity to modify submission requirements in this course in order to be able to assess Indicators 9.3 and possibly 9.4 are currently being explored in time for the upcoming academic year.
2. In addition, the opportunity to use some writing assignments in the MECH 226/227 technical writing course to jointly assess Attributes 7 and 9 are currently being explored. Specifically, the course includes several assignments dealing with impacts of engineering and safety. Currently only the communication elements (Attribute 7) are assessed, but steps are being taken to include assessment of Indicator 9.2 (Impact of Human Activity) in the coming academic year. In addition, there are activities in the course directed at addressing Indicator 9.5 (Intercultural Sensitivity), but assessment data does not currently exist. Work is underway with the MECH 226/7 course instructors to ensure assessment data for Indicator 9.5 is collected in future.
3. Considering fourth year, and MECH 45X specifically, as mentioned elsewhere, data collection and analysis methods were inadequate but are currently being reviewed and revised in time for the coming academic year. The rigour in terms of the use of rubrics, as well as the assessment of additional indicators to be assessed are being explored.
4. Efforts are underway to collect data from the faculty-wide APSC 450 (Professional Engineering Practice). Some data was collected in this course, but was not processed in time for this exhibit. It is believed there is some data available for the assessment of Indicator 9.1 (Legal Requirements).

1.13 *Graduate attribute # 10 Ethics and equity*

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

Curriculum maps:

While there is attention paid to Ethics and Equity throughout the curriculum, assessment has been sparse. At the time of writing this exhibit, assessment data for this attribute was available in only three places in the curriculum. In a new introduction to engineering course in first year (APSC 100, level "I"), students are introduced to the engineering profession and professional ethics. In particular, there is a module on Codes of Ethics (both for [redacted] and [redacted] Engineering), and resolving ethical dilemmas. This includes topics of ethical theory, gradual escalation, conflict of interest, and more. In a compulsory course on professional engineering practice (APSC 450, level "A"), topics include legislation affecting the practice of engineering, ethical principles and responsibilities, management of engineering enterprises, and labour relations, safety and environmental legislation. In MECH 431 (Engineering Economics, level "D"), students complete a project that includes an assessment of ethical considerations. This information is summarized in Table 20 below.

Table 20. Curriculum Map for Attribute 10

Course	Title	Indicators	IDA	Details
APSC 100	Introduction to Engineering I	10.1, 10.2, 10.3	I	Design course; includes module on professionalism and ethics, with emphasis on codes of ethics, ethical theory, and ethical decision-making.
APSC 450	Professional Engineering Practice	10.2, 10.3, 10.4	A	Compulsory complementary studies course; covers professional and ethical responsibilities.
MECH 431	Engineering Economics	10.3	D	Engineering economics course; includes large course project that requires consideration of ethics as part of proposal.

Given the sparsity of data sources above, it is worth briefly outlining other places within the curriculum where Ethics and Equity are introduced and developed. In MECH 223 (second year design), MECH 328 (third year design), and MECH 45X (capstone design) considerations of professional ethics is required to complete the course work, and informal feedback is provided on an ongoing basis. Specifically, the Code of Ethics and professional obligations for engineers in the context of design projects are regularly discussed. In MECH 226/7 (technical communications), students complete several case studies and assignments where they must respond to an ethical dilemma or consider a scenario from different ethical perspectives; however, the ethical aspects of these assessments have not been assessed to date. In addition, MECH 224 (integration of engineering concepts) and MECH 30X (mechanical engineering laboratories) both include community-based experiential learning (CBEL) experiences (i.e. community-service learning), to which ethics, accountability, and equity are important. Lastly, ethics considerations appear in various elective courses (as an example, in the MECH 478 course on internal combustion engines, policy and the recent Volkswagen scandal are discussed), but, as these courses are not compulsory, data has not been collected. The steps planned incorporate assessment data from these and other sources in future is discussed further below.

Indicators:

Five indicators have been used to describe the Ethics and Equity attribute:

10.1 Ethical Behaviour: Demonstrate behaviour congruent with academic integrity expectations of university and faculty
10.2 Codes of Conduct: Identify and iterate items from the professional codes of conduct
10.3 Ethical Issues: Describe ethical issues and how they affect the individual, the organization, and the public
10.4 Consequences of Code Violation: Describe consequences of deviating from professional codes of conduct and the University code of conduct
10.5 Equity: Act in a manner that upholds the principles of respect, civility, equal opportunity, and inclusion; recognize the value and benefit of these principles and appreciate the seriously damaging consequences of not upholding them

Indicators 10.1 through 10.3 and 10.5 map directly to the CEAB definition of Attribute 10: "*An ability to <u>apply professional ethics</u> (10.2, 10.3), <u>accountability</u> (10.1), and <u>equity</u> (10.5).*" Indicator 10.4 was added to ensure students understand the "why" of upholding ethics and equity.

There is a proposal to revise these indicators for the 2017/18 academic year. Changes include consolidating Indicators 10.2 and 10.4 to a single indicator, and revising the language in the remaining indicators. This is described further below and in Section 2, Continual Improvement.

Performance expectations (below expectations, marginal, meets expectations, and exceeds expectations) in each indicator are relative to the year level. The descriptors of the detailed assessment rubrics for each course activity indicate performance expectations in each course and year.

Assessment tools:

Assessment tools for the Ethics and Equity indicator are based on quiz and examination questions (APSC 100 and APSC 450) and project reports (MECH 431), as shown in Table 21 below. The value preceding an assessment tool indicates the number of items of that type assessed in that course.

Table 21. Assessment Tools for Attribute 10

Year	Course	Assessment Tools	Indicators assessed				
			10.1	10.2	10.3	10.4	10.5
1	APSC 100	1 × final exam; 1 × quiz	✓	✓	✓		
4	APSC 450	1 × final exam		✓	✓	✓	
	MECH 431	1 × project report* (MECH431-Rubric-Report.pdf)			✓		

* indicates the assessment was completed using a rubric and the name in parentheses is the associated rubric filename available for review;

Assessment results:

Assessment data were collected for three of the above five indicators in two courses (years 1 and 4). This resulted in a total of five assessment points.

Data are reported in Figure 28 below, sorted by indicator and academic year. See "Addendum 1: Data Analysis and Presentation" above for a description of the histogram grid, including descriptions of the histograms and assessment strength rating scale (○ ◔ ◑ ◕ ●).

