Questionnaire for Evaluation of an Engineering Program - Exhibit 1

Submitted by:

[redacted]

INDUSTRIAL ENGINEERING

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Canadian Engineering Accreditation Board
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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

The Faculty of Engineering and Computer Science (ENCS) of [redacted] has adopted a holistic approach for implementing and sustaining a Continual Improvement Program (CIP) in all its engineering programs. Senior administration that includes Dean, Associate Deans, Department Chairs, and Undergraduate Program Directors (UGPD) introduced a sustainable outcome based assessment philosophy. In recent years, the Department Curriculum Director position was created to undertake leadership of the CIP within the Departments. In turn, faculty members have taken ownership of the CIP implementation in their courses and through the departmental committees.

Below is a short description of individuals and committees that are directly engaged in the successful implementation of CIP. Later in this section, the level and the nature of the faculty members', students' and other stakeholders' engagements are discussed.

1.1.1 Faculty Level Organization

[redacted] is a licensed professional engineer with Professional Engineers Ontario. [redacted] authored the most recent ENCS strategic plan that focuses on training the next generation of engineering and computer science leaders. As articulated in this strategic plan, ENCS's vision for training future engineers aligns very well with the expectations of CEAB. Dean Asif has allocated considerable resources (including a new faculty hire) to implement innovations in engineering education inspired by the graduate attributes, and to oversee efforts in the continuous improvement process.

Associate Dean of Academic Programs, [redacted] is a licensed professional engineer with Professional Engineers Ontario. [redacted] oversees all activities related to accreditation and CIP on the behalf of the Dean of ENCS. [redacted] chairs following committees that were formed in recent years in order to support continual improvement process.

- Engineering and Computer Science Undergraduate Studies Committee (ECSUSC)
- Faculty Design Committee
- Continuous Improvement Process ad-hoc committees for non-technical skills

[redacted] chairs CIP ad-hoc committees for analyzing non-technical (complementary skills) graduate attributes. These committees meet annually to analyze the results of graduate attribute measurements. Members of the ad-hoc CIP committees are those faculty members who taught and measure non-technical attributes in the previous academic year and are disciplinary experts in complementary studies (primarily from the Center for Engineering in Society). These attributes covered by the faculty-level ad-hoc committees are:

- Individual and Team Work

- Communication Skills
- Professionalism
- Impact of Engineering on Society and the Environment
- Ethics and Equity
- Economics and Project Management

ENCS has chosen to analyze the non-technical attributes at the faculty level in order to:

- Maintain a faculty wide standard for all graduating students in these critical skills across all programs of study
- Assure consistency among all ENCS programs
- Enable fast, efficient knowledge transfer between different programs through greater collaboration
    - ENCS Philosophy for CIP is:
      Experiment → Learn → Adopt → Transfer lessons learned to all programs → Sustain and improve

ENCS leadership has introduced several major initiatives to ensure a successful and sustainable CIP in all engineering programs including:

1. The creation of a "Department Curriculum Director" positions in 2011 in all ENCS departments
2. The establishment of "Faculty Design Committee" in 2013.
3. The establishment of the "Center for Engineering in Society" in 2011, focusing on non-technical attributes in all engineering programs.
4. The provision of IT support for the development of "Information Systems Solution for Graduate Attribute Assessment" (ongoing).
5. The enrollment of ENCS as an institutional member of Canadian Engineering Education Association (CEEA) since 2013. The Faculty has been sponsoring one faculty member from each department to attend CEEA conferences since 2013.
6. The involvement of ENCS as a founding and active member of EGAD (Engineering Graduate Attribute Development).
7. A leadership role as a member of the Engineering Change Lab with strong participation in the education community.
8. The hiring of a full-time faculty member with expertise in Engineering Education, [redacted] who is expected to join soon.
9. The securing of the prestigious NSERC Design Chair in 2015.
    - [redacted] Design Co-chair
    - [redacted]Design Co-chair

<u>Department Chairs</u> are leaders in their departments who oversee all accreditation related activities. Chairs closely work with the Dean, Associate Dean of Academic Programs and department Curriculum Coordinators. Table 1 includes the list of Department Chairs at ENCS.

Table 1. List of Department Chairs (2016-2017)

Name	Academic Rank	Department	Licensure Status
[redacted]	Professor	Electrical and Computer Engineering (ECE)	ing.
[redacted]	Professor	Computer Science and Software Engineering (CSSE)	PEng
[redacted]	Professor	Building, Civil and Environmental Engineering (BCEE)	PEng
[redacted]	Professor	Mechanical, Industrial and Aerospace Engineering (MIAE)	PEng
[redacted]	Associate Professor	Center for Engineering in Society (CES)	None

Department Curriculum Director positions were created in 2011 to lead the outcome based assessment and continual improvement process at the departmental level. Curriculum directors oversee all continuous improvement related activities within their departments and work closely with the Associate Dean of Academic Programs to design and test Faculty-level strategies to achieve effective and sustainable CIP and adopt these strategies in all engineering programs in ENCS. Curriculum Directors work closely with the undergraduate and co-op program directors and also the writers of the CEAB documents (see Figure 1 for illustration).

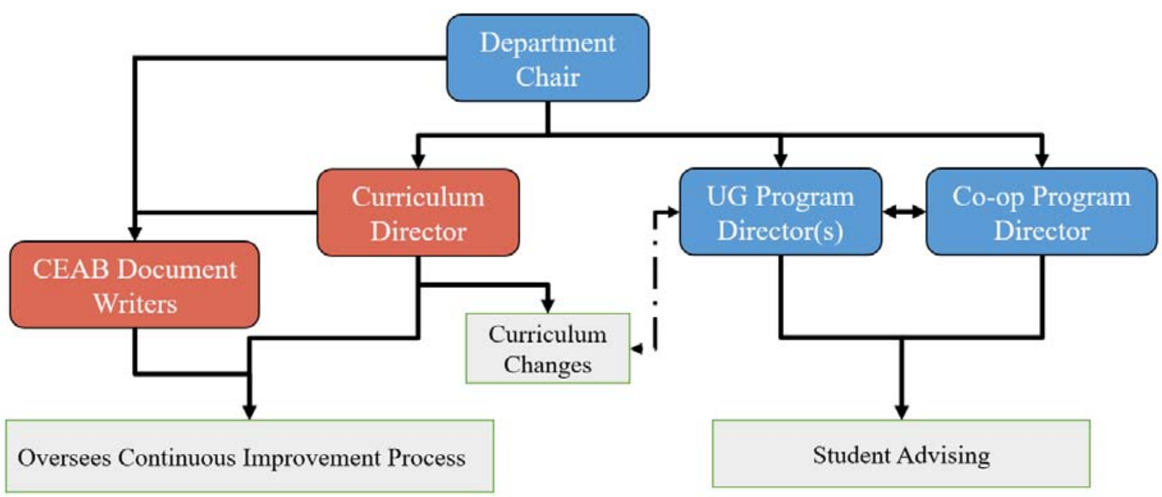

Figure 1. Role of Curriculum Directors within each ENCS department

Engineering and Computer Science Undergraduate Studies Committee (ECSUSC) is the faculty-level curriculum committee that oversees all activities related to the development of new programs, offering of new courses or changes in existing courses. Furthermore, ECUSC facilitates and coordinates CIP throughout all engineering programs. The CIP philosophy adopted in ENCS is the result of the work done by the current and past members of ECSUSC. Moreover, the ECSUSC continuously monitors current definitions of indicators, rubrics and student learning objectives, making revisions as necessary. The current membership of the ECSUSC is:

Table 2. Members of Engineering and Computer Science Undergraduate Studies Committee (2016-2017)

Name	Academic Rank	Current Position	Licensure Status	Role
[redacted]	Professor	Associate Dean of Academic Programs	PEng	Chair
[redacted]	N/A	Assistant to the Associate Dean	None	Secretary
[redacted]	Associate Professor	Curriculum Director, MIE	PEng	Member
[redacted]	Assistant Professor	Curriculum Director, CES	N/A	Member
[redacted]	Associate Professor	Curriculum Director, ECE	ing	Member
[redacted]	Associate Professor	Curriculum Director, MIAE	ing	Member
[redacted]	Associate Professor	Curriculum Director, CSSE	None	Member
[redacted]	Undergraduate Student	VP Academics for Engineering and Computer Science Association (ECA)	None	Member

Some of the major initiatives led by ECSUSC in recent years to sustain and support graduate attribute assessment and CIP are:

- Integration of CIP in all engineering programs
- Definition of indicators
- Creation of suggested rubrics for indicators
- Description of "Student Learning Objectives" (SLO) for each indicator at each learning level (introduction, intermediate and advanced). These levels are equivalent to Introduced, Developed and Applied levels proposed by CEAB.
- Description of requirements and specifications for the information management system developed in-house for managing graduate attribute assessment and supporting CIP.
- Organization of workshops for training faculty members and administrative staff for CIP

<u>The Faculty Design Committee</u> was established in 2012 to promote and coordinate design education in all undergraduate programs of ENCS. The current CEAB requirements for design education were central in the establishment of the committee. The committee is comprised of two NSERC Design Co-chairs and faculty members with strong and expertise in engineering design from across ENCS. The current membership of the Faculty Design Committee is shown in Table 3.

Table 3. Members of Faculty Design Committee

Name	Academic Rank	Current Position	Licensure Status	Role
[redacted]	Professor	Associate Dean of Academic Programs	PEng	Chair
[redacted]	N/A	Assistant to the Associate Dean	N/A	Secretary
[redacted]	Associate Professor	NSERC Design Co-Chair for Aerospace Education	PEng	Member
[redacted]	Professor	NSERC Design Co-Chair for Design Research	PEng	Member
[redacted]	Professor	[redacted] Co-Director for Education	ing	Member
[redacted]	Professor	Faculty member in ECE	PEng	Member
[redacted]	Professor	Faculty Member in MIAE	PEng	Member
[redacted]	Associate Professor	Faculty Member in BCEE	PEng	Member
[redacted]	Assistant Professor	Faculty Member in CSSE	PEng	Member

1.1.2 Department-Level Organization

[redacted] is a licensed professional engineer with Professional Engineers Ontario, responsible for coordinating all activities for CIP in the Department of Mechanical, Industrial and Aerospace Engineering. (MIAE) The Chair is a crucial liaison between the Dean and the department. He works closely with the Curriculum Director, [redacted] to realize a successful CIP at all three programs under MIAE.

MIAE Department Undergraduate Curriculum Director [redacted] is a registered professional engineer with Ordre des ingénieurs du Québec (OIQ), responsible for establishing liaison between faculty and the department and leading all curriculum and continuous improvement initiatives on the behalf of [redacted]. [redacted] chairs the Department Curriculum Committee and coordinates ad-hoc CIP committees in the department for analyzing the following graduate attributes:

- A knowledge base for engineering
- Problem analysis
- Investigation
- Design
- Use of engineering tools
- Life-long learning

MIAE Department Undergraduate Curriculum Committee (UCC) reviews all new curriculum initiatives that include new program and course developments and curriculum changes and makes recommendations to the Department Council accordingly. Since it was first mandated by the CEAB, the UCC has been coordinating and promoting all activities concerning outcome based assessment and CIP. While general frameworks for the CIP is clearly defined by the ECSUSC, all departments have the flexibility to include their perspectives.
Some of the fundamental responsibilities of the UCC relevant to the CIP are:

- Overseeing all CIP related activities within MIAE
- Establishing practices for curriculum mapping and graduate attribute measurement
- Implementing the Faculty's recommendations
- Enforcing the processes for graduate attribute measurement, data collection, and data analysis
- Making recommendations to Department Council for the membership of ad-hoc CIP committees for analyzing graduate attribute assessment results
- Evaluating the recommendations of ad-hoc CIP committees
- Making recommendations to Department Council for curriculum improvements.
- Administering the implementation CIP.

Current members of the MIAE UCC are:

Table 4. Members of Department Curriculum Committee for 2016-2017

Name	Academic Rank	Licensure Status	Role in the committee
[redacted]	Assoc. Professor	ing	Chair
[redacted]	Professor	PEng	Member
[redacted]	Associate Professor	PEng	Member
[redacted]	Associate Professor	PEng	Undergraduate Program Director (MECH)
[redacted]	Professor	ing	Undergraduate Program Director (AERO)
[redacted]	Professor	PEng	Ex-officio (Dept. Chair)
[redacted]	Professor	PEng	Member (Dept. Associate Chair)
[redacted]	Associate Professor	PEng	Undergraduate Program Director (INDU)
[redacted]	ETA	ingJr	Co-op director

*ETA: Extended Term Appointment (Lecturer)

CIP Ad-Hoc Committees for Analyzing Graduate Attribute Measurement

The Department of Mechanical, Industrial and Aerospace Engineering (MIAE) has 6 standing continual improvement sub-committees that meet annually to analyze the measurement results for the following graduate attributes:

- A knowledge base for engineering
- Problem analysis
- Investigation
- Design
- Use of engineering tools
- Life-long learning

These sub-committees review their respective attributes for all three UG programs in the Department. Whilst each of the three programs has its own Curriculum Map and attribute assessment collection methods, the results of the assessments are reviewed by these sub-committees at the departmental level to ensure best practice across the three programs and to allow a wider perspective when considering the attributes. In many cases these attributes are being assessed across common courses. It also means that there are only 6 sub-committees in the department and not 18, which would be cumbersome and untenable.