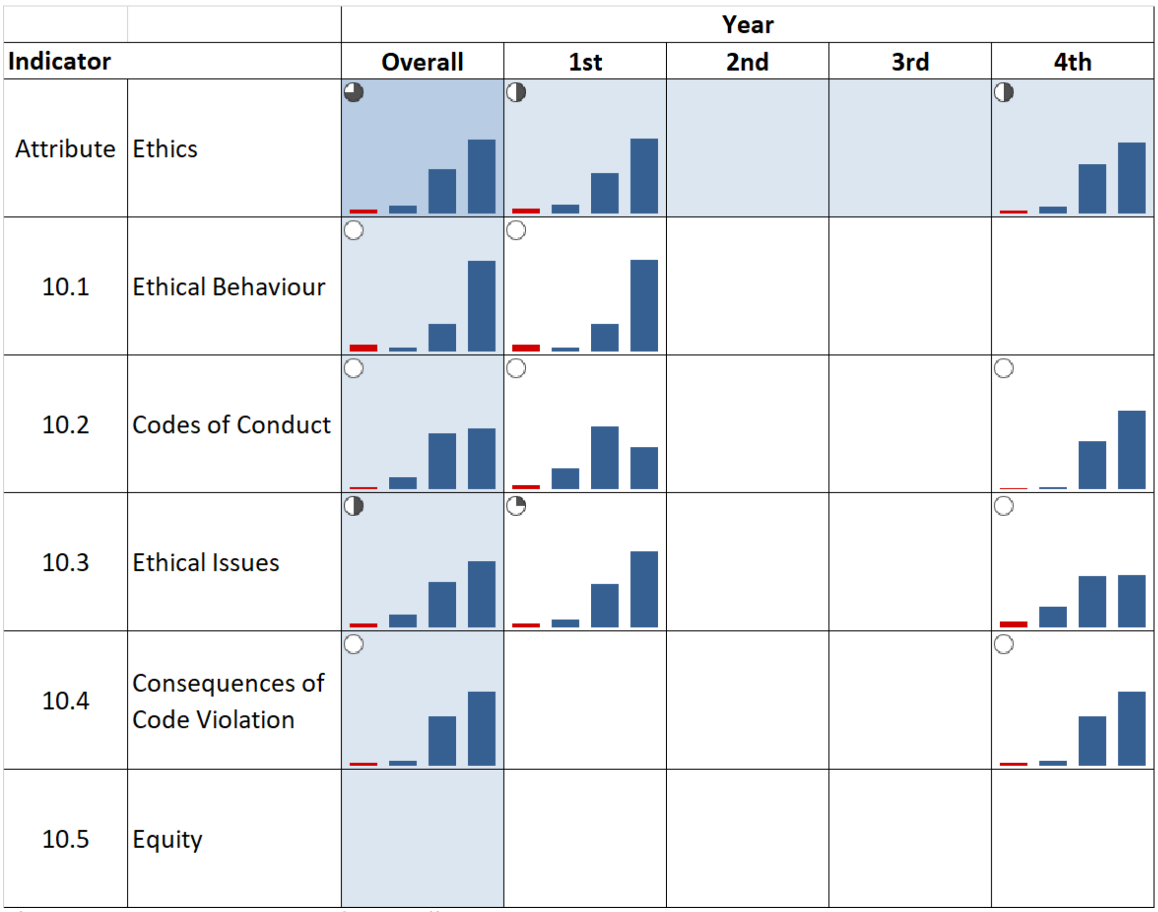

Figure 28. Assessment Data for Attribute 10

In Figure 29, the overall academic data—all indicators and years combined, as shown in the top-left cell from Figure 28 above—are compared below to survey data from current students, alumni, and co-op employers. See "Addendum 1: Analysis and Presentation" above for more information on data collection methods and interpretation of the data.

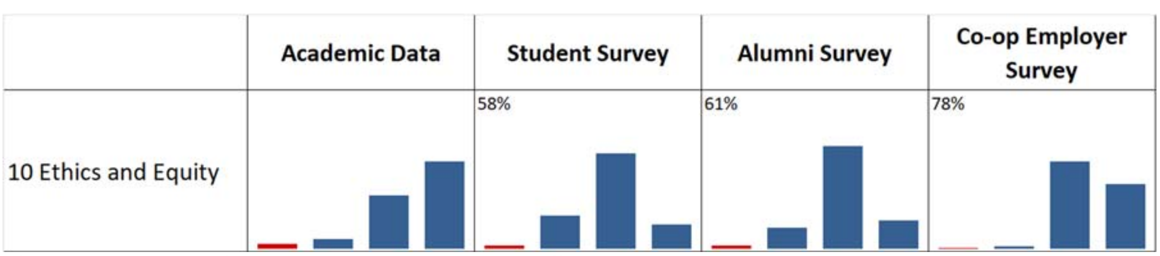

Figure 29. Comparison to Survey Data for Attribute 10

The data that have been collected, although sparse, do not suggest there is an issue in terms of student competency in the Ethics and Equity attribute; however, more data are required. In addition, there are some notable discrepancies between our academic assessment data and survey data from students, alumni, and employers—we tend to rate student performance more favourably than other stakeholders do—but, again, no group has identified significant concerns. Nevertheless, without more complete data, it is difficult to comment further on performance in this attribute. The following actions have already been taken or are being explored to provide additional data in this attribute for future:

1. The Curriculum Committee (i.e. graduate attributes committee) and Design Course Committee have jointly reviewed the indicators for Attribute 10 and have proposed several changes. In particular, Indicators 10.2 (Codes of Conduct) and 10.4 (Consequences of Code Violations) are strongly related and have been amalgamated into a new Indicator 10.2. In addition, Indicator 10.1 has been rephrased to include non-academic contexts. Full details are included in Section 2, Continual Improvement.
2. The peer evaluation rubrics for APSC 100 and 101, and MECH 223, 325, 326, 328, and 45X have already been modified for this coming academic year to add assessment of equity (Indicator 10.5) at every year of the program.
3. The rubrics used to assess project deliverables in MECH 223, MECH 328, and MECH 45X are being examined to explore opportunities to incorporate assessments of Indicator 10.3, and possibly 10.4 to those courses.
4. The opportunity to use some writing assignments in the MECH 226/227 technical writing course to assess Attribute 10 are currently being developed. Specifically, the course already includes an ethical case study that requires an analysis from perspectives of both parties involved. An additional ethical case takes the perspective of an EIT who identifies a deficiency in the safety of hazardous materials handling equipment and protocols and explores the ethical issues around whistleblowing. Adequate tools to assess student competence in handling ethical issues do not currently exist in the course, but are now under development.
5. Similarly, the opportunity to incorporate assessment of ethics and equity within existing community-based experiential learning (CBEL) experiences in second and third year are being explored.
6. Lastly, the Curriculum Committee and Design Course Committee have jointly discussed the possibility of employing additional validated assessment tools if sufficient data cannot be gathered through in-course assessments, as described above. Two such tools identified in a preliminary search include the Defining Issues Test (Rest, et al., 1999) and the Engineering Ethical Reasoning Instrument (Zoltowski, et al., 2013).

1.14 *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:

Assessment of the Economics and Project Management attribute has primarily occurred in major design courses, where students must manage budgets and complex, long-duration projects. The MECH 223 design course (level "D") in second year includes two full-time projects (4 weeks and 3 weeks) which require the use of PERT, CPM, and Gantt Charts, as well as maintaining a budget and scoring based on the final cost in the bill of materials. Teams submit reports and meet with teaching assistants on a semi-weekly basis. Instruction and formal assessment includes the topics of project management techniques, economic principles, time value of money, and more. The MECH 328 course (level "D") involves one major term-long project, with detailed record-keeping for time spent and budget. Students meet once per week with the same teaching assistant and instructor, during which time they give regular reports related to project management. MECH 45X (level "A") involves a full-year project, with detailed budget, economic analysis, and project management. As with the other two courses, teams meet regularly with a faculty member. Cost considerations and project management are assessed through the project dossier submitted at the end. Finally, MECH 431 (Engineering Economics, level "A") is an engineering economics course, and it focuses on business principles and economic analysis. It includes several assignments and a final project, all which required detailed economic, risk, and project analysis. This information is summarized in Table 22 below.

Table 22. Curriculum Map for Attribute 11

Course	Title	Indicators	IDA	Details
MECH 223	Introduction to the Mechanical Design Process	11.1, 11.2, 11.3, 11.4, 11.5	D	Design course; includes two major projects, and instruction and assessment on project management and economics. Students submit project management materials and regularly meet with teaching assistants.
MECH 328	Mechanical Engineering Design Project	11.2, 11.3, 11.4, 11.5	D	Design course; includes one major project. Students regularly meet with teaching assistants and instructors to review project progress. Economic analysis is required in the projects.
MECH 431	Engineering Economics	11.1, 11.2, 11.3, 11.4	A	Economics course; includes several assignments and a large course project, all of which required detailed consideration of economics and project management.
MECH 45X	Capstone Design Project	11.2, 11.5	A	Design course; includes one major project. Students regularly meet with faculty supervisors to review project progress. Economic analysis is required in the projects.

Indicators:

Five indicators have been used to describe the Economics and Project Management attribute. The indicators examine key aspects of the attribute and allow independent assessment in each:

11.1 Economic and Business Principles: Outline principles of business; appreciate the significance of the business principles; develop economic justification for a new project, product, or venture
11.2 Cost Considerations: Incorporate cost considerations throughout the design and execution of a project, and manage the project budget (e.g. estimate life-cycle costs)
11.3 Project Scope: Assess and manage the scope and dimensions of a project
11.4 Project Risk: Assess risks in projects, including limitations in modeling and management processes, and devise and implement strategies for managing these risks
11.5 Project Management Techniques: Describe industry-standard project management techniques, including processes for handling project changes, and apply them effectively in practice

Indicators 11.1, 11.3, 11.4 and 11.5 map directly to the CEAB definition of Attribute 10: "*An ability to appropriately incorporate economics and business practices (11.1, 11.2) including project (11.3), risk (11.4), and change management (11.5) into the practice of engineering and to understand their limitations.*" These indicators include the use of various skills and tools (11.2 and 11.5), as well as broader understanding and the ability to exercise judgement (11.1, 11.3, and 11.4).

There is a proposal to revise these indicators for the 2017/18 academic year by consolidating Indicators 11.3 and 11.4. The feeling is that these two indicators are strongly linked, and the CEAB definition of the attribute does not suggest that this high degree of resolution in these indicators in necessary. This is described further below and in Section 2, Continual Improvement.

Performance expectations (below expectations, marginal, meets expectations, and exceeds expectations) in each indicator are relative to the year level. The descriptors of the detailed assessment rubrics for each course activity indicate performance expectations in each course and year.

Assessment tools:

Assessment tools for Economics and Project Management are drawn from the four major project courses (MECH 223, 328, and 45X), and additional economics data are drawn from the engineering economics course (MECH 431). In the case of MECH 223, in addition to the project deliverables, there is instruction on economics and project management assessed through formal examinations. The primary reason for choosing the courses and assessment tools below is the opportunity for authentic assessment in the context of realistic engineering project work. The assessment tools are summarized in Table 23 below. The value preceding an assessment tool indicates the number of items of that type assessed in that course.

Table 23. Assessment Tools for Attribute 11

Year	Course	Assessment Tools	Indicators assessed				
			11.1	11.2	11.3	11.4	11.5
2	MECH 223	1 × Final Exam; 1 × Midterm Exam;	✓	✓	✓	✓	✓

		5 × Project Management Charts* (MECH223-Rubric-ProjMan.pdf)					
3	MECH 328	1 × Final Report* (MECH328-Rubric-Report.xlsx); 1 × Oral Presentation* (MECH328-Rubric-Pres.pdf); 1 × Concept Selection Review* (MECH328-Rubric-Concept.xlsx)		✓	✓	✓	✓
4	MECH 431	1 × Final Report* (MECH431-Rubric-Report.pdf); 2 × Midterm; 4 × Assignments* (MECH431-Rubric-Asst*.pdf)	✓	✓	✓	✓	
	MECH 45X	1 × Project dossier** (MECH45X-Rubric-Dossier.pdf)		✓			✓

* indicates the assessment was completed using a rubric and the name in parentheses is the associated rubric filename available for review;

** indicates a rubric was used to complete the assessment but detailed rubric data were not recorded; raw grades from the assessment tool were used to determine performance levels. (We are working to eliminate this practice by instructors and to record all rubric data directly, where possible.)

Assessment results:

Assessment data were collected for all five indicators in Years 2 and 4, and for 4 of 5 indicators in Year 3. There were a total of 14 assessment tools used (and approximately 40 points, with an average of approximately 3 indicators assessed per tool).

Data are reported below in Figure 30, sorted by indicator and academic year. See "Addendum 1: Data Analysis and Presentation" above for a description of the histogram grid, including descriptions of the histograms and assessment strength rating scale (○ ◔ ◑ ◕ ●).

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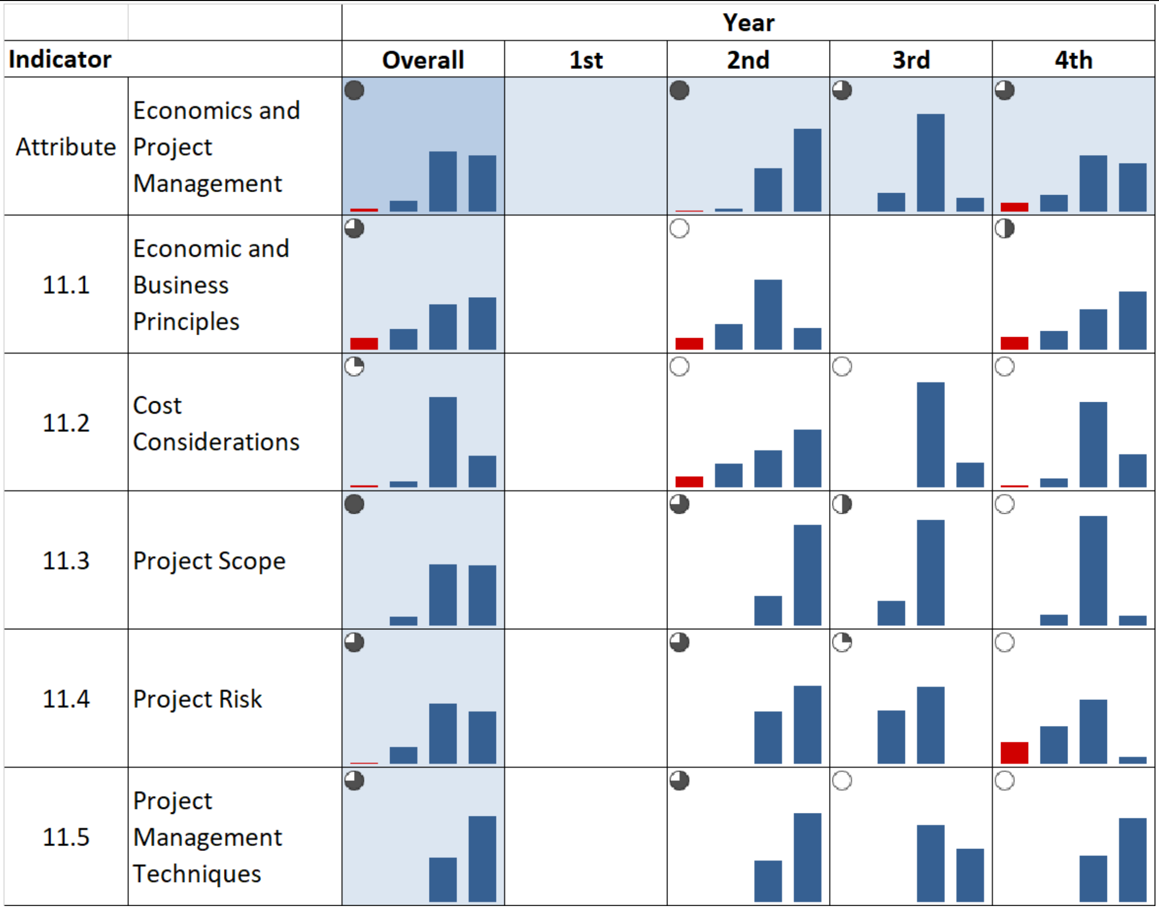

Figure 30. Assessment Data for Attribute 11

The overall academic data—all indicators and years combined, as shown in the top-left cell from Figure 30 above—are compared below to survey data from current students, alumni, and co-op employers in Figure 31. See "Addendum 1: Analysis and Presentation" above for more information on data collection methods and interpretation of the data.

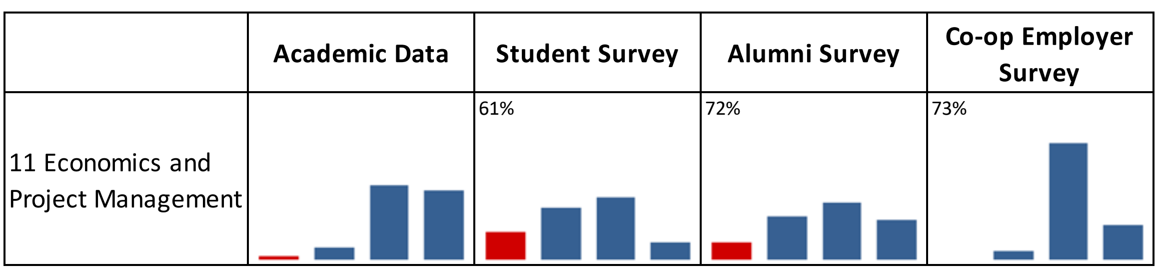

Figure 31. Comparison to Survey Data for Attribute 11

The overall academic assessment, as well as the co-op employer survey, suggest satisfactory performance in the Economics and Project Management attribute. However, concerns are evident in students' understanding of economic and business principles (Indicator 11.1, almost 10% are performing at a "below expectations" level. In addition, in Indicator 11.4 (Project Risk), over 15% of students are performing "below expectations" in fourth year, although this is based on a single, low-reliability and -validity assessment on a final report in one course (MECH 431).