The chairs and the membership of the committees are nominated by the UCC and approved by the Department Council. The department invites faculty members who teach courses that are assessing the particular graduate attribute during the academic year to join the ad-hoc committees as members. Since the committee members already measure a particular graduate attribute in the course in the given academic year, their feedback has been found to be accurate and complements the data that is collected from students as part of the CIP. Moreover, course instructor based CIP committees have increased the faculty members' engagements in the process. Their overall contributions to the CIP have increased significantly.

Table 5. Members of Department CIP Committees

(a) *A Knowledge base for engineering*

Name	Academic Rank	Current Position	Licensure Status	Role in the committee
[redacted]	Professor		PEng	
[redacted]	Professor		PEng	
[redacted]	Assoc. Prof	Curriculum Director	ing	Co-Chair
[redacted]	Assis. Prof		ing	
[redacted]	Assoc. Prof		ing	
[redacted]	Assoc. Prof	INDU Program Director	PEng	Chair
[redacted]	Professor	AERO Program Director	ing	

(b) Problem Analysis

Name	Academic Rank	Current Position	Licensure Status	Role in the committee
[redacted]	Professor		PEng	
[redacted]	Professor		PEng	
[redacted]	Assoc. Prof	Curriculum Director	ing	Co-Chair
[redacted]	Assis. Prof		ing	
[redacted]	Assoc. Prof		ing	
[redacted]	Assoc. Prof	INDU Program Director	PEng	Chair

(c) *Investigation*

Name	Academic Rank	Current Position	Licensure Status	Role in the committee
[redacted]	Professor		PEng	Chair
[redacted]	Professor		PEng	
[redacted]	ETA	COOP-Director 17/18	ingJr	
[redacted]	Professor	COOP-Director 16/17	ing	
[redacted]	Assoc. Prof		PEng	
[redacted]	Professor		ing	
[redacted]	ETA		PEng	
[redacted]	Professor	Dept. Chair	PEng	
[redacted]	Professor		PEng	
[redacted]	Professor		PEng	

(d) *Design*

Name	Academic Rank	Current Position	Licensure Status	Role in the committee
[redacted]	Professor		PEng	
[redacted]	Professor		PEng	
[redacted]	Professor		ing	Co-Chair
[redacted]	Professor		PEng	
[redacted]	Professor		PEng	
[redacted]	ETA	COOP-Director 17/18	ingJr	
[redacted]	Assoc. Prof		PEng	
[redacted]	Professor		ing	
[redacted]	LTA		PEng	
[redacted]	Assoc. Prof	Curriculum Director	ing	
[redacted]	ETA		PEng	Co-Chair
[redacted]	Assoc. Prof	INDU Program Director	PEng	
[redacted]	Professor		PEng	
[redacted]	Engineer in Residence		ing	
[redacted]	Professor		PEng	
[redacted]	Professor		PEng	
[redacted]	Assoc. Prof		ingJr	
[redacted]	Professor		PEng	

***(e)** Use of Engineering Tools*

Name	Academic Rank	Current Position	Licensure Status	Role in the committee
[redacted]	Professor		PEng	
[redacted]	Professor		PEng	
[redacted]	Professor	COOP-Director 16/17	ing	
[redacted]	ETA	COOP-Director 17/18	ingJr	
[redacted]	Assoc. Prof		PEng	
[redacted]	Professor		ing	
[redacted]	LTA		PEng	
[redacted]	ETA		PEng	
[redacted]	Assoc. Prof		ing	
[redacted]	Assoc. Prof	INDU Program Dirct.	PEng	
[redacted]	Engineer in Residence		ing	
[redacted]	Professor		PEng	
[redacted]	Professor	Dept. Chair	PEng	
[redacted]	Professor		PEng	
[redacted]	Assoc. Prof		ingJr	Chair
[redacted]	Professor		PEng	

***(f)** Life-long Learning*

Name	Academic Rank	Current Position	Licensure Status	Role in the committee
[redacted]	ETA	COOP-Director 17/18	ingJr	Chair
[redacted]	LTA		PEng	
[redacted]	ETA		PEng	
[redacted]	Professor		PEng	
[redacted]	Professor	Dept. Chair	PEng	
[redacted]	Assoc. Prof		ing	

1.2 Indicators

This section introduces the ENCS philosophy for establishing the CIP in all eight engineering programs. The indicators, rubrics, student learning objectives, and the continual improvement process are similar across all departments. Later in the document, information specific to the computer engineering program is provided.

1.2.1 History of Indicator Evolution

Common Indicators

ENCS has adopted common indicators for all engineering programs. Indicators reflect ENCS's philosophy for training the next generation of engineers on a particular attribute. Each indicator is further elaborated by the "Student Learning Objectives" at the introductory, intermediate and advanced levels. Student Learning Objectives (SLO) provide an abstract description of expectations for a particular graduate indicator from students at each learning level.

Introducing common indicators helped the faculty to achieve two goals:

i. **Define the desired identity of the graduates of** [redacted] Independent from the field of study, the given twelve graduate attributes sets the expected standards for Canadian engineering graduates. Indicators further enabled ENCS to highlight [redacted]s vision for graduating engineers. Since the current graduate attribute assessment systems evaluates students based on their competencies on various engineering skills, the common indicators help ENCS to monitor the quality of different programs, identify weaknesses, adopt solution strategies to overcome these deficiency and expand these solution strategies to all programs. Consequently, students graduating from all ENCS programs exceed the minimum academic expectations to become an engineer.

ii. **Facilitate collaboration among departments:** From the beginning, ENCS has realized that a successful Continual Improvement Process is only possible with the engagement of all parties (faculty members, student, support staff and leadership team). A common system encouraged programs to work closely with the leadership teams. The process has also helped faculty members to become familiar with the expectations of the continual improvement process.

Stakeholders

The current definitions of indicators are the result of meticulous work performed by a number of different stakeholders over an extended period of time. Some of the main stakeholders are:

- **Course Instructors**
  The main contributors to the indicator definition process are the course instructors. During the 2010-12 assessment periods, ENCS did not have a list of indicators. Instead, course instructors were asked to suggest indicators for the graduate attributes that were assigned to their courses. Starting in the 2011-12 academic year, ECSUSC has been compiling these indicators and grouping them under more general titles. These titles helped ECSUSC in forming the current indicator lists.

- **External Experts to ENCS**

  Under the leaderships of the previous [redacted] and the current [redacted] Associate Dean of Academic Programs, a number of ad-hoc committees have been formed with both internal and external experts. ENCs invited experts from non-engineering disciplines such as education, communication and business to define the indicators. External experts have provided valuable contributions for the definition of graduate attributes. In some occasions, these members took part in ad-hoc committees that eventually defined the earlier version of common graduate indicators. Some of the external experts that ENCS worked with are:

  [redacted] is a University Teaching Fellow and a member of The Centre for Teaching and Learning Services (CTL). She is also a faculty member in the Applied Human Sciences. Dr. Reilly helped ENCS in the development of graduate indicators for *Individual and Teamwork* graduate attribute.
  [redacted] Dean of JMSB, is an expert in teamwork and peer evaluation methodologies. He has published journal and conference articles on the effectiveness of peer evaluation methods (Donia, O'Neill and Brutus, 2015; Brutus, 1999; Brutus 2010). His peer evaluation tools have been available in the [redacted] course management system (Moodle) for ENCS faculty members to use for measuring "Individual and Teamwork" graduate attributes. Dr. Brutus helped ENCS to define indicators for the *Individual and Teamwork* attribute.
  [redacted] CTL, assisted ENCS in the process of defining graduate indicators for *Use of Engineering Tools*, *Design* and *Problem Analysis* graduate attributes.

- **Internal Experts**

Center for Engineering in Society (CES):
In 2011, ENCS established a center to assist students as they develop skills in communication, innovation, critical reasoning and an understanding of the relationship between technology and society on a global scale. The Centre for Engineering in Society (CES) currently includes 5 tenured or tenure-track faculty members and 3 full-time teaching stream faculty members from a variety of disciplinary backgrounds, including communication, ethics, technology assessment, public policy, engineering design and philosophy. A new teaching stream faculty member, [redacted], in the area of engineering education will join soon. [redacted] will work closely with the Associate Dean of Academic Programs to lead the Continual Improvement Process. Members of CES have greatly contributed to the development of the current graduate indicators.

NSERC Design Chairs:
[redacted] and [redacted] are NSERC Design co-chairs. [redacted] was also NSERC Tier II Research Chair in Design for 2 terms. They contributed significantly in the definition of indicators, rubrics and student learning objectives for the Design attribute. They are ex-officio members of the Faculty Design Committee. They both contribute to the analysis of the Design attribute at the faculty level.

- **Other Resources**

Engineering Graduate Attribute Development (EGAD) Project:
ENCS has been a founding member of EGAD. Workshops, publications and teleconferencing with all involved institutions helped ENCS to shape its graduate indicators. In the past 7 years, EGAD Project coordinator [redacted] from Queen's University and EGAD member [redacted] from l'École de technologie supérieure (ÉTS) have visited ENCS twice and provided extensive feedback on graduate indicators and the continual improvement process. ENCS continue working with EGAD through teleconferencing and organized workshops.

Canadian Engineering Education Association (CEEA) Conferences:
ENCS has been an institutional member of CEEA and the American Society for Engineering Education (ASEE). In order to increase the engagement of faculty members, ENCS has started a financial support program for the full-time faculty members who wish to attend CEEA Conferences. The support program has been running for 5 years. For the 2017 CEEA Conference in Toronto, ENCS will provide financial support for junior faculty members in order to increase the engagement of junior faculty members with the engineering education research and accreditation process. ENCS has successfully synthesized the best practices

presented in these conferences in its curriculum and continual improvement process.

CEAB Summits:

- [redacted] has been attending the CEAB Ontario Summit since the summit became available for non-Ontario universities.

- ENCS has been attending BCAPG QC (*Bureau canadien d'agrément des programmes de génie Québec*) (CEAB Seminar for Québec Universities) regularly. [redacted] was the host University for the BCAPG seminar in 2017.
  Both BCAPG and CEAB Ontario Summit have influenced the CIP established in the ENCS.

Engineering Change Lab:
ENCS has been a member as a Champion of Engineering Change Lab (ECL) which is the think tank organization aimed at defining the role of engineers in today's rapidly changing environment. The ECL members come from universities, industry, government and non-profit organizations. The topics studied in the lab such as leadership, global engineering, diversity, education are closely linked to the graduate attributes. Hence, the work performed at the lab had a significant impact on the indicator development process.

Engineering education literature:
In recent years, the academic interest in engineering education has increased. A number of universities (e.g. Purdue University, University of Calgary, University of Toronto and University of Illinois) have initiated formal postgraduate programs in Engineering Education. Moreover, the outcome based assessment mandate requested by the accreditation boards has brought challenges and opportunities for engineering education research. Consequently, topics relevant to accreditation and graduate attributes have started to appear in the proceedings of engineering education conferences (e.g. CEEA, ASEE or EEE Global Engineering Education Conference and engineering education journals (e.g. Journal of Engineering Education and International Journal of Engineering Education). The findings reported in the literature were used to arrive at the definitions of the attribute indicators.

Academic leadership:
Current definitions of the graduate indicators have been finalized by the Faculty Undergraduate Studies Committee and approved by the Department Councils of all programs.

In summary, the graduate indicator development process is depicted in Figure 2.

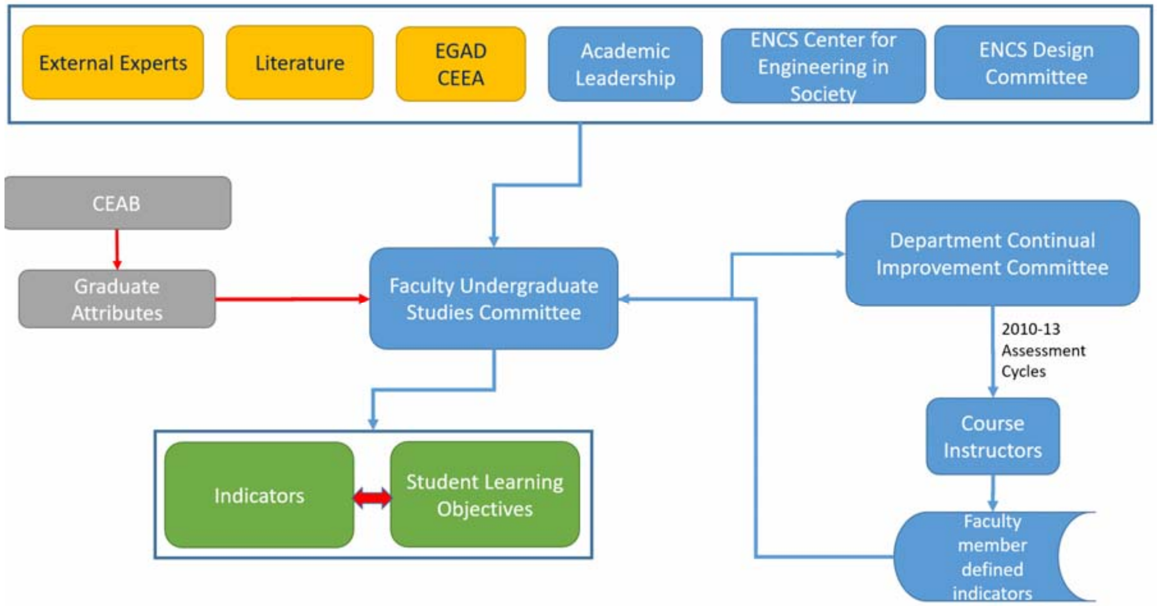

Figure 2. Development of Graduate Indicators in ENCS

Quantity

All graduate attributes are described by 2 to 4 graduate indicators. ENCS had initially decided to have four indicators for all attributes. Yearly reviews of CIP ad-hoc committees and ECSUSC revealed that it is unnecessary to describe all graduate attributes by four graduate indicators. Consequently, necessary changes have been made, and the current system of assessing 2 to 4 graduate indicators has been established in all departments.