In comparing the academic assessments and co-op employer survey results with survey results reported by current students and alumni, there are substantially more students and alumni who self-evaluate at a “below expectations” level. The Curriculum Committee has discussed this observation and has planned the following in response:

1. This finding will be shared with the Mechanical Engineering External Advisory Council at the next meeting (early in the 2017/18 academic year) to seek their input on the nature of the discrepancy.
2. At the next student focus group meeting (near the middle of the upcoming fall academic term), students will be asked for their input on the nature of the discrepancy.
3. In the next curriculum survey sent to students and alumni, additional question will be added to differentiate self-rated ability in economics from project management (to see if one dimension of the attribute is more strongly driving student perception).
4. This finding has been brought to the attention of the Acting Associate Director (Student Experience) at the Engineering Co-op office. We will continue to work with Co-op such that coordinators can try to gain insight on these findings in their conversations with students and employers.

In addition, the following actions have or will be taken for the 2017/18 academic year to improve the quality of data:

5. In MECH 45X, has only provided assessment in two indicators and the assessment strength is weak in both cases. The rubrics in that course are being redeveloped to increase the reliability, validity, and number of indicators assessed. Rigour is also being added to the assessment and data collection processes.
6. Through a joint meeting of the Curriculum Committee and the Design Course Committee, to merged Indicators 11.3 (Project Scope) and 11.4 (Project Risk) into a single indicator. The amalgamated indicator has been drafted and will go to the Department for approval in the fall. This change will help to simplify and consolidate assessment, leading to increased assessment strength for the revised indicator.

1.15 *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:

While we believe there is significant emphasis on to developing self-directed and life-long learning skills in the curriculum, at the time of writing this exhibit, we have limited assessment data to demonstrate this attribute. Assessment data for this attribute was available in three places in the curriculum. In the MECH 223 design course (level "D"), students are given two large design projects and are expected to identify knowledge gaps, and then locate, evaluate, and synthesize technical information for use in their decision-making. They record their research and it implications in logbooks, and describe the process they underwent during design review meetings with instructors. In MECH 328 (also a design course, also level "D") students must locate and evaluate relevant information for their project in terms of prior art, as well as applicable codes, standards, and other technical information. In MECH 431 (engineering economics, level "I"), students must locate relevant data for use in a project, with assessment based on how comprehensive the data are and whether or not students use primary sources in their work. This information is summarized in Table 24 below.

Table 24. Curriculum Map for Attribute 12

Course	Title	Indicators	IDA	Details
MECH 223	Introduction to the Mechanical Design Process	12.1, 12.3	D	Design course; two major design projects require students to identify knowledge gaps and seek information.
MECH 328	Mechanical Engineering Design Project	12.3	D	Design course; one major project requires students to identify relevant information in terms of prior art, applicable codes and standards, and more.
MECH 431	Engineering Economics	12.3	I	Economics course; includes several assignments and a large course project, all of which require detailed consideration of economics and project management.

Given the sparsity of data sources above, it is worth briefly outlining other places within the curriculum where Life-long Learning is developed. In MECH 224 (integration of engineering concepts), students engage in a community-based experiential learning (CBEL) project, at the conclusion of which is a reflection based on what was learned. This currently takes place as a discussion with the TA, but ways to adapt or change this activity to allow assessment of the reflections is being explored. In MECH 226/7 (technical communication), there are multiple case studies and assignments that require students to seek out information sources (primarily journal articles), evaluate the information contained within, and evaluate that information in terms of authority and relevancy. In the MECH 30X (data analysis and laboratories) course, students also engage in a CBEL project; this may yield possibilities for an assessment of a reflection, pending how successful this is in MECH 224 and changes to the MECH 30X course. In terms of possible changes to MECH 30X, the course is currently being reviewed and redesigned. Life-long learning elements (including application and assessment) are being considered as part of the focus on design of experiments. Lastly, there are many opportunities to assess life-long learning in MECH 45X (capstone project). There are various reflections that take place through the course where students reflect on what they have learned through the course, and teams reflect on their development. There are deliverables submitted for these tasks, but they are currently not suitable for assessment. In addition, in the projects, teams must identify knowledge gaps and seek out and evaluate information to address those. The steps planned incorporate assessment data from these and other sources in future is discussed further below.

Indicators:

Six indicators have been used to describe the Life-long Learning attribute. Indicators 12.1 to 12.5 are meant to represent elements in sequence for identifying and addressing a learning need. Indicator 12.6 is meant to capture the broader affective goal of valuing and internalizing the need for life-long learning.

12.1 Identification of Learning Need: Recognize the limits of personal knowledge and expertise; Identify specific learning needs and knowledge gaps
12.2 Learning Strategy: Develop strategy to address learning need, considering personal learning style
12.3 Identify Information Sources: Identify appropriate technical literature, expert advice and other information sources to meet a need
12.4 Evaluation and Synthesis of Information: Critically evaluate for authority, currency, and objectivity, and synthesize information procured from information sources
12.5 Reflection: Reflect on the efficacy of a learning strategy that has been applied and identify opportunities for improvement
12.6 Motivation for Self-Education: Describe the consequences of not keeping current regarding new developments in field

Indicators 12.1 to 12.5 were drawn directly from the definition of Attribute 12: "*An ability to <u>identify</u> (12.1) and to <u>address</u> (12.2, 12.3, 12.4) their own educational needs in a changing world <u>in ways sufficient to maintain their competence and to allow them to contribute to the advancement of knowledge</u>* (12.5)." Indicator 12.6 was added to provide assessment of higher-level affective elements of the attribute. In the case of Indicators 12.2 to 12.4, these were felt to be discrete, measurable elements of "addressing their own educational needs."

There is a proposal to revise these indicators for the 2017/18 academic year by removing Indicator 12.2 (Learning Strategy), as this was felt to be redundant with full and correct application of Indicators 12.1 (Identification of Learning Need), 12.3 (Identification of Information Sources), 12.4 (Evaluation and Synthesis of Information), and 12.5 (Reflection), and by removing Indicator 12.6 (Motivation for Self-Education) as this was felt to go beyond the CEAB definition of Attribute 12, and, as part of the effective domain, has been difficult to assess with validity, reliability, and authenticity. This is described further below and in Section 2, Continual Improvement.

Performance expectations (below expectations, marginal, meets expectations, and exceeds expectations) in each indicator are relative to the year level. The descriptors of the detailed assessment rubrics for each course activity indicate performance expectations in each course and year.

Assessment tools:

Assessment tools for the Life-long Learning indicator are sparse, and are currently based on project work in MECH 223, MECH 328, and MECH 431. These are summarized in Table 25. The value preceding an assessment tool indicates the number of items of that type assessed in that course.

Table 25. Assessment Tools for Attribute 12

Year	Course	Assessment Tools	Indicators assessed					
			12.1	12.2	12.3	12.4	12.5	12.6
2	MECH 223	1 × design review* (MECH223-Rubric-Review.pdf); 2 × logbook evaluation* (MECH223-Rubric-Logbook.pdf)	✓		✓			
3	MECH 328	1 × final report* (MECH328-Rubric-Report.xlxs)			✓			
4	MECH 431	1 × project report* (MECH431-Rubric-Report.pdf)			✓			

* indicates the assessment was completed using a rubric and the name in parentheses is the associated rubric filename available for review

Assessment results:

Assessment data were collected for two of five indicators in Years 2, 3, and 4. There were a total of 5 assessment tools used (one assessing two indicators, the rest assessing one).

Data are reported in Figure 32 below, sorted by indicator and academic year. See "Addendum 1: Data Analysis and Presentation" above for a description of the histogram grid, including descriptions of the histograms and assessment strength rating scale (○ ◔ ◑ ◕ ●).

(continued)

		Year				
Indicator		**Overall**	**1st**	**2nd**	**3rd**	**4th**
Attribute	Life-long Learning					
12.1	Identification of Learning Need					
12.2	Learning Strategy					
12.3	Identify Information Sources					
12.4	Evaluation and Synthesis of Information					
12.5	Reflection					
12.6	Motivation for Self-Education					

Figure 32. Assessment Data for Attribute 12

In Figure 33, the overall academic data—all indicators and years combined, as shown in the top-left cell from Figure 32 above—are compared below to survey data from current students, alumni, and co-op employers. See "Addendum 1: Analysis and Presentation" above for more information on data collection methods and interpretation of the data.

	Academic Data	**Student Survey**	**Alumni Survey**	**Co-op Employer Survey**
12 Life-long Learning		76%	70%	77%

Figure 33. Comparison to Survey Data for Attribute 12

The data that have been collected, although sparse, do not suggest there is an issue in terms of student competency in the Life-long Learning attribute; however, more data are required. In addition, there are some slight discrepancies between our academic assessment data and survey data from students, alumni, and employers—we tend to rate most students as performing at a "meets expectations" level, while students, alumni, and co-op employers tend to have more spread in their assessments. However, without more complete data, it is difficult to comment further on performance in this attribute. The following actions have already been taken or are being explored to provide additional data in this attribute for future:

1. The Curriculum Committee (i.e. graduate attributes committee) and Design Course Committee have jointly reviewed the indicators for Attribute 12 and have proposed several changes. In particular, Indicator 12.2 (Learning Strategy) was dropped due to redundancy with other indicators, and 12.6 (Motivation for Self-Education) was dropped for not strongly aligning with the attribute definition (and for being difficult to assess). Further details are included in Section 2, Continual Improvement.
2. The rubrics used to assess project deliverables in MECH 223, MECH 328, and MECH 45X are being examined to explore opportunities to incorporate further assessments of Indicators 12.1, 12.3, and 12.4 to those courses.
3. The MECH 226/7 course rubrics are being expanded to include assessment of locating, evaluating, and synthesizing information sources in several existing assignments (including an incident report, an adjustment letter, a team report, and a summary assignment).
4. Similarly, the opportunity to incorporate assessment of life-long learning within existing community-based experiential learning (CBEL) experiences in second and third year are being explored.
5. Opportunities to include assessments of identifying, evaluating, and synthesizing information sources in new laboratories in MECH 30X developing skills in research and design of experiment are being considered. The MECH 30X course is currently being reviewed and revised for the 2017/18 academic year.

2 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:

2.1 *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 Department has historically had a robust and active continual improvement process, utilizing stakeholder engagement from semi-annual course review meetings, annual Department retreats, regular student interactions (semi-annual focus groups and surveys), regular Mechanical Engineering External Advisory Council consultations (at least three per year), and input from formal external reviews (conducted at the conclusion of the term of a Department Head). Within the second year ([redacted] program, there are also weekly meetings, additional separate course review meetings, and an annual retreat. To complement these existing processes, a continual improvement process based on graduate attribute assessment has been adapted from the 6-step process recommended by the Engineering Graduate Attributes Development project (EGAD), as shown in Figure 34 below. A brief summary of each stage follows.

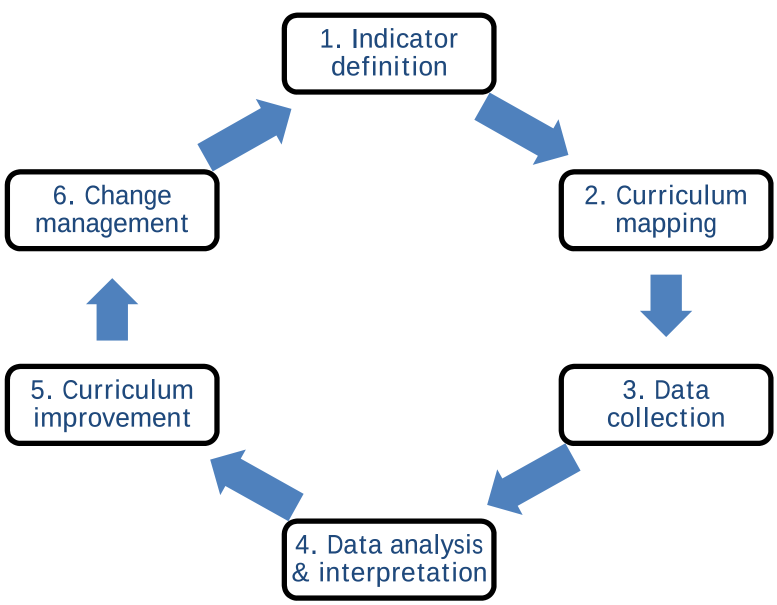

Figure 34. Continual Improvement Process

Stage 1: Indicator definition. Indicators were collectively defined in 2010 for most of the engineering programs in the Faculty of Applied Science at [redacted] Following the 2011 accreditation visit, indicators were reviewed and revised through meetings of ad hoc committees within the Mechanical Engineering Department in 2013, 2014, 2015, and 2016. In

2014 and 2015, the Department reviewed and adopted the proposed new indicators. Through a formal vote, the Department agreed to expand Indicator 1.4 (discipline-specific knowledge base) to ten sub-disciplines in mechanical engineering, as recognized by [redacted] as this was seen to add value to the graduate attribute data for the Department.

Stage 2: Curriculum mapping. The Department engaged in a formal curriculum mapping exercise in 2010, using a survey distributed to all course instructors. The results from 2010 continue to be used, and adjustments to the curriculum map have proceeded in a more informal manner since. Notably, assessment opportunities have been identified, where possible, in conjunction with Stage 1 (Indicator Definition). In addition, in the development of new courses or revision of existing courses (e.g. APSC 100 and 101, or MECH 30X, currently), indicators have been used to guide the development of learning objectives and to identify assessment tools. Lastly, since the 2011 accreditation visit, we have examined the areas of our curriculum with insufficient accreditation data and have tried to identify where in the curriculum those competencies were developed and what assessments exist to measure them.

Stage 3: Data Collection. Starting in 2010, the decision was made to incorporate data measurement in attribute-rich courses as part of normal course operation. The courses were strategically selected based on the curriculum mapping, and were predominantly design project and lab courses. Evaluation in these courses has been heavily rubric-based. While we are still working to refine the process, as has been discussed elsewhere, in principle, data are always available for review and analysis with minimal effort. In addition, by focusing on a sub-set of courses, it is easier to ensure the graduate attribute assessment tools and data collection processes are preserved. For Attribute 1 and several other attributes not readily captured in the above courses, call-outs to course instructors were given as needed; the most recent set of wide-spread call-outs occurred last year (2015/16) and this year (2016/17), although we are working on formalizing this data collection schedule too.

Stage 4: Data Analysis and Interpretation. Data analysis predominantly involves sorting performance data into four levels (below expectations, marginally meets expectations, meets expectations, and exceeds expectations), and collating data from multiple sources. As noted in Addendum 1 of Section 1, a new method of weighting assessments (through the "Assessment Strength" metric) was developed in 2016 in order to combine different data sources. To date, prior to preparing for this 2017 accreditation visit, data analysis has only taken place on a small scale as a means by which to pilot for the larger scale process. During this developmental phase, data interpretation was handled on an ad hoc basis by the members of the Design Course Committee (although, at the time, they were an unofficial committee). The Department has since formalized data analysis and interpretation as a responsibility of the Curriculum Committee. The role of the Committee, the flow of information, and the decision-making process within the Department are described further below.

Stage 5: Curriculum Improvement. To date, curriculum improvement in the program has been guided by input from faculty (through course review meetings at the end of each term); from students (through regular focus group meetings, contact with student representatives, and surveys); from the Mechanical Engineering External Advisory Council (MEAC, through regular meetings); and through formal external reviews. As yet, we have not had a complete set of analyzed graduate attributes data for review and consultation; however, data that has been collected and analyzed has indirectly informed areas of curriculum review. Since the compilation of the current data, faculty, students, and the MEAC have all been consulted for input on analyzing the data and providing recommendations. The results of these consultations, and the formal structure that has been developed and approved, are outlined further below.

Stages 6: Change Management. This stage was added to our process in 2016, to parallel the process recommended by EGAD (also recently expanded from a five- to six-step model). We are in the early stages of formalizing a process to manage this stage. Discussions are ongoing within the Curriculum Committee, with input from the Design Course Committee and Lab Course Committee, and we hope to have a proposal ready for Department approval early in the 2017/18 academic year. This involves formalizing roles and responsibilities, as well as the consultation, information flow, and decision-making processes. These are summarized below.

Continual Improvement Organizational Structure

The organizational structure for those involved in the continual improvement process is similar to the graduate attribute data collection process (start of Section 1). It is included here in full for completeness.