Level of skill development activities

It is expected that learning activities associated with the graduate attributes follow a progression from basic to advanced skills. ENCS follows the 3 levels of learning activities recommended by CEAB (CEAB, 2015).

Introductory (Introduced): At the introductory level the students learn the working vocabulary of the area of content, along with some of the major underlying concepts. Many of the terms need defining and the ideas are often presented in a somewhat simplified way.

Intermediate (Developed): At the intermediate level the students use their working vocabulary and major fundamental concepts to begin to probe more deeply, to read the literature, and to deepen their exploration into concepts. At this level, students can begin to appreciate that any field of study is a complex mixture of sub-disciplines with many different levels of organization and analysis.

Advanced (Applied): At the advanced application level the students approach mastery in the area of content. They explore deeply into the discipline and experience the controversies, debate and uncertainties that characterize the leading edges of any field. An advanced student can be expected to relate learned material across different courses, to begin to synthesize, integrate and achieve fresh insights. Students at this level are working with the knowledge very differently, perhaps even creating new knowledge through independent investigation.

Student Learning Objectives (SLO)

Student Learning Objectives are developed to describe the expected competency levels of students on each graduate indicator at each learning level (introductory, intermediate and advanced). When the indicators were first introduced, ENCS described the expected student learning objectives without considering the progression from introductory through intermediate to advanced levels. This created confusion among course instructors for measuring the competency of students in different learning levels. Consequently, ENCS has consulted with education expert [redacted] and a continuous improvement specialist [redacted] to define SLOs according to the Bloom's taxonomy (Bloom, 1956). The current SLOs are not only providing the course instructors with a better perspective, but also helping them to interpret given rubrics for measuring student competencies on graduate indicators. The list of SLOs is provided later in the document describing each graduate attribute in detail.

Rubrics

Rubrics have been developed to assist course instructors to measure the student competency on a given graduate indicator in a homogenous way. Similar to the graduate indicator development process, course instructors provided the initial rubric descriptions. During 2010-13 assessment cycles, faculty members were asked to suggest rubrics for the graduate indicators that they introduced. Later, ECSUSC compiled these rubrics according to patterns/commonalities. Accordingly, a set of initial rubrics for each indicator was introduced using the list collected from the course instructor. Through consultation with the experts, the current rubrics were finalized at the Faculty level. Departments are encouraged to make modifications on the rubric definitions to reflect the unique characteristics and needs of their programs.

In order to obtain meaningful measurement data, the interpretation and the usage of rubrics is essential. When used with the SLOs, we expect the data reliability to increase.

1.3 Curriculum Map

1.3.1 Development

ENCS has adopted a philosophy of developing curriculum maps that are faculty member-centric. Once graduate indicators and SLOs were defined, course instructors were asked to provide a course-based curriculum map. In order to facilitate the process, first an Excel-based support tool was developed. Later, the functionality of the excel tool was expanded into the [redacted] Graduate Attribute Assessment System (CGAAS) which is an in-house information support system. Using this tool, faculty members have provided:

- The list of graduate attributes that are relevant to their courses
- Graduate indicators that are covered in the course
- The level of student's learning experience
- Comments to justify the proposed mapping

Following two figures (3 and 4) illustrate how faculty members provide the feedback for the curriculum mapping.

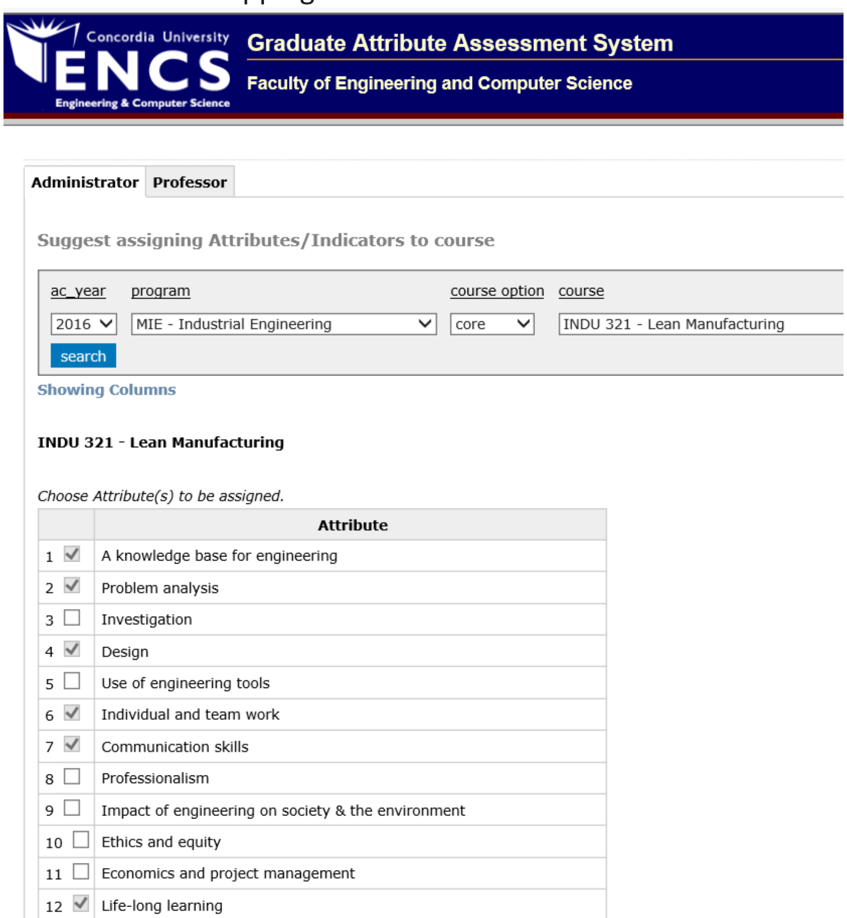

Figure 3. Process of Suggesting and/or Assigning Attributes/Indicators to a Course

Attribute					
2 Problem analysis					
Indicators	**Introductory**	**Intermediate**	**Advanced**	**Reason for the Relationship**	**Methods of Assessment**
PA-1 - Problem identification and formulation	○	◉	○	This course requires modeling of production systems. Hence, students should demonstrate their understanding of the system.	☑ Assignment ☑ Quiz ☑ Midterm ☑ Final ☑ Project ☐ Others
PA-2 - Modelling	○	◉	○	Various production systems should be modeled mathematically.	☑ Assignment ☑ Quiz ☑ Midterm ☑ Final ☑ Project ☐ Others
PA-3 - Problem solving	○	◉	○	Solution methodologies are introduced.	☑ Assignment ☑ Quiz ☑ Midterm ☑ Final ☑ Project ☐ Others
PA-4 - Analysis (uncertainty and incomplete knowledge)	◉	○	○	Demand variations, system failures etc should be included in the analysis.	☑ Assignment ☑ Quiz ☑ Midterm ☑ Final ☑ Project ☐ Others

Figure 4. Suggesting graduate indicators and providing justifications (Example for Problem Analysis)

The curriculum map development and approval process is illustrated in Figure 5.

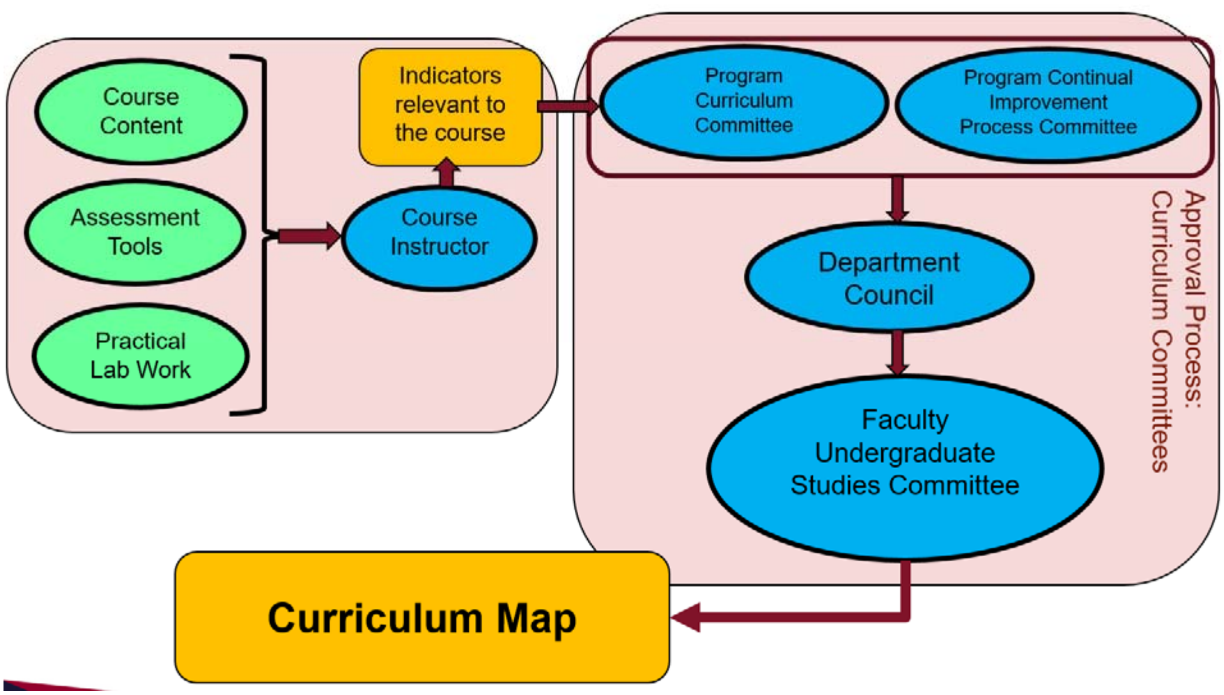

Figure 5. Curriculum map development and approval process

1.3.2 Curriculum Map Alignment

While faculty members' feedback on courses was the backbone of the curriculum map structure, further refinements were necessary to ensure the course content and graduate indicator level alignment and course sequence and graduate level alignment are accurate. ENCS has developed a tool as part of its CGAAS to crosscheck the competency of the current curriculum map and the course sequence to identify possible conflicts. Below, Figure 6 illustrates the output of course sequence and curriculum map alignment.

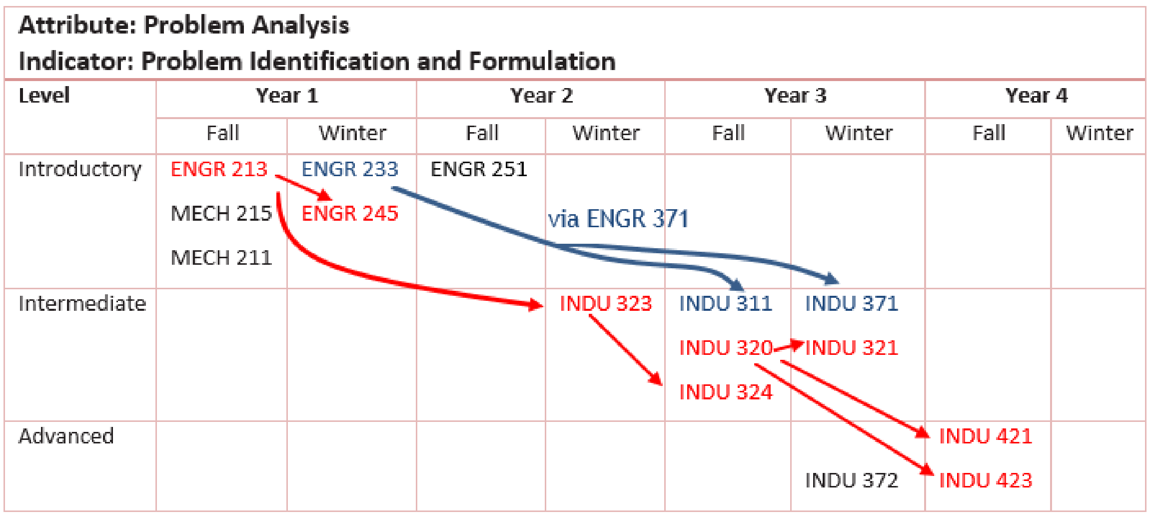

Figure 6. Course sequence and curriculum map alignment (Arrows show the prerequisite relationships.

Next, ENCS provided departments methods for aligning course content and indicator levels. As suggested by the CEAB, all course instructors (or coordinators for multi section courses) have defined a list of Course Learning Outcomes (CLO) that best describe the expected skill sets acquired by the students by the end of the term. Student Learning Objectives on the other hand are specific to learning levels at each indicator (introductory, intermediate and advanced). The relationship between CLOs and SLOs provides a more accurate alignment between the course content and the graduate indicator levels. Below, Figure 7 illustrates how CLOs and SLOs can be coupled to map courses on different learning levels. ENCS is currently working with the course instructors to validate the indicator level mapping for all core-courses using CLO-SLO relationship.