As shown in Figure 35, ultimate responsibility falls to the Department Head, although management of the process is the responsibility of the Curriculum Committee. The Curriculum Committee is chaired by the Associate Head for Teaching, and it includes representatives from each option (Biomedical, Mechatronics, and Thermofluids) as well as several members at-large drawn from other faculty in the Department. The Department Head, in consultation with faculty and staff, appoints the Associate Head for Teaching and the Curriculum Committee members. The Curriculum Committee is responsible for recommending curriculum changes to the Head and the rest of the Department. The Department Head also appoints a faculty member as an Accreditation Advisor (who may or may not sit on the Curriculum Committee). The Accreditation Advisor is expected to have special expertise in accreditation, outcomes-based assessment, and continual program improvement, and is responsible for recommending policy and changes for the accreditation and continual improvement processes to the Curriculum Committee. The Accreditation Advisor is also responsible for overseeing the preparation of formal accreditation documentation. One of the staff member managers in the Department (the Facilities and Technical Administration Manager for this accreditation cycle) is assigned to provide support with communication, data collection, data analysis, report writing, and other work for accreditation purposes. They report to the Department Head, but receive direction in accreditation matters from the Accreditation Advisor. An occasional worker is hired as needed to assist with accreditation tasks in the lead-up to accreditation visits; this person reports to the manager assigned to accreditation, and receives further direction from the Accreditation Advisor. As design and lab course instructors have historically been involved with the bulk of graduate attribute data collection, two standing committees—the Design Course Committee and the Lab Course Committee—have been defined. They report to the Associate Head for Teaching, and advise on matters related to graduate attribute assessment, data collection, and data interpretation in the respective course areas. Lastly, student representatives (both formally elected to student government positions in “Club Mech” and informally selected students on an ad hoc basis for focus groups) and the MEAC engage with and report to the Department Head on a regular basis.

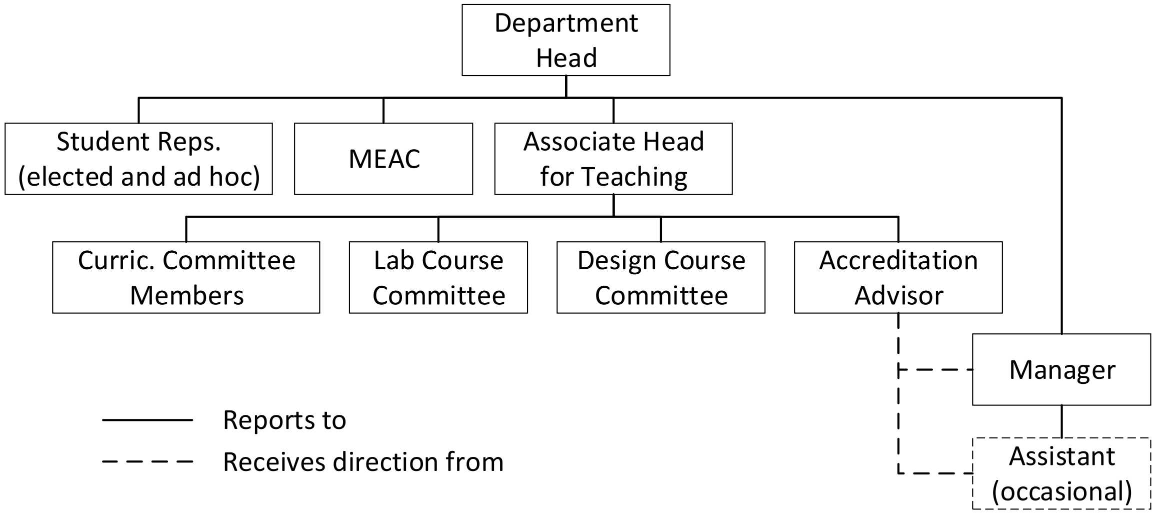

Figure 35. Continual Improvement Organizational Chart

This arrangement was formalized in 2017; in prior years the Department Head worked with the Accreditation Advisor (although that role was not officially recognized at the time) and a manager assigned to work on accreditation.

Responsibilities, Information, and Decision-Making Chart

A chart showing the responsibilities, information flow, and decision-making process for the above groups is shown in Figure 36 below.

(continued)

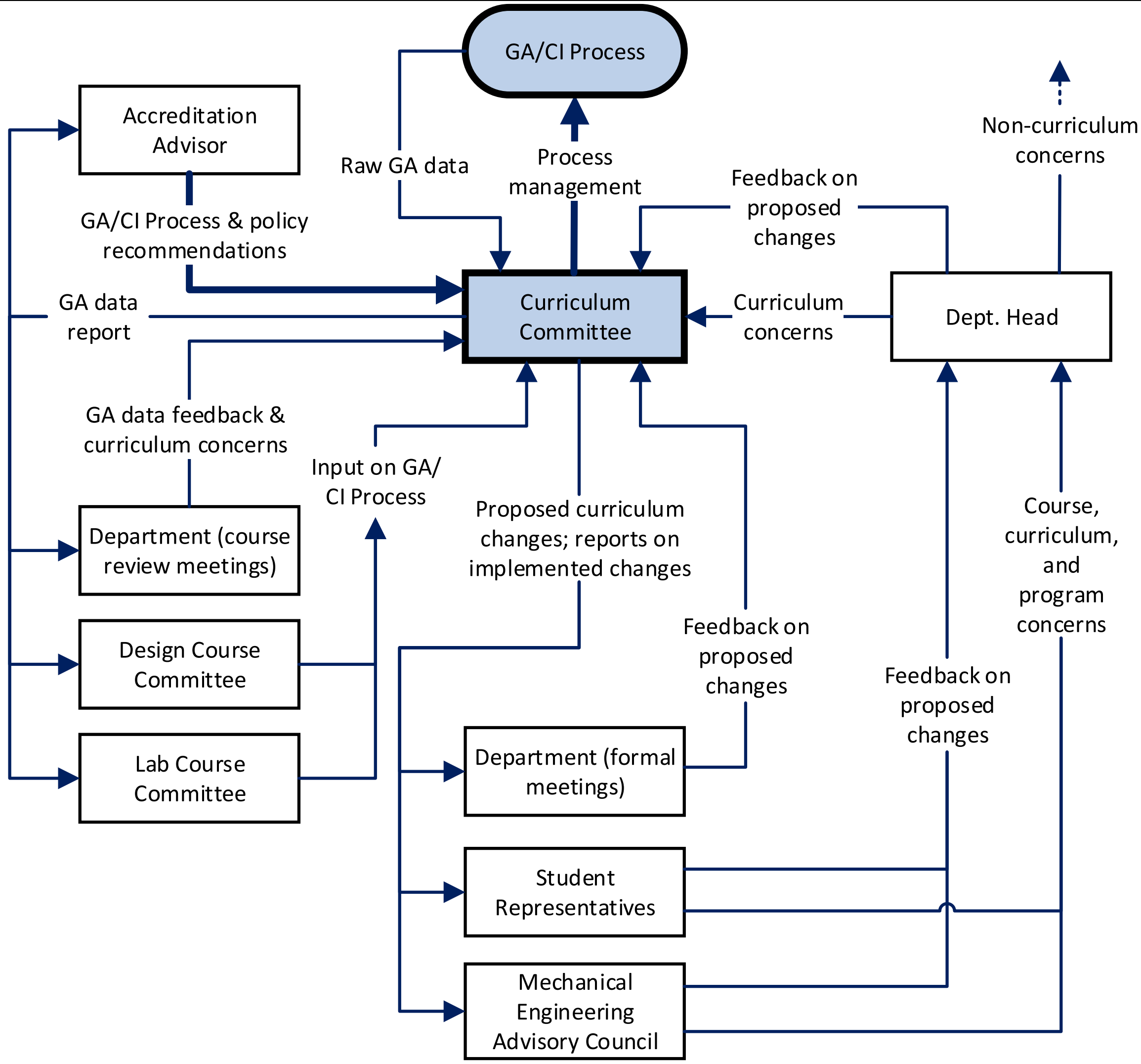

Figure 36. Current Continual Improvement Process Flowchart

The Curriculum Committee manages the graduate attribute (GA) and continual improvement (CI) processes and collects and collates the GA data into a report. The "GA data report" is not intended to be an in-depth formal written report, but rather a summary document or presentation on GA performance and its implications for the curriculum. The CI process is the 6-stage process shown at the start of this section. The GA data report is shared with the Design Course Committee and Lab Course Committee, which in turn give input on the GA/CI process. The GA data report is also shared with the Department members during course review meetings held twice per year at the end of term (before grades are posted). This gives the Department an opportunity to provide feedback on the data as well as to identify any general curriculum concerns. (See also "Timelines" below.)

This arrangement was formalized in 2017; in prior years, the Accreditation Advisor (although, that title did not formally exist at the time) worked closely with the Design and Lab Course Committees (which were also not formally recognized at the time) to develop and manage the GA process. Formal mechanisms for curriculum change through the GA/CI process were inadequate. For completeness, this prior arrangement is shown below in Figure 37. GA data reporting to the Curriculum Committee and the Design Committee was informal and intermittent.

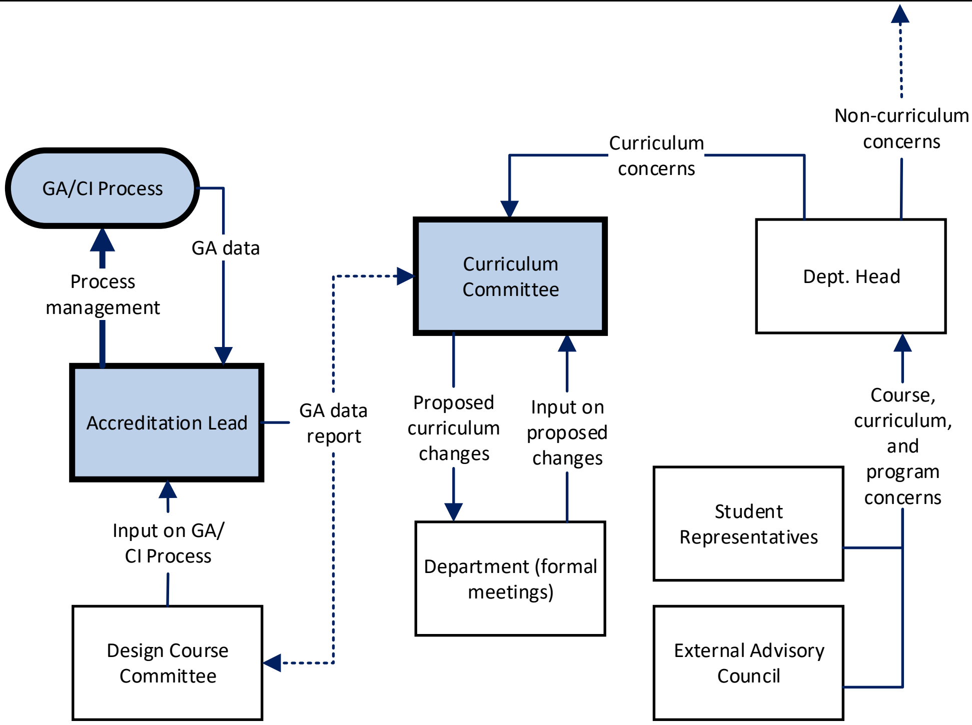

Figure 37. Continual Improvement Process Flowchart, Prior System

Timelines

To date, the GA/CI process has been ongoing and active, but informal. The emphasis from 2010 to 2016 was on developing a functioning system, running pilot studies, and learning about the process, rather than on establishing a formal, sustainable system. Data has been collected in increasing amounts every year, but analysis and interpretation has taken place on an ad hoc basis to the degree needed to ensure the viability of the process.

Timelines moving forward with the new process have been tentatively established. Proposed curriculum change discussions in formal Department meetings, Departmental course review meetings, and meetings with student representatives in focus groups all already happen twice per year. Meetings with the MEAC typically take place three times per year, with additional ad hoc meetings scheduled with MEAC sub-committees as needed. The next two years (until the end of 2019) will be to focus on addressing shortcomings identified through the current GA/CI process (i.e. deficiencies in quantity or quality of measurement data), in order to develop a more reliable data set. Coordinated with course review meetings starting January 2018 (and occurring every May and January thereafter), attribute data will be officially analyzed, interpreted, and shared with the Department in 3-year cycles. A minimum of two attributes will be considered at each course review meeting (four attributes per year), so as to review all twelve attributes within three years. The priorities of which attributes to consider first—which also dictates which attributes will be considered multiple times before the next visit—will be determined by the Curriculum Committee in the fall of 2017.

Lastly, the Department undergoes independent external reviews at the conclusion of the term of the Department Head. The most recent review occurred in 2016, and was conducted by a panel of professors and emeriti from four schools across North America. The panel conducted a site visit and interviews, and produced an eight-page recommendation report[2] in response to over 1000 pages of documentation submitted by the Department. The full report was shared with all faculty, as was the Department's response to the report. The Department has already implemented many of the recommendations and continues to work on implementing others (discussed further below).

2.2 *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 key stakeholders involved in the continual improvement process, and their roles in decision-making, are detailed above. To summarize, the key stakeholders include

- the Department faculty and key staff, engaged through semi-annual course review meetings, formal department meetings, department retreats, and informal discussions (e.g. communities of practice and mentoring);
- students (both formally elected to student government positions in "Club Mech" and informally selected on an ad hoc basis), engaged through semi-annual focus group sessions;
- the Mechanical Engineering External Advisory Council, engaged through three meetings per year, with additional ad-hoc meetings with sub-committees, as necessary; and
- formal external review panels (in addition to CEAB).

In addition, we survey current students and recent alumni as part of our GA/CI process, and could foreseeably add questions on a survey to gather broad feedback on proposed curriculum changes.

The rationale for the above stakeholder groups is that it provides broad input from different perspectives, including those who provide the training, those who learn and use the training, and those from industry who employ graduates. In addition, the needs of supervisors of graduate students are captured through feedback from our faculty.

2.3 *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 <u>at the program level</u>. 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.

<u>Do not describe incremental course-level actions that are routinely implemented by instructors.</u>

Continual improvement actions taken to date fall into four broad categories: changes to the curriculum based on stakeholder consultation, possible curriculum deficiencies identified for further study, changes to the continual improvement process, and other changes to support teaching, learning, and student wellbeing. Key examples of curriculum improvement actions in each of these four categories are outlined below.

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[2] Zu, J., Ulsoy, G., Riley, J., and Wetton, B., "FINAL REPORT - External Review of the Department of Mechanical Engineering, [redacted] November 1, 2016.

Changes to the Curriculum

The following changes to the curriculum have been implemented in the last several years.

- Common First Year Introduction to Engineering: The first year Introduction to Engineering courses have recently been reviewed and redesigned. This initiative began due to ongoing informal student and faculty complaints from across the Faculty of Applied Science about the previous, now discontinued, courses (specifically APSC 122 and APSC 150). In 2014/15, an extensive consultation process began, with stakeholders including students and alumni (through workshops, focus groups, and surveys), program heads, curriculum committee members, design instructors from all disciplines, sustainability instructors from all disciplines, communications instructors, learning technology experts, faculty and staff with expertise in equity, faculty and staff involved in student professional development, and many more. Significant deficiencies in the previous curriculum were identified through this consultation process, and two new courses (APSC 100 and 101) were developed, again, with ongoing stakeholder consultation. In the 2015/16 academic year, these courses were offered for the first time. Through ongoing stakeholder engagement, the courses continue to evolve.
- Communication Skills: Based on student deficiencies in communication noted during regular Departmental course review meetings, starting in 2014, a communication diagnostic test was introduced into the start of second year. This diagnostic is used to direct students into either the standard MECH 226 course (Technical Communications for Mechanical Engineers, 3 credits), or the MECH 227 course (Approaches to Technical Communications for Mechanical Engineers, 5 credits). The MECH 227 course runs in the summer, instead of normal winter term, and provides additional instruction, support, and guidance to students with weaker communication skills. The faculty member responsible for technical communications in the Department (Dr. [redacted] was responsible for developing the course, in consultation with the [redacted] Coordinator (Dr. [redacted] and the Curriculum Committee at the time.
- Third Year Design: Based on feedback provided by students during regular focus group meetings in 2013/14, concerns were raised about effectiveness and utility of the MECH 326 course (Mechanical Design II). The Department Head assigned a new faculty member to the course and a consultation process ran for the 2014/15 academic year (including student meetings, student surveys, and Design Course Committee meetings). This resulted in changes to the content of MECH 325 (Mechanical Design I) and MECH 326, as well as a realignment between these courses and MECH 328 (Mechanical Engineering Design Project). The revised MECH 325 and 326 courses were launched in 2015/16 academic year, with MECH 325 focusing more specifically on mechanical components in, machine design, and MECH 326 focusing on analysis tools in machine design, including shafts and welds.
- Coverage of Fracture and Fatigue: In a 2016/17 curriculum review, the Mechanical Engineering External Advisory Council (MEAC) noted that fracture and fatigue were covered in MECH 326 and strongly advocated that an understanding of these two topics was critical and should be emphasized. A review of other mechanical engineering curricula in both Canada and the US was undertaken. As a result, additional coverage fracture was added to MECH 360 (Mechanics of Materials). Now, fatigue is covered in MECH 221 (Engineering Science I) and MECH 326, and fracture is covered in MECH 326 and MECH 360.
- Third Year Laboratory and Statistics Course: Through student focus group meetings over several years, students have complained about the effectiveness of the MECH 30X course (Data Analysis and Mechanical Engineering / Mechatronics Laboratories). Students were proficient at completing well-defined laboratory experiments and preparing lab reports (as evidenced by performance in the MECH 30X course, for example), but had limited exposure to designing their own experiments. Similar concerns were observed by instructors of design project courses, and by technicians who monitor labs on a day-to-day basis (the