+

INDU 311 – Simulation of Industrial Systems		
Course Learning Outcomes (from course outlines)	Student Learning Objective (PA-PIF)	Level
• Collect data that helps students to understand the behavior of a system • Analyze data so system can be defined by representative distributions • Model a system in computer using a simulation software • Validate the accuracy of the computer model • Generate alternative scenarios • Formulate hypothesis to compare each alternative against each other for the given set of objectives • Compare alternatives • Apply acquired skills on a real-life case • Master working in groups • Master the technical communication skills	• Explain/describe the problem • Explain given information and ideas • Identify missing information	Introduction
	• Draw connections among ideas • Interpret unknowns and ambiguities • Examine all facts to produce new solutions	Intermediate
	• Justify and defend solutions • Formulate/produce new solutions based on supporting evidence	Advanced

Figure 7. The relationship between CLOs and SLOs to map courses: Example for Problem Analysis in INDU 311 course.

Figure 8 further illustrates the development of the curriculum map. In the figure, development of indicators and feedback loop for the development of the curriculum map is depicted.

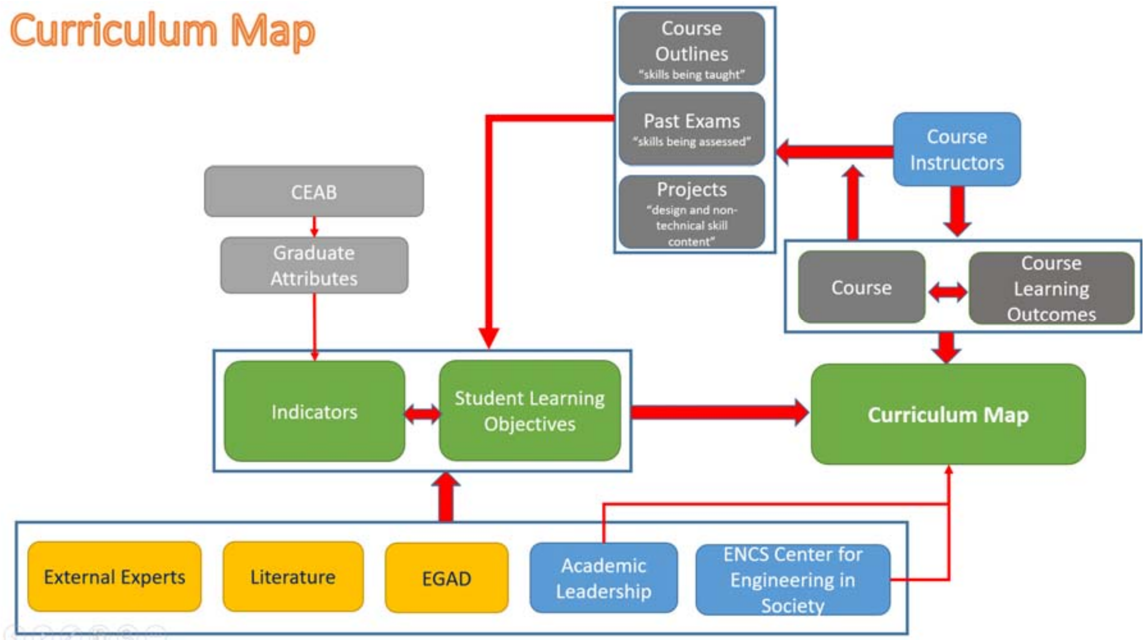

Figure 8. Curriculum Map Development Process

The curriculum maps for individual graduate attributes are provided later in the document, in which each graduate attribute is discussed in detail.

1.4 Assessment Tools

The list of common assessment tools used for measuring student competencies is provided below. Naturally, the most common tools for measurement is the course work. Exit surveys, co-op reports and ENCS advisory boards are other assessment tools used regularly to assess student competencies on graduate attributes. In recent years, some of the programs have formed Student Continuous Improvement Process Committees to capture student's feedback on their study experiences at [redacted]

Common Assessment Tools

- Course work
  - Assignments
  - Exams
  - Lab work
  - Group projects
  - Peer evaluations

- Exit surveys (Annual)
  The analysis of recent exit surveys are provided in Graduate Attribute Dossier (GAD) Section G.

- Student Continuous Improvement Process Committees
  Their report is enclosed in the GAD-Section I.

- Co-Op Industry Advisor Feedback
  In order to support the outcome based continuous improvement process in ENCS, the Co-Op office has built a database to analyze the industry advisor feedback reports. While these reports were reviewed by the Co-Op program directors of each department, the Co-Op office has not taken a formal role in the attribute assessment process. In order to capture the industry feedback better, we have decided to invite a member from the Co-Op office for the future attribute assessment meetings. Sample of Co-Op reports are provided in the GAD-Section J.

- ENCS Industry Advisory Board
  Department chairs and Associate Dean of Academic Programs have served as the liaison between the attribute assessment process and ENCS Industry Advisory Board meetings. Various topics closely related to graduate attributes such as Design, Impact of Engineering in Society and the Environment have been discussed in these meetings. Samples of discussions took place in recent years have been enclosed in the GAD-Section K.

Students are assessed in core courses through aforementioned methods using 4 levels grading scheme

Grade **A**: Excellent
Grade **B**: Good
Grade **C**: Satisfactory
Grade **F**: Unsatisfactory

ENCS's goal is to continually improve the students' learning experience at [redacted] so that at the time their graduation, all students receive a satisfactory or better grade on all graduate attributes.

Rubrics

In order to obtain consistent measurement data on student competencies on each attribute/indicator, ENCS has developed rubrics for indicators. Two examples: i) rubric for a technical attribute –*Knowledge base for engineering*; and ii) rubric for a non-technical attribute –*Impact of engineering on society and the environment* are provided below. Full list of rubrics for all graduate attributes are given in the GAD-Section D.

Rubric Examples

i) Attribute: Knowledge base for engineering
Indicator: Knowledge base of mathematics

A	Can consistently answer more than 85% of relevant questions correctly.
B	Can consistently answer more than 75% of relevant questions correctly.
C	Can consistently answer more than 60% of relevant questions correctly.
F	May only answer up to 60% of relevant questions correctly.

ii) Attribute: Impact of engineering on society and the environment
Indicator: Sustainability in design

A	Able to demonstrate knowledge of more than one contemporary societal or community issue. Excellent discussion of engineering implications of multiple contemporary issues with reasoned examples and sound rationale. Excellent discussions of one or more larger community need that being addressed by the project partner.
B	Able to demonstrate knowledge of one or more contemporary societal or community issue. Able to describe engineering implications of one or more contemporary issues with some examples and rationale. Able to describe at least one larger community need that is being addressed by the project partner.
C	With assistance, can demonstrate some knowledge of one contemporary community or societal issue. Explanation of implications of engineering to a societal issue is mostly ineffective and

	lacking. Needs assistance to identify one larger community need being addressed by their project partner.
F	Unable to demonstrate knowledge of one or more contemporary societal or community issue. Unable to describe engineering implications of one or more contemporary issues. Unable to describe at least one larger community need that is being addressed by the project partner.

Peer Evaluation System is an online system developed for assessing Individual and teamwork graduate attribute. Group members provide feedback on their teammates on following indicators:

- Cooperation
- Conceptual contribution
- Practical contribution
- Work ethic

A sample that is extracted from INDU 311 course is provided below. The identity of students are removed from the text.

Group 1

Group Size: 6

Completed Evaluations: 6

Private comments for the professor:

- The group worked very well together. We had issues in the beginning trying to meet up because of our different schedules and other projects, but once we got through that, I believe that we worked well and each of us did our best to contribute to the work effort. (Written by: …….)
- The group project was interesting. However, it was longer than expected. Please be advised that students have more than 5 courses each semester. The project should have had information about how many departments and doctors are being used and we should research the rates of arrivals and processes. This way we will focus more on the scope of the course it self and we will have a limit on the size of the project. However, we spent more time trying to understand how the hospital works than we spent on simulation itself. Also, there was no size limit. People were spending endless nights growing the size of their project because they see their teammates working on something bigger. This lead to alot of anxiety and competitive environment which is not what education is about. (Written by: …….)
- Need more computer labs with Arena installed, and more license for Arena……

  Maybe student should model something smaller. Modelling a hospital is quite big for 1 semester. (Written by: ……)

Evaluation of [redacted] ([redacted]):

Evaluator	Cooperation	Conceptual Contributions	Practical Contributions	Work Ethic	Average Across All
[redacted]	7	7	7	7	7
[redacted]	7	7	7	7	7
[redacted]	7	7	7	7	7
[redacted]	7	7	7	7	7
[redacted]	7	7	7	7	7
[redacted]	7	7	7	7	7
Average	7	7	7	7	**7**

- Good to work with but should speak up more with ideas. Great contribution to animation. (*Written by:* ….)
- Great work! Responsible! (*Written by:* …..)
- Responsible (*Written by:* ….)
- She's smart but sometimes she's too shy to express herself. (*Written by:* ……)
- A very smart and pleasant individual. From the beginning [redacted] proved to be an essential member of the group. (*Written by:* …..)
- [redacted] has wonderful work ethic and it was a pleasure to get to know her in this project. (*Written by:* …..)

Evaluation of [redacted] ([redacted]):

Evaluator	Cooperation	Conceptual Contributions	Practical Contributions	Work Ethic	Average Across All
[redacted]	3	4	5	6	4.5
[redacted]	6	6	7	7	6.5
[redacted]	7	6	7	6	6.5
[redacted]	5	5	7	5	5.5
Average	5.25	5.25	6.5	6	**5.75**

- Valerie contributed at the end of the project, but could have been more present and make more contributions in the earlier and middle stages of the project. (*Written by:* ….)
- It has been a pleasure to meet you and work with you. I think I would have liked to know you better (*Written by:* ….)
- Hard worker (*Written by:* …)
- Contributions in the end were much better than at the beginning. Showed positive attitude towards finishing the report and putting together the presentation. However, would have liked to see more conceptual contributions. (*Written by:* ….)

1.5 Assessment Results

ENCS started measuring student competencies in all departments in 2010 on a subset of graduate attributes:

- Design
- Problem Analysis
- Communication Skills
- Impact of engineering on society and the environment

The year after, four other graduate attributes were assessed to gain further experience. The goal of ENCS was to develop best practices for measurement, learn from the experience and adopt the measurement techniques as an alternative and transfer the knowledge to other programs. The final goal was to develop strategies to sustain the practice. Starting the data collection process for a subset of graduate attributes (4 graduate attributes in 2010) has enabled the ENCS to apply the five-step process:

The following progress has been made:

Table 6. Assessment plan for all 12 Graduate Attributes

2010-11 Academic Year	**2011-12 Academic Year**	**2012-13 Academic Year**
• Design • Problem Analysis • Communication Skills • Impact of Engineering on Society and the Environment	• Investigation • Use of Engineering Tools • Professionalism • Ethics and Equity	• A Knowledge Base for Engineering • Individual and Team Work • Economics and Project Management • Life-long Learning
2013-2014 Academic Year	**2014-2015 Academic Year**	**2015-2016 Onwards**
• Design • Problem Analysis • Communication Skills • Impact of Engineering on Society and the Environment	• Design • Communication Skills • Investigation • Use of Engineering Tools • Professionalism • Ethics and Equity	• All 12 Graduate Attributes were assessed in 2015-16 and 2016-17 and will be assessed annually henceforth.

1.6 Review of Graduate Attributes

Below, twelve graduate attributes are analyzed for the Industrial Engineering program. For each attribute, first the curriculum map is introduced. Next, the interpretation of indicators for the program is discussed. Later, assessment tools specific to the given attribute for the Industrial Engineering program are provided. Finally, measurement statistics for the past 6 years are provided.

1.6.1 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:

Table 7 shows the courses that are mapped to the Knowledge Base for Engineering attribute (KB). As expected, this attribute is well covered throughout the curriculum to reflect the knowledge that Industrial Engineering students should acquire at different levels of learning as they progress in their studies.

Table 7. Curriculum Map for Knowledge Base for Engineering

Indicators	Introductory	Intermediate	Advanced
Knowledge-base of mathematics • **Vectors** • **Differential Equations** • **Calculus** • **Matrix operations** • **Formulating Systems equations** • **Regression/Curve fitting** • **Probability and Statistics** • **Numerical solutions**	ENGR 213 ENGR 233	ENGR 244 ENGR 245 ENGR 311 INDU 323 INDU 371 INDU 372	ENGR 371 ENGR 391 INDU 311 INDU 324 INDU 421
Knowledge-base of natural science • **Statics/Dynamics** • **Energy** • **Velocity** • **Vibration** • **Mass/Force/Momentum/ Gravity/Acceleration** **…**	ENGR 245 ENGR 251 MECH 221	ENGR 233 ENGR 244 MECH 311 MECH 313	INDU 411
Knowledge base in a specific domain: ***In Industrial Engineering***	ENGR 245 INDU 323 MECH 215	ENGR 311 INDU 311 INDU 320 INDU 321 INDU 371 INDU 372 MECH 311 MECH 313	ENGR 371 ENGR 391 INDU 324 INDU 411 INDU 421 INDU 423

Indicators:

ENCS's objective is to train students who have strong knowledge in engineering mathematics, natural sciences and in the field specific domain in which the student is trained. Hence the attribute "A Knowledge base for engineering" is defined with the three unique indicators. Moreover, the student learning objectives on each indicator are grouped into three categories namely Introductory, Intermediate and Advanced.