latter were brought to the attention of the head through one of the staff managers). Finally, this was also discussed by the MEAC ad hoc curriculum committee in the summer of 2016, as they independently brought up the importance of students understanding how to design and conduct experiments (rather than follow a set of prepared lab instructions). This recommendation was brought to the full MEAC, who ratified it and presented it to the Department. In 2016, a committee led by the Associate Head for Teaching was struck by the Department Head to study this issue. Consultation is ongoing, and two faculty members have been assigned to redevelop the MECH 30X course, with first changes expected to be introduced in 2018. The new course is expected to have a significant design of experiments component, but, more broadly, the role of labs through the entire third year curriculum is being examined. In addition, the integration of statistics within the MECH 30X course is being reviewed. Final changes to the course are expected to be implemented by the 2018/19 academic year.

Possible Deficiencies Highlighted for Further Study

Through the current GA/CI process, we have identified several possible deficiencies in the curriculum; however, the data are not sufficiently robust as to be able to draw firm conclusions yet. We have highlighted these issues and will collect further data for at least one more year, as well as consult with our student representatives and the MEAC before recommending any changes. The possible deficiencies highlighted include:

- Indicator 5.1 (Visual Representations), where 7% of students are "below expectations" and 13% are "marginally meeting expectations," and Indicator 5.3 (Model, Analyze, and Simulate Systems), where 9% are "below expectations" and 10% are "marginally meeting expectations;"
- Indicator 6.1 (Appreciation of Team Diversity), where 18% of students are "below expectations" and 10% "marginally meeting expectations;
- Attribute 8 (Professionalism), where there is a discrepancy between academic data and other data (our measurements suggest roughly two-thirds of students perform at an "exceeds expectations" level, while students, alumni, and co-op employers report roughly one-third of students achieve this level);
- Indicator 9.3 (Sustainability) and Indicator 9.4 (Management Techniques for Sustainable Development), where, although data are sparse, significant numbers of students perform below expectations (17% "below expectations" or "marginally meeting expectations" for Indicator 9.3. and 15% for Indicator 9.4);
- Indicator 11.1 (Economic and Business Principles), where almost 10% are performing at a "below expectations" level, and Indicator 11.4 (Project Risk), where over 15% of students are performing "below expectations" in fourth year; and
- Attribute 11 (Economics and Project Management) overall, where there is a significant discrepancy between academic data and student and alumni survey data (students and alumni are both more pessimistic in their self-appraisals).

Changes to the Process

In completing the GA data analysis for this report, several deficiencies in the GA data collection process were noted, and are currently being addressed. This include the following:

- Assessment of Indicator 4.2 (Need and Constraint Identification): In Indicator 4.2, 42% of second year students are performing below expectations. This is likely due to the assessment tool used (open-ended final exam question). Alternative or supplementary assessments with higher validity, reliability, and authenticity are being sought for second year. In third and fourth year, where this indicator is required to complete projects, student performance is strong (hence the reason this is not believed to be a deficiency in the curriculum, but rather in the data collection).
- Enhancements to Rubrics: Rubrics from across the curriculum are being reviewed and revised. This is being done to increase the number of indicators assessed, but also the alignment between assessments and indicators.

- o In MECH 223 and MECH 226, additional assessments are being identified for indicators in Attributes 9, 10, and 12, as described previously.
- o In MECH 328, the validity and reliability of rubrics are being examined.
- o In the new version of the MECH 30X course under development, rubrics are being designed, and will likely be based off of similar rubrics for second year lab courses.
- o In MECH 45X, as mentioned previously, data collection and analysis methods were inadequate. In most cases, rubrics lacked well-defined descriptors at each level of mastery, but, in addition, different instructors used the rubrics in different ways (leading to low validity and low reliability in the accreditation data) and data was not recorded on an indicator-by-indicator level. Here it is worth stressing that the concern is not in the quality of the course or in the abilities of the students, but rather in the way assessment data are collected and recorded. This has been flagged as a critical issue, and the MECH 45X rubric currently being reviewed and revised in time for the start of the 2017/18 academic year.
- o The rubrics for peer evaluation in APSC 100, APSC 101, MECH 223, MECH 325, MECH 326, MECH 328, and MECH 45X have been redeveloped in time for the 2017/18 academic year, and, at the time of this document, have been circulated for review to faculty members teaching in those courses for approval.

- <u>Changes to Indicators</u>: Having gone through the GA/CI process, it has become apparent that some of the indicators needed to be changed. At a joint meeting between the Curriculum Committee and Design Course Committee, the following changes have been proposed. Official changes are pending Department approval the next department meeting in September, 2017:

- o Indicator 8.3 (Meeting Participation) had been included from 2011 until 2016, but will be dropped moving forward. Having now collected and analyzed extensive data for this attribute, it has become clear that Indicator 8.3 (Meeting Participation) overlaps strongly with Indicators 6.2 (Communication), 6.3 (Responsibility), 6.4 (Initiative), and 6.5 (Leadership). It is proposed to drop Indicator 8.3;
- o Indicator 10.1 (Ethical Behaviour) was expanded to include non-academic-related matters;
- o The closely-related Indicators 10.2 (Codes of Conduct) and 10.4 Consequences of Code Violation) were merged into one indicator;
- o Indicators 11.3 (Project Scope) and 11.4 (Project Risk) were closely related and were merged into one indicator;
- o Indicator 12.2 (Learning Strategy) was removed as it was felt to be redundant with full and correct application of Indicators 12.1 (Identification of Learning Need), 12.3 (Identification of Information Sources), 12.4 (Evaluation and Synthesis of Information), and 12.5 (Reflection); and
- o Indicator 12.6 (Motivation for Self-Education) was removed as it was felt to go beyond the CEAB definition of Attribute 12, and as part of the affective domain was difficult to assess with validity, reliability, and authenticity.

Other Changes to Support Teaching, Learning, and Student-Wellbeing

In addition to the curriculum and GA/CI process-related improvements above, the Department continuously seeks to improve in all areas. Three items of note related to undergraduate students that were raised in the External Review Report (November, 2016) are listed below, followed by a synopsis of the official Department responses.

- <u>Recommendation: Increase international exchange programs.</u> Response: The Department is currently working actively with the Dean's Office to increase international exchanges, through the Coordinated International Experience (CIE) program.
- <u>Recommendation: Implement online course offering.</u> Response: The Department has begun work on three online course offerings. MECH 484 (Aircraft Design: Aerodynamics, technical elective) will be offered in a blended-delivery mode for September 2017, including online instruction and discussions, video content, weekly in-person tutorials with TAs, field trips,

and in-person laboratory sessions. A section of MECH 431 (Engineering Economics) will be offered as on online course in May 2018 (summer). The delivery model is under development. The Department will continue to offer an in-person section for students who prefer face-to-face learning. A new course that satisfies the Impact of Technology on Society requirement is under development, for delivery beginning in May, 2018.

- Recommendation: Work with the Dean's office to pursue the upgrade and improvement of space and facilities in the Department. Response: The Department has recognized for a long time that it is in dire need of more and better quality space, and has worked with the Dean's office to make replacement of the Rusty Hut the top priority for new buildings within Applied Science.