<u>Knowledge-base of Mathematics</u>: At the time of their graduations, students are expected to be competent on topics such as Vectors, differential equations, calculus, matrix operations etc.

Expected learning outcomes:

- *At the introductory level*: to be able to Identify appropriate technique for solving mathematical problems
- *At the intermediate level*: apply acquired knowledge on systems problems
- *At the advanced level*:
    - adapt mathematics knowledge for tackling engineering problems
    - evaluate and validate results
    - show in-depth understanding of the university level mathematics

<u>Knowledge-base of natural science</u>: At the time of their graduation, students are expected to demonstrate satisfactory competence on natural science topics such as Statics/Dynamics, energy, velocity, vibration, gravity, acceleration, momentum etc. Expected student learning objective at each level are:

- *At the introductory level*:
    - remember solution techniques
    - identify appropriate techniques for tackling natural science problems
- *At the intermediate level*: apply techniques on natural science systems problems
- At the advanced *level*:
    - utilize acquired knowledge for tackling engineering problems
    - evaluate and validate results
    - show in-depth understanding of university level natural science

<u>Knowledge-base in a specific domain</u>: Finally, engineering students graduating from [redacted] are expected to have an in-depth knowledge in the field of their specific discipline at the time of their graduation. Students are expected to recall the acquired knowledge, apply it to the given engineering problems, use the knowledge in new situations and expand the knowledge to tackle unfamiliar challenges. Accordingly, the indicator is described as:

- *At the introductory level*:
    - remember solution techniques
    - identify appropriate techniques for tackling engineering problems
- *At the intermediate level*: apply techniques on engineering systems problems

- *At the advanced level*:
    - utilize acquired knowledge for tackling engineering problems
    - evaluate and validate results
    - show in-depth understanding of university level of engineering knowledge in Industrial Engineering

Table 8. Indicators and Student Learning Objectives for A knowledge Base for Engineering

Indicators	Student Learning Objectives		
	Introductory	**Intermediate**	**Advanced**
Knowledge-base of mathematics • **Vectors** • **Differential Equations** • **Calculus** • **Matrix operations** • **Formulating Systems equations** • **Regression/Curve fitting** • **Probability and Statistics** • **Numerical solutions**	• Identify appropriate techniques for solving mathematical problems	• Apply knowledge to systems problems	• Adapt math knowledge for tackling engineering problems • Evaluate and validate results • Show in-depth understanding of the university level mathematics
Knowledge-base of natural science • **Statics/Dynamics** • **Energy** • **Velocity** • **Vibration** • **Mass/Force/Momentum/ Gravity/Acceleration**	• Remember solution techniques • Identify appropriate techniques for tackling natural science problems	• Apply techniques to natural science systems problems	• Utilize acquired knowledge for tackling engineering problems • Evaluate and validate results • Show an in-depth understanding of the university level natural science
Knowledge base in a specific domain **Industrial Engineering**	• Remember solution techniques • Identify appropriate technique for tackling engineering problems	• Apply techniques to engineering systems problems	• Combine multiple methods for tackling system problems • Evaluate and validate results • Show an in-depth understanding of engineering knowledge in the field of study

Assessment tools:

The knowledge base for engineering is the most widely taught and utilized skill in the curriculum. Most classes use exams and assignments to test the knowledge. Furthermore, through surveys, graduating students' feedback is obtained. Co-op industry reports include sections relevant to overall engineering knowledge. Finally, alumni feedback is obtained through industry advisory boards and an alumni continual improvement committee in order to capture how alumni is utilizing their engineering knowledge acquired during their studies at [redacted] Feedback received from external sources is enabling ENCS and/or individual programs to identify issues in the curriculum.

Student surveys: ENCS conducts a semi-annual survey among graduating students. The 46-question survey includes 4 questions aim at capturing student feedback on A Knowledge Base for Engineering.

3.1.1 A knowledge base for engineering: Questions
I am prepared to make use of my computer science or engineering knowledge and skills to solve real-world problems in my discipline.
I have a good understanding of the specialized computer science or engineering knowledge appropriate to my program.
I have acquired skills in mathematics and the natural sciences and am able to apply them to real-world problems.
My program has given me a broad knowledge of computer science or engineering fundamentals.

Assessment results:

ENCS started measuring graduate attributes in the 2011-12 academic year. In order to build a system and change the culture, only 4 graduate attributes were measured in the first year followed by a different set of 4 in the second year and the final 4 in the third year. The first measurement on "A knowledge base for engineering" was conducted in the 2012-13 academic year. The next round of measurement was done in the 2015-16 academic year. In 2015-16, ENCS established a systematic process to handle the graduate attribute assessment process and consequently has decided to assess all 12 graduate attributes annually. Table 9 illustrates the progress of measurement on "A knowledge based in engineering" attribute.

Table 9. History of assessing a knowledge base for engineering

Assessment Cycle	Academic Year	Number of Attributes Assessed	Measure Courses		
			Introductory	Intermediate	Advanced
I	2011-12	4	Attribute was not measured		
II	2012-13	4	ENGR 242	INDU 311	
III	2013-14	4	Attribute was not measured		
IV	2014-15	6	Attribute was not measured		
V	2015-16	12	ENGR 245 ENGR 251 INDU 323 INDU 371 MECH 215 MECH 221	ENGR 233 ENGR 244 ENGR 245 ENGR 311 INDU 311 INDU 323 INDU 371 INDU 372 MECH 311 MECH 313	ENGR 371 ENGR 391 INDU 311 INDU 324 INDU 411 INDU 421 INDU 423
VI	2016-17	12	ENGR 213 ENGR 245 ENGR 251 INDU 323 MECH 215 MECH 221	ENGR 233 ENGR 244 ENGR 245 ENGR 311 INDU 311 INDU 323 MECH 311 MECH 313	ENGR 371 ENGR 391 INDU 311 INDU 321 INDU 411 INDU 421 INDU 423

1.6.2 Graduate attribute #2 Problem analysis

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

Curriculum maps:
Table 10 shows the courses that are mapped to Problem Analysis (PA) in Industrial Engineering. These courses contain elements of PA at varying levels of learning.

Table 10. Curriculum Map for Problem Analysis Attribute for Industrial Engineering program

Indicators	Introductory	Intermediate	Advanced
Problem identification and formulation	ENGR 213 ENGR 233 ENGR 245 ENGR 251 INDU 323 MECH 211	INDU 311 INDU 320 INDU 321 INDU 323 INDU 324 INDU 371	INDU 372 INDU 421 INDU 423
Modeling	ENGR 213 ENGR 245 INDU 323 MECH 211	ENGR 233 INDU 311 INDU 320 INDU 321 INDU 371	INDU 324 INDU 372 INDU 421 INDU 423
Problem solving	ENGR 213 ENGR 245 ENGR 251 ENGR 311 INDU 323 MECH 211 MECH 215	ENGR 233 INDU 311 INDU 320 INDU 321 INDU 324 INDU 371	INDU 372 INDU 421 INDU 423
Analysis	ENGR 251 INDU 320 INDU 321 INDU 323 INDU 324 MECH 211	ENGR 244 INDU 311 MECH 215	INDU 372 INDU 421

Indicators:

Problem analysis is a skill that includes ability to identify and describe a problem, examine the possibilities and solution strategies, execution, predicting and evaluating the results. Analytical thinking, logical reasoning and creativity are the key ingredients of Problem Analysis attribute. Consequently, ENCS categorized the Problem Analysis attribute under four indicators:

Problem identification and formulation: requires creativity and logical reasoning.
Desired student learning objectives at each level are:

- *At the introductory level*:
  - explain/describe the problem
  - explain given information and ideas
  - identify missing information
- *At the intermediate level*:
  - interpret unknowns and ambiguities
  - draw connections among ideas
  - examine all facts to produce new solutions
  - generalize formulations from examples already seen
- At the advanced *level*:
  - justify and defend solutions
  - formulate/produce new solutions based on supporting evidence

Modeling: requires a strong logical reasoning, creativity and deep understanding of the subject. Modeling in the context of industrial engineering includes computer models (simulation), mathematical models (operations research, production planning, and natural science problems), and occasionally physical models (computer integrated manufacturing, facilities planning). Furthermore, models are differentiated based on deterministic and stochastic model, and static and dynamic models. Desired student learning objectives at each level are:

- *At the introductory level*:
  - identify parameters and variables from a problem statement
  - recall existing models for similar problems
- *At the intermediate level*:
  - compare modeling strategies: Logical-Mathematical models vs. Physical Models
  - draw valid assumptions
- *At the advanced level*:
  - weigh limitations, barriers and opportunities
  - evaluate assumptions to formulate a prototype

Problem Solving: is an analytical skill that requires logical reasoning as well as creativity. Moreover, problem solving demonstrates a deep understanding of the engineering knowledge. Desired student learning objectives at each level are:

- *At the introductory level*:
    - identify methods to tackle the problem
    - select the right method to solve the problem
- *At the intermediate level*:
    - interpret problems for a special case
    - test solutions using computer programs and computer simulation
    - solve problems by making educated guesses
- *At the advanced level*:
    - evaluate the problem for general cases
    - justify and verify solutions

Analysis: is a skill to critically evaluate the results, identify limitations and provide a roadmap for implementation to resolve an engineering problem, desirably a system problem, in a multi-disciplinary setting. Desired student learning objectives at each level are:

- *At the introductory level*:
    - identify elements of uncertainty
    - identify patterns
    - describe the knowledge acquired from the experience
- *At the intermediate level*:
    - relate a given problem to similar problems
    - reorganize a problem by splitting it into sub-parts
    - distinguish/calculate range of expected inputs and outputs
    - interpret results of analysis, degree of accuracy
    - distinguish and choose between different alternatives
- *At the advanced level*:
    - weigh a model to simplify it and remove unnecessary details
    - develop/derive new fact
    - evaluate and justify a chosen solution based on criteria

Table 11. Student Learning Objective for Problem Analysis

Indicators	Student Learning Objectives		
	Introductory	**Intermediate**	**Advanced**
Problem identification and formulation	• Explain/describe the problem • Explain given information and ideas • Identify missing information • Formulate by recalling similar example	• Interpret unknowns and ambiguities • Draw connections among ideas • Examine all facts to produce new solutions • Generalize the formulations from examples already seen	• Justify and defend solutions • Formulate/produce new solutions based on supporting evidence
Modeling	• Identify parameters and variables from a problem statement • Recall existing models for the similar problems	• Compare modeling strategies: Logical-Mathematical models vs. Physical Models • Draw valid assumptions	• Weigh limitations, barriers and opportunities • Evaluate assumptions to formulate a prototype
Problem solving	• Identify methods to tackle the problem • Select the right method to solve the problem	• Interpret problem for a special case • Test solutions using computer programs and computer simulation • Solve problem by making educated guesses	• Evaluate the problem for general cases • Justify and verify solutions
Analysis	• Identify elements of uncertainty • Identify patterns • Describe the knowledge acquired from the experience	• Relate a given problem to similar problems • Reorganize a problem by splitting it into sub-parts • Distinguish/Calculate range of expected inputs and outputs • Interpret results of analysis, degree of accuracy • Distinguish and choose between different alternatives	• Weigh a model to simplify it and remove unnecessary details • Develop/derive new facts • Evaluate and justify a chosen solution based on criteria

Assessment tools:

In the industrial engineering program, the Problem Analysis attribute is measured using a wide range of tools including traditional tools like exams, assignments, lab work and projects. Moreover, through surveys, graduating students' feedback is obtained. Alumni is also playing a key role in providing feedback through their experiences in industry or academia. Alumni input is achieved through industry advisory boards. The goal is to capture the problem analysis skills that alumni utilize in their professional careers and to crosscheck the industry needs and the skills being emphasised at ENCS. This exercise enables ENCS to identify areas in which to invest further for training engineers who can tackle real-world engineering problems as well as continue in postgraduate studies in different universities.

<u>Student surveys</u>: ENCS conducts a semi-annual survey among graduating students. The 46-question survey includes 3 questions to capture feedback on Problem Analysis skills.

3.1.2 Problem analysis: Questions
I am well-prepared to analyze and solve real-life computer science or engineering problems.
My program has given me the knowledge and skills to identify and formulate real-life computer science or engineering problems.
My program has given me the necessary skills and knowledge to create mathematical, computer or physical models of real-life computer science or engineering systems.

Assessment results:
The Problem Analysis attribute is well covered in the core industrial engineering curriculum. The attribute has been assessed 3 times since 2011. As shown in Table 12, the number of courses provide measurement data is sufficiently large. The program aims at using the same number of courses as it was in 2016-17 assessment year to measure Problem Analysis attribute in the future assessment cycles.

Table 12. Assessment History for Problem Analysis in Industrial Engineering

Assessment Cycle	Academic Year	Number of Attributes Assessed	Measure Courses		
			Introductory	Intermediate	Advanced
I	2011-12	4	Attribute was not measured		
II	2012-13	4	Attribute was not measured		
III	2013-14	4	INDU 423	INDU 311	INDU 423
IV	2014-15	6	Attribute was not measured		
V	2015-16	12	ENGR 233 ENGR 245 ENGR 251 ENGR 311 INDU 323 INDU 324 MECH 211 MECH 215	ENGR 233 ENGR 244 INDU 311 INDU 371 INDU 421 MECH 215	INDU 324 INDU 372 INDU 421 INDU 423
VI	2016-17	12	ENGR 213 ENGR 233 ENGR 245 ENGR 251 INDU 321 INDU 323 MECH 211 MECH 215	ENGR 233 ENGR 244 INDU 311 INDU 321 INDU 323 MECH 215	INDU 421 INDU 423

1.6.3 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:

After careful evaluation of the curriculum, the following courses are found to be covering and/or utilizing the investigation attribute in Industrial Engineering.

Table 13. Curriculum map for Investigation for Industrial Engineering

Indicators	Introductory	Intermediate	Advanced
Background and Hypothesis Formulation	ENGR 244 ENGR 371	INDU 311	INDU 372
Designing Experiments	ENGR 244 ENGR 371	INDU 311 INDU 372	INDU 412
Conducting Experiments and Collection of Data	ENGR 244	ENGR 371 INDU 311 INDU 372	INDU 412
Analysis and Interpretation of Data		ENGR 244 ENGR 371 INDU 311	INDU 372

Indicators:

Investigation is a set of skills necessary to develop a systematic approach in order to answer questions in the natural environment. The goal of ENCS is to equip engineering students with the necessary skills to design and conduct repeatable experiments to understand the complex engineering problems, collect reliable data and extract unbiased and meaningful conclusions from the experiments. The following four graduate indicators have been identified as targeting the most appropriate investigation skills for ENCS graduates, and the faculty is developing a curriculum for training future engineers with these necessary investigation skills.

Background and Hypothesis Formulation: aims at describing the objective of an investigation study. Accurate and clear hypothesis formulation leads to a better understanding of the problem and successful interpretation of the results.
Desired student learning objectives at each level are:

- *At the introductory level*:
    - Describe the setting for the investigation
        - Why are we doing it?
        - What are we expecting?
- *At the intermediate level*:
    - Consider whether it has been done before and how it relates to theory/other information
- At the advanced level:
    - Compare alternative engineering solutions

Designing Experiments: is as an essential skill for engineering students to able to conduct repeatable experiments. Desired student learning objectives at each level are:

- At the Introductory level
    - Comprehend randomness
    - Choose instruments and testing method
    - Demonstrate understanding of concepts of reproducibility, accuracy, feasibility, cost, size
- At the Intermediate level
    - Avoid bias
    - Consider limitations of equipment
    - Discuss issue of materials vs. measurements
    - Discuss difficulty of duplication
- At the Advanced level
    - Design a controlled experiment

Conducting Experiments and Collection of Data: targets the accurate execution of the designed experiment and collection of meaningful and valid data. Desired student learning objectives at each level are:

- At the Introductory level
    - Identify the available tools for conducting experiments and collecting data
    - Demonstrate the knowledge for using tools
    - Report all data objectively
- At the Intermediate level
    - Consider variability/operator error
    - Discuss random sampling
    - Debate safety issues

    - Discuss ethical issues including obtaining appropriate permission if experiments involve humans
- At the Advanced level
    - Develop strategies to analyze/capture the performance of engineering systems

Analysis and Interpretation of Data: aims at providing the students the necessary knowledge and skills to use various statistical tools to analyze data and derive statistically sound conclusions concerning engineering systems. Desired student learning objectives at each level are:

- At the Introductory level
    - Identify the available tools for conducting experiments and collecting data
    - Demonstrate the knowledge for using tools
    - Report all data objectively
- At the Intermediate level
    - Use methods from probability and statistics to analyze and interpret data
    - Match experimental results with theory
    - Synthesize information to arrive at substantiated conclusions
- At the Advanced level
    - Validate assumptions
    - Discuss what went wrong/error analysis

The student learning objective and their relationship to graduate indicators are summarized in the below table.

Table 14. Student Learning Objective for Investigation

Indicators	Student Learning Objectives		
	Introductory	**Intermediate**	**Advanced**
Background and Hypothesis Formulation	• Describe the setting for the investigation o Why are we doing it? o What are we expecting?	• Consider whether it has been done before and how it relates to theory/other information	• Compare alternative engineering solutions
Designing Experiments	• Comprehend randomness • Choose instruments and testing method • Demonstrate understanding of concepts of reproducibility, accuracy, feasibility, cost, size	• Avoid bias • Consider limitations of equipment • Discuss issue of materials vs. measurements • Discuss difficulty of duplication	• Design a controlled experiment
Conducting Experiments and Collection of Data	• Identify the available tools for conducting experiments and collecting data • Demonstrate the knowledge for using tools • Report all data objectively	• Consider variability/operator error • Discuss random sampling • Debate safety issues • Discuss ethical issues including obtaining appropriate permissions if experiments involve humans	• Develop strategies to analyze/capture the performance of engineering systems
Analysis and Interpretation of Data	• Aware of mathematical tools required for data analysis	• Use methods from probability and statistics to analyze and interpret data • Match experimental results with theory • Synthesize information to arrive at substantiated conclusions	• Validate assumptions • Discuss what went wrong/error analysis

Assessment tools:

Fundamentals of Investigation skills are introduced to student in ENGR 371, a second year Industrial Engineering course. One of the early impacts of graduate attribute assessment process was on the ENGR 371 course. In order to better address the expectations of investigation skills and to measure the student competency more accurately, course instructors have introduced a term project. Students collect data, build a hypothesis test and statistically prove the validity of their hypothesis. Investigation skill is also widely covered in INDU 311 and INDU 371 courses. Various assignments in INDU 311 include data collection from real systems, comparison of collected data against historical trends or hypothetical distributions, and hypothesis testing to verify if statistically significant differences exist. Students work on a term project that includes data collection, design and comparison of alternative systems through hypothesis tests and analysis. In the INDU 421 course, students design alternative facility layouts as part of their term project assignment. Using statistical tools and systems simulation, students compare alternative facility plans against each other. Finally, most lab work provides an environment for students to design an experiment, collect data and analyze the results.

Student surveys: ENCS conducts a semi-annual survey among graduating students. The 46-question survey includes 4 questions to capture feedback on Investigation attribute.

3.1.3 Investigation: Questions
I am satisfied with the opportunities that I had during my education to develop my ability to analyze and interpret data
My program has given me the skills to collect data from real systems or experiments.
My program has prepared me to design and conduct a range of experiments.
My program has prepared me to statistically compare alternative systems to reach valid conclusions.

Assessment results:

Since the assessment of graduate attributes started in the 2010-11 academic year, the investigation attribute has been measured for 4 times. It was part of the second assessment cycle (2011-12 cycle) where only four graduate attributes were assessed. Since then, the investigation attribute has been measured in 2014-15, 2015-16 and 2016-17.

The current curriculum map and the CIP results have revealed that the coverage of the investigation attribute in Industrial Engineering core courses is not at the desired level. The department continuous improvement process committee for investigation has determined that the lab experiments are not adequately utilized to reinforce and measure the investigation attribute. In reality, most labs involve experiment design, data collection, error analysis and measurement. The department has been working with course instructors and lab coordinators to improve the involvement of lab work in teaching investigation skills.

Below Table 15 illustrates the evolution of assessment of Investigation attribute in industrial engineering core courses.

Table 15. Assessment History for Investigation in Industrial Engineering

Assessment Cycle	Academic Year	Number of Attributes Assessed	Measure Courses		
			Introductory	Intermediate	Advanced
I	2011-12	4	ENGR 371	INDU 311	INDU 411
II	2012-13	4	Attribute was not measured		
III	2013-14	4	Attribute was not measured		
IV	2014-15	6	ENGR 371	INDU 311	INDU 412
V	2015-16	12		ENGR 244 INDU 311	ENGR 371 INDU 412
VI	2016-17	12	ENGR 244 ENGR 371	ENGR 244 ENGR 371 INDU 311 INDU 321	INDU 412

1.6.4 Graduate attribute # 4 Design

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

Curriculum maps:
The Design attribute is mainly covered in 3rd and 4th year courses in the Industrial Engineering curriculum. Most of these courses include a term project (many of them are open-ended). In the meantime, students are exposed to design training early in their programs. Courses such as ENGR 245 and MECH 215 provides the introductory skills in the Design attribute.

Table 16. Curriculum map for Design in Industrial Engineering

Indicators	Introductory	Intermediate	Advanced
Objective identification	INDU 372	INDU 311 INDU 320 INDU 321 MECH 311	INDU 421 INDU 490
Idea generation and selection	ENGR 245 INDU 372	INDU 311 INDU 321 MECH 313	INDU 411 INDU 421 INDU 490
Detailed design	MECH 215	INDU 311 INDU 421 MECH 313	INDU 412 INDU 490
Validation and implementation	INDU 372 MECH 215	INDU 311 INDU 321 INDU 421	INDU 490

Indicators:
Engineering design is a systematic approach to provide solutions to address specific needs of the society. The term "society" includes a wide range of stakeholders from individuals to corporations, governments and even the natural environment. The key components of the design are the in-depth understanding of stakeholder needs. Hence the definition of the objective is listed as the first indicator for the design attribute. The next step in design is to generate ideas that serve the needs of the client. In this step, idea generation and

the selection of an alternative that best address the needs of client is included as the second graduate indicator. The detailed design, which is the natural extension of design process, is considered as the third indicator. Finally, a design process is concluded with an implementation and evaluation. The graduate indicator definitions used by ENCS enables the engineering programs to train customer-focused design engineers. Below, the expectations from students at each graduate indicator are discussed.

Objective Identification: focus on the understanding of the needs of customers/clients, the review of existing solutions, study of environmental and societal consequences and feasibility considerations.

- At the Introductory level
  - Consult/discuss with client
  - Gather information
  - Describe the problem
  - Define client objectives
- At the Intermediate level
  - Analyze social and environmental needs
  - Examine prior solutions
  - Evaluate benchmark solutions available in the market
- At the Advanced level
  - Evaluate future societal/corporation needs and technologies

Idea Generation and Selection: is a process whereby engineers produce alternative solution strategies to best satisfy the objectives defined at the earlier stages of the design. This process involves the review of existing solutions and available technology, compatibility of various alternatives on the manufacturing and service capabilities and the impact on the future considerations of the client, society and the environment. Desired student learning objectives at each level are:

- At the Introductory level
  - Identify exiting solutions that would satisfy the requirements/expectations of the design
  - Identify the required technology to satisfy the needs of given design
- At the Intermediate level
  - Define features/capabilities to be evaluated
  - Define conceptual alternatives
  - Discuss how each feature satisfies the client's needs
- At the Advanced level
  - Critique alternative solutions
  - Create new, unique, untried solutions
  - Develop ideas outside the box

  - Weigh solutions using techniques such as brainstorming and lateral thinking
  - Select appropriate solutions using decision grids or force-field analysis

Detailed Design: is the process where information extracted so far is refined and 2D, 3D plans, solid mockups are created, specifications are detailed and estimates are made. Material selection, manufacturing technology selection, compatibility studies are made. If needed, regulation compliance is demonstrated. Desired student learning objectives at each level are:

- At the Introductory level
  - Describe a complex solution that allows implementation
- At the Intermediate level
  - Relate and synthesize solutions to sub-problems
  - Demonstrate/show details
  - Adapt the best available solution for the given design challenge
- At the advanced level
  - Validate/ substantiate solutions

Validation and Implementation: The final stage of the design process is the validation and implementation. Hence students are provided the necessary skills to tackle validation of complex engineering solutions and when possible implement and analyze the outcome. Desired student learning objectives at each level are:

- At the Introductory level
  - Describe the required methodology/tools for validation
  - Select the right methodology for validation and implementation
- At the intermediate level
  - Question/check for accuracy
- At the Advanced level
  - Validate design against specs (does it meet all requirements, e.g., cost, efficiency, codes, etc.?)
  - Weigh solution against multiple, objective criteria of evaluation
  - Defend the originality of the design

The following table provides the student learning objectives at each graduate indicator.

Table 17. Student Learning Objectives for Design

Indicators	Student Learning Objectives		
	Introductory	**Intermediate**	**Advanced**
Objective identification	• Consult/discuss with client • Gather information • Describe the problem • Define client objectives	• Analyze social and environmental needs • Examine prior solutions • Evaluate benchmark solutions available in the market	• Evaluate future societal/corporation needs and technologies
Idea generation and selection	• Identify exiting solutions that would satisfy the requirements/expectatio ns of the design • Identify the required technology to satisfy the needs of given design	• Define features/capabilities to be evaluated • Define conceptual alternatives • Discuss how each feature satisfies the client's needs	• Critique alternative solutions • Create new, unique, untried solutions • Develop ideas outside the box • Weigh solutions using techniques such as brainstorming and lateral thinking • Select appropriate solutions using decision grids or force-field analysis
Detailed design	• Describe a complex solution that allows implementation	• Relate and synthesize solutions to sub-problems • Demonstrate/show details • Adapt the best available solution for the given design challenge	• Validate/ substantiate solutions
Validation and implementation	• Describe the required methodology/tools for validation • Select the right methodology for validation and implementation	• Question/check for accuracy	• Validate design against specs (does it meet all requirements, e.g., cost, efficiency, codes, etc.) • Weigh solution against multiple, objective criteria of evaluation • Defend the originality of the design

Assessment tools:

The Design attribute is mainly measured in term projects. In industrial engineering, most 3rd and 4th years courses (both core and technical electives) include a term project. Most term projects are open-ended which provides students an environment to demonstrate their skills at all 4 graduate indicators except the implementation. Furthermore, assignments and exams are used to assess students at particular aspects of indicators.

Student surveys: ENCS conducts a semi-annual survey among graduating students. The 46-question survey includes 4 questions relevant to design skills.

3.1.4 Design: Questions
I have the knowledge necessary to design systems, components or processes that meet specified needs.
I have the necessary skills and knowledge to generate alternative design solutions and compare these alternatives to defined criteria (objectives) to select the best design solution
My education at [redacted] has given me the ability to design solutions to real-life, open-ended computer science or engineering problems.
My education at [redacted] has taught me the tools to acquire user expectations and incorporate these expectation into a Computer Science or Engineering Design

Assessment results:

The Design Attributes has been measured 5 times in the industrial engineering program. When it was first measured in the 2010-11 assessment cycle, there were only 3 core courses that provided the measurement data. In 2016-17 academic year, a total of 13 measurement results were collected. The program aims at continually collecting a similar number of measurements in future assessment cycles.

Table 18. History of assessments for Design Attribute in Industrial Engineering

Assessment Cycle	Academic Year	Number of Attributes Assessed	Measure Courses		
			Introductory	Intermediate	Advanced
II	2011-12	4	Attribute was not measured		
III	2012-13	4	Attribute was not measured		
IV	2013-14	4	INDU 412		INDU 412 INDU 490
V	2014-15	6			INDU 412
VI	2015-16	12	ENGR 244 INDU 372 MECH 215	INDU 311 INDU 421 MECH 311 MECH 313	INDU 411 INDU 412 INDU 421
VII	2016-17	12	ENGR 244 MECH 215	INDU 311 INDU 321 INDU 421 MECH 311 MECH 313	INDU 411 INDU 412 INDU 421 INDU 490

1.6.5 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:
A variety of engineering tools relevant to general engineering and specific to Industrial Engineering are introduced throughout the program. Students learn unique tools from machining to modeling and simulation such as robot and machine programming in INDU 411, system simulation in INDU 311, 3-dimensional modeling for facilities planning in INDU 421 and optimization solvers in INDU 323 and 324.

Table 19. Curriculum map for Use of engineering tools in Industrial Engineering

Indicators	Introductory	Intermediate	Advanced
Ability to use appropriate engineering tools, techniques and resources	INDU 323	ENGR 391 INDU 311 INDU 324 INDU 423 MECH 215 MECH 313	INDU 342 INDU 372 INDU 411 INDU 412 INDU 421 MECH 311
Ability to select appropriate tools, techniques, and resources	INDU 323	ENGR 391	INDU 372 INDU 421 MECH 311
Awareness of limitations of tools, create and extend tools as necessary	INDU 323	ENGR 391	INDU 372

Indicators:
ENCS's goal from the "Use of Engineering Tools" attribute is to provide students a learning environment where they can get sufficient exposure to usage and creation of engineering tools so that they can learn how to use wide range of engineering tools effectively; they are able to select the most appropriate tools to tackle given engineering problems under the changing circumstances; and finally they must be able to assess the capabilities of existing tools and able to create new ones when necessary (or modify the existing ones). Hence the following three graduate indicators have been adopted in the faculty to develop a sustainable curriculum.

Ability to use appropriate engineering tools, techniques and resources: this indicator aims at training students to master various engineering tools relevant to their field of study. Desired student learning objectives at each level are:

- At the Introductory level
  - Describe the experiment
- At the Intermediate level
  - Use library tools with accuracy and precision
  - Demonstrate the usage of tools in lab environment
  - Show competence in using various engineering software
  - Show competence in understanding of experiments
- At the advanced level
  - Improve the capabilities of tools

Ability to select appropriate tools, techniques, and resources: is the next step in engineering tool usage. Once students learn a variety of engineering tools in their field of study, the next skill is to be able to select the most appropriate one to tackle the specific problem under specific conditions. Desired student learning objectives at each level are:

- At the Introductory level
  - Demonstrate knowledge of/awareness of standards
- At the Intermediate level
  - Compare the capabilities of different tools
- At the advanced level
  - Select appropriate technical documentation
  - Evaluate suitability of the tools for the task
  - In labs, choose the right tools/techniques for problem
  - In projects, demonstrate ability to select appropriate tools and techniques

Awareness of limitations of tools, create and extend tools as necessary: It is predominantly the responsibility of engineers to create new tools and/or modify and extend the capabilities of exiting tools as necessary. Hence, ENCS aims at training students on tool design development in a systematic way. Students are challenged to evaluate the capabilities/limitations of exiting tools and to modify/create new solutions to address the specific needs. Desired student learning objectives at each level are:

- At the Introductory level
  - Demonstrate awareness of limitations of tools
- At the Intermediate Level
  - Address limitations of given tools by extending tools and combining tools
- At the advanced level
  - Address limitations of given tools by creating new tools
  - Weigh limitations of given tools by choosing different tools

Below table provides the list of student learning objectives expected at each level.

Table 20. Student Learning Objective for Use of Engineering Tools Attribute

Indicators	Student Learning Objectives		
	Introductory	**Intermediate**	**Advanced**
Ability to use appropriate engineering tools, techniques and resources	• Describes the experiment	• Use library tools with accuracy and precision • Demonstrate the usage of tools in lab environment • Show competence in using various engineering software • Show competence in understanding of experiments	• Improve the capabilities of tools
Ability to select appropriate tools, techniques, and resources	• Demonstrate knowledge of/awareness of standards	• Compare the capabilities of different tools	• Select appropriate technical documentation • Evaluate suitability of the tools for the task • In labs, choose the right tools/techniques for problem • In projects, demonstrate ability to select appropriate tools and techniques
Awareness of limitations of tools, create and extend tools as necessary	• Demonstrate awareness of limitations of tools	• Address limitations of given tools by extending tools and combining tools	• Address limitations of given tools by creating new tools • Weigh limitations of given tools by choosing different tools

Assessment tools:

Lab work is the most frequently used assessment tool for measuring student competencies. Assignments, exams and term projects are also frequently used for assessment. In industrial Engineering, student are expected to learn:

Software Tools

- Simulation: Arena, Excel
- Optimization: Lindo/Lingo, CPLEX, OPL as the interface
- Facilities planning: Factory CAD, AutoCAD
- Manufacturing: G-code for operating CNC machines
- Programming: C++

- Product design: Catia and AutoCAD

Hardware tools
- Manufacturing equipment (machine shop)
- Testing and measurement equipment

Student surveys: ENCS conducts a semi-annual survey among graduating students. The 46-question survey includes 3 questions relevant to Use of Engineering Tools.

3.1.5 Use of engineering tools: Questions
I am satisfied with the engineering or computer science tools available in the computing labs
I have had access to well-maintained laboratories that are related to my field of study
I have had opportunities to create, adapt, or extend computing or engineering techniques and tools during the course of my studies at [redacted]

Assessment results:

The Use of Engineering Tools attribute was assessed for the first time in the 2010-11 assessment cycle by 3 core industrial engineering courses. In the 2016-17 academic year, this number was increased to 11 measurements in core courses.

Table 21. History of assessments for Use of Engineering Tools Attribute in Industrial Engineering

Assessment Cycle	Academic Year	Number of Attributes Assessed	Measure Courses		
			Introductory	Intermediate	Advanced
I	2011-12	4	ENCS 282 INDU 320	MECH 215	-
II	2012-13	4	Attribute was not measured		
III	2013-14	4	Attribute was not measured		
IV	2014-15	6	INDU 320 INDU 412		INDU 412
V	2015-16	12	INDU 323	ENGR 391 INDU 311 INDU 324 MECH 215 MECH 313	INDU 372 INDU 411 INDU 412 INDU 421 MECH 311
VI	2016-17	12	INDU 323	ENGR 391 INDU 311 INDU 423 MECH 215	INDU 411 INDU 412 INDU 421 MECH 311

1.6.6 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:
Most 3rd and 4th year core courses in the Industrial Engineering program include a term project. While some projects are well defined with limited number of outcomes, most term projects are open-ended, which gives an opportunity for course instructors to both train and measure students for their individual contributions and teamwork performance. Students are introduced to teamwork, have sufficient opportunity to demonstrate their leadership skills and finally learn how to deal with conflict resolution in group work. The curriculum map below provides the list of courses that cover "Individual and Teamwork" attribute.

Table 22. Curriculum Map for Individual and Team Work Attribute in Industrial Engineering

Indicators	Introductory	Intermediate	Advanced
Cooperation and work ethics	ENGR 213 INDU 372	INDU 311 INDU 423	INDU 320 INDU 321 INDU 421 INDU 490
Contribution: practical/conceptual	INDU 372	INDU 311	INDU 320 INDU 321 INDU 421 INDU 490
Initiative and leadership	INDU 372	INDU 311 INDU 320 INDU 321	INDU 330 INDU 421 INDU 490
Delivering Results	INDU 372	INDU 311 INDU 320 INDU 321	INDU 421 INDU 490

Indicators:

ENCS has described the "individual and team work" attribute in four categories (graduate indicators). ENCS's goal is to design a curriculum that stimulates students' to cooperate with peers in group works, provide both practical and conceptual contribution to the project, demonstrate leadership when needed and finally learn how to tackle conflicts in group work. Accordingly, the following four indicators have been adopted in ENCS to define the "Individual and Teamwork" attribute.

Cooperation and Work-Ethic: This indicator aims at generating awareness of the acceptable standards to becoming a member of a team. Student learning objectives help both course instructors and students to focus on developing set of skills to become a valuable and professionally acceptable member in a team. Hence the expected competencies to be developed at each level are:

- At the introductory level
  - Be aware of expectations from team members
- At the intermediate level
  - Actively participating in meetings
  - Communicate within the group
  - Cooperate within the group
- At the advanced level
  - Respect team-mates
  - Assist teammates when needed
  - Volunteer for tasks

Contribution: Practical and Conceptual: This indicator focuses on generating an environment where student can develop skills to provide both technical and practical contributions to the team. Expected student learning objectives at each level are:

- At the introductory level
  - Identify the knowledge/skills required to make impact on team projects
- At the intermediate level
  - Research and gather information
- At the advanced level
  - Suggest ideas
  - Write reports or section of reports
  - Provide constructive feedback on the report(s) or presentations
  - Contribute to the presentation

Initiative and leadership: This indicator focuses on the development of leadership. ENCS unconditionally accepts that all engineering students have the leadership skills to offer when the right conditions are established. Therefore, the curriculum designed for enforcing the individual and teamwork attribute must provide opportunities for all students to explore and express their leadership skills. Consequently, the following student learning objectives at each learning level have been adopted in all programs:

- At the introductory level

    - Recognize your own strengths that would have a positive impact on the team
- At the intermediate level
    - Identify teammates' strengths that would make a positive impact on the team
- At the advanced level
    - Assesses contribution as measured by peer-evaluation
    - Demonstrates leadership and initiative
    - Supports shared leadership

Delivering results: indicator focuses on training students on conflict resolution skills. ENCS's vision is that the team work should not only produce the best engineering solution to a given problem, but that the team members should also demonstrate the willingness to work together again on future projects. Continuity in teamwork is as equally important as the quality of the work produced by the team members. Consequently, the following student learning objectives at each learning level are defined:

- At the introductory level
    - Accept his/her role in the group
- At the intermediate level
    - Identify differences among group members that negatively impact the working environment
    - Suggest strategies to avoid conflict
- At the advanced level
    - Assess if the group delivered the expected results in a timely manner
    - Assess if the group members will productively work together on a new project in the future

The table below provides the list of student learning objectives expected at each level.

Table 23. Student Learning Objectives for Individual and Teamwork Attribute

Indicators	Student Learning Objectives		
	Introductory	**Intermediate**	**Advanced**
Cooperation and work ethics	• Be aware of expectations from team members	• Actively participating in meetings • Communicate within the group • Cooperate within the group	• Respect team-mates • Assist teammates when needed • Volunteer for tasks
Contribution: practical/conceptual	• Identify the knowledge/skills required to make impact on team projects	• Research and gather information	• Suggest ideas • Write reports or section of reports • Provide constructive feedback on the report(s) or presentations • Contribute to the presentation
Initiative and leadership	• Recognize your own strengths that would make positive impact on the team	• Identify teammates' strengths that would make positive impact on the team	• Assess contribution as measured by peer-evaluation • Demonstrates leadership and initiative • Supports shared leadership
Delivering Results	• Awareness of his/her role in the group	• Identify differences among group members that cause uncontrollable working environment • Suggest strategies to avoid conflict	• Has the group delivered the expected results in a timely manner? • Will the group members work together on a new project in the future?

Assessment tools:

Peer Evaluation: Academic studies suggest that peer evaluation can successfully measure the performance of team members (Donia, O'Neill and Brutus, 2015). Moreover, there is evidence that centralized peer evaluation systems where students can provide comments on their peers' performances make incremental improvements on student's teamwork skills. [redacted] offers a peer evaluation system, designed by [redacted] who is the co-author in Donia, O'Neill and Brutus (2015), in the centralized course management system Moodle. ENCS encourages faculty members to use the peer evaluation system.

Co-op Industry Advisor Reports: In ENCS, the co-op training is optional. Yet, a large number of ENCS students are part of Co-op program. Hence the feedback received from the co-op industry advisors provided a significant feedback on students' competency.

Student surveys: ENCS conducts a semi-annual survey among graduating students. The forty-six question survey includes 2 questions to provide feedback on Individual and Teamwork attribute.

3.1.6 Individual and team work: Questions
I feel well-prepared to work effectively as a member of an engineering or computer science technical team.
I have had an opportunity to be a leader of a team during my studies at [redacted]

Student Continuous Improvement Committee: the Industrial Engineering program has established a student committee to provide feedback on all graduate attributes. The five-member team provides:

- Strengths of the program
- Weaknesses of the program
- Suggestion to improve and opportunities on all 12 graduate attributes including Individual and teamwork.

Assessment results:

ENCS's goal is to minimize discrepancies over students' training on Individual and Teamwork attribute among the different programs. Hence the analysis is coordinated by the Associate Dean. Below is the history of data collection on the Individual and Teamwork attribute in the Industrial Engineering program only. The details of this assessment are discussed later in the document.

Table 24. History of measurements for Individual and Teamwork Attribute in Industrial Engineering

Assessment Cycle	Academic Year	Number of Attributes Assessed	Measure Courses		
			Introductory	Intermediate	Advanced
I	2011-12	4	Attribute was not measured		
II	2012-13	4	ENCS 282	-	INDU 490
III	2013-14	4	Attribute was not measured		
IV	2014-15	6	-	INDU 311	-
V	2015-16	12	INDU 372	INDU 311	INDU 421
VI	2016-17	12	ENGR 213	INDU 311 INDU 423	INDU 421 INDU 490

1.6.7 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:

All ENCS students are required to take ENCS 282 – Technical Writing and Communication. ENCS 282 is coordinated by the Center for Engineering in Society (CEA). [redacted] the current chair of CES and a professional communication and rhetoric expert, is the lead faculty member in the training of ENCS students in technical communication skills. The other coordinator for ENCS 282 from CES [redacted] is a philosopher and ethicist. Since CES is part of ENCS, they closely work with the other departments and engineering programs. Consequently, under their leadership, all ENCS students receive formal training on communication skills tailored for the needs of engineers.

Furthermore, due to the large number of courses having team based term projects, the Industrial Engineering program covers communication skills sufficiently. All students take part in writing process and oral presentations in several occasions during their studies in industrial engineering. Finally, all students demonstrate their communication skills in the senior design course, capstone. The following curriculum map identifies where each communication skill indicator is taught and utilized.

Table 25. Curriculum Map for Communication Skills in Industrial Engineering

Indicators	Introductory	Intermediate	Advanced
Information Gathering	ENCS 282 MECH 211	ENGR 392	INDU 490
Documentation	INDU 324 MECH 211	ENCS 282 ENGR 392 INDU 423 MECH 311	INDU 490
Writing Process	ENCS 282	ENGR 392 INDU 311 INDU 330 INDU 421 INDU 423	INDU 320 INDU 321 INDU 490
Oral Presentation	ENCS 282 INDU 324 INDU 372	ENGR 392 INDU 311 INDU 330 INDU 423 MECH 311	INDU 320 INDU 321 INDU 421 INDU 490

Indicators:

In order for engineers to continue providing solutions to the complex challenges of society, it is of great importance for them to be equipped with the necessary communication skills so that they can capture the needs of society and effectively communicate with all involved stakeholders. Communication skill involves information gathering (research and listening), documentation, writing process and oral communication. Expected learning objectives for each graduate indicators are described below.

Information Gathering: indicator aims at providing students to listening and research skills. Expected learning objectives at each learning level are:

- At the introduction level
    - Comprehend verbal instructions
- At the intermediate level
    - Articulate research questions orally and in writing
    - Demonstrate effective use of databases, library resources
    - Formulate research plans and data collection strategies

    - Maintain complete and accurate records of sources used
- At the advanced level
    - Evaluate quality and usefulness of sources

Documentation: indicator reinforce the importance of systematic recording and referencing. Student learning objective at each level are

- At the introductory level
    - Identify and utilize correct citation format
- At the intermediate level
    - Organize information appropriately for readers' use
    - Differentiate between correct source usage and plagiarism
- At the advanced level
    - Select correct genre and format

Writing Process: indicator aims at designing a curriculum to develop students' skills in both traditional technical document writing process and effective use of communication technology such as e-mails and social media. Expected student learning objectives are:

- At the introductory level
    - Recognize audience needs, interests and level of knowledge
- At the intermediate level
    - Identify and utilize relevant, high quality resources
    - Frame supportable, significant theses and arguments
    - Develop appropriate expository and argumentative strategies
- At the advanced level
    - Create drafts and revisions
    - Respond to critical feedback (argue, defend, etc.)

Oral Communication: indicator focuses on developing curriculum to provide future engineers an ability to master their oral communication skills, which includes: presentation skills; debate skills; discussion and public speaking skills. Expected student learning objectives at each level are:

- At the introduction level
    - Identify audience needs, interests and level of knowledge
    - Identify strategies to overcome linguistic difference
    - Demonstrate understanding of cognitive and conceptual differences between oral and written presentation
- At the Intermediate level
    - Utilize effective presentation techniques
    - Create appropriate scope for treatment of topic in oral presentation
    - Plan, design and effectively utilize visual materials
- At the advanced level

- o Adapt presentation to heterogeneous audiences
- o Adapt written text to oral presentation

Below table provides the summary of expected student learning objective for all communication indicators.

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Table 26. Student Learning Objectives for Communication Skills

Indicators	Student Learning Objectives		
	Introductory	**Intermediate**	**Advanced**
Information Gathering	• Comprehend verbal instructions	• Articulate research questions orally and in writing • Demonstrate effective use of databases, library resources • Formulate research plans and data collection strategies • Maintain complete and accurate records of sources used	• Evaluate quality and usefulness of sources
Documentation	• Identify and utilize correct citation format	• Organize information appropriately for readers' use • Differentiate between correct source usage and plagiarism	• Select correct genre and format
Writing Process	• Recognize audience needs, interests and level of knowledge	• Identify and utilize relevant, high quality resources • Frame supportable, significant theses and arguments • Develop appropriate expository and argumentative strategies	• Create drafts and revisions • Respond to critical feedback (argue, defend, etc.)
Oral Communication	• Identify audience needs, interests and level of knowledge • Identify strategies to overcome linguistic difference • Demonstrate understanding of cognitive and conceptual differences between oral and written presentation	• Utilize effective presentation techniques • Create appropriate scope for treatment of topic in oral presentation • Plan, design and effectively utilize visual materials	• Adapt presentation to heterogeneous audiences • Adapt written text to oral presentation

Assessment tools:

Common tools for assessing communication skills are project reports, presentations, lab reports and assignments.

Center for Engineering in Society (CES) in Capstone Courses: In 2015, in response to the expectations of outcome based assessment, ENCS has started a pilot study where an expert from CES collaborates with capstone course instructors to train engineering students in non-technical graduate attributes including the communication skills. Two rounds of measurements have been performed by capstone course instructors in collaboration with the expert from CES. [redacted] is the expert currently working with the capstone instructors.

Other indirect assessment methods that are utilized for analyzing the communication skills at ENCS are:

Co-op Industry Advisor Reports: In ENCS, the co-op training is optional. Yet, a large number of ENCS students are part of Co-op program. Hence the feedback received from the co-op industry advisors provided a significant feedback on students' competency.

Student surveys: ENCS conducts a semi-annual survey among graduating students. The 46-question survey includes 3 questions to receive feedback on Individual and Teamwork attribute.

3.1.7 Communication skills: Survey Questions
I have improved my oral presentation skills through classroom presentations.
My ability to communicate effectively within teams has improved over the course of my studies at [redacted]
My program included sufficient written reports to help me develop good written communication skills.

Student Continuous Improvement Committee: the Industrial Engineering program has established a student committee to provide feedback on all graduate attributes including communication skills.

Assessment results:

The Communication attribute has been measured five times since the data collection for graduate attribute assessment started in 2010-11 academic year. The table below provides the progress in assessing the communication skills graduate attribute.

Table 27. Measurement History for Communication Skills in Industrial Engineering

Assessment Cycle	Academic Year	Number of Attributes Assessed	Measure Courses		
			Introductory	Intermediate	Advanced
I	2011-12	4	Attribute was not measured		
II	2012-13	4	Attribute was not measured		
III	2013-14	4	INDU 211 INDU 412	ENCS 282 INDU 423	INDU 490
IV	2014-15	6	INDU 211	ENCS 282	
V	2015-16	12	ENCS 282 INDU 324 INDU 372 MECH 211	ENCS 282 ENGR 392 INDU 311 INDU 421 MECH 311	INDU 421 INDU 490
VI	2016-17	12	ENCS 282 MECH 211	ENCS 282 ENGR 392 INDU 311 INDU 421 INDU 423 MECH 311	INDU 321 INDU 421 INDU 490

1.6.8 Graduate attribute # 8 Professionalism

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

Curriculum maps:
The Professionalism attribute is introduced to students via dedicated courses under the leadership of Center for Engineering in Society. Later in their programs, students receive opportunities to master this skill in courses where open-ended design projects are given.

Table 28. Curriculum Map for Professionalism in Industrial Engineering

Indicators	Introductory	Intermediate	Advanced
Role and responsibilities of professional engineers	ENCS 282 ENGR 201 ENGR 202	INDU 321 ENGR 392	INDU 490
Professional practice	ENCS 282 ENGR 201	INDU 372	INDU 490

Indicators:
In Canada, Engineering is a professional designation and self-regulated. Only those who graduate from a 4 year engineering program and successfully satisfy the requirements of the provincial regulatory bodies can use the title "Engineer". Hence, the professionalism attribute aims at preparing engineering students for the role and responsibilities of the Professional Engineers in Quebec and Canada. Many engineers, unlike scientists, practice as professionals. Being a professional entails that individuals adhere to a body of laws called the Code of Engineers or the Professional Code. This code requires the professional to abide by its different provisions that deal with duties and obligations to society. Our students are taught professionalism, the engineering code and ethical practice of engineers with special reference to Quebec and Canada. We seek to develop among students 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. ENCS defined professionalism attribute under two indicators.

Role and Responsibilities of Professional Engineers: This indicator aims at introducing curricular and co-curricular activities for engineering students to appreciate the responsibilities of engineers for protecting the public. In order to achieve this goal, following student learning objectives have been defined for each learning level.

- At the introductory level
    - Describe the role of engineers in society
    - Identify legal issues on occupational safety and intellectual property
    - Demonstrate a good understanding of liability in Quebec's legal system

- At the intermediate level
  - Appreciate the role filled by professional engineers in society
  - Differentiate between professional and personal roles
  - Distinguish between dimensions of responsibility – moral, legal & social
  - Apply responsibility in professional context
- At the advanced level
  - Assess various situations in case studies

Professional Practice: indicator focuses on providing skills that are necessary to perform engineering task according to the expectations of the society, regulating bodies and the other engineers. Expected student learning objectives at each learning level are:

- At the introductory level
  - Identify relevant professional standards
- At the intermediate level
  - Communicate through accepted professional means
- At the advanced level
  - Adapt in the work environment

The relationship between student learning objectives and the graduate indicators are provided in the table below.

Table 29. Student Learning Objectives for Professionalism Attribute

Indicators	Student Learning Objectives		
	Introductory	**Intermediate**	**Advanced**
Role and responsibilities of professional engineers	• Describe the role of engineers in society • Identify legal issues on occupational safety and intellectual property • Demonstrate a good understanding of liability in Quebec's legal system	• Appreciate the role filled by professional engineers in society • Differentiate between professional and personal roles • Distinguish between dimensions of responsibility – moral, legal & social • Apply responsibility in professional context	• Assess various situations in case studies • Demonstrate professionalism in open-ended team projects
Professional practice	• Identify relevant professional standards	• Communicate through accepted professional means	• Adapt in the work environment

Assessment tools:
At the introductory level, we offer students ENGR 201 – Professionalism and Responsibility. This course is taken during each ENCS student's first year. In this course students are introduced to the professional system for engineering in Canada with a specific focus on Quebec's professional system. Students are tested on their familiarity with the structure of the OIQ, the Code of Ethics for Engineers, and the "mixed" legal system in Quebec. Students are taught and then tested on their knowledge of the relevant parts of the Quebec Civil Code including the Professional Code and the Engineer's Act for engineering practice (legal liability, professional liability, occupational health and safety, intellectual property, etc.). Students are also given case study scenarios in tutorials that allow them to apply their knowledge about the ethical, professional and legal requirements for engineering in Quebec. These case studies are evaluated for proper understanding and appreciation of the responsibilities of engineers in Quebec.

At the intermediate level we offer students ENCS 282 – Technical Communication. This course is typically taken in the first or second year. In this course students are taught how to comply with the professional norms governing technical communication in engineering practice. Students are required to craft mechanism descriptions, instruction manuals, feasibility reports, technical proposals and reports, professional memos, etc. Each of these assignments are assessed for proper adherence to professional norms (in terms of both structure and style). Students are also taught and evaluated on how to properly deliver oral presentations that adhere to the professional norms of contemporary engineering practice.

At the advanced level we offer students INDU 490, our Capstone design course. For the last two years, students working in capstone projects have been required to apply "Real-time Technology Assessment" (a technology assessment method introduced in ENGR 392) to their individual projects. Students are assessed through appendices attached to the midterm reports as well as the final capstone reports. For the midterm reports, the assessment method requires each team to write a report on an analogical case study mapping the ethical, social, and legal experiences of their chosen analogue and then applying the lessons learned from those experiences to their own design iterations. Students are then required to map the current R&D activities at regional, national, and international levels within their area of innovation and apply those lessons to their own design iterations. Students are assessed on their ability to demonstrate gained knowledge through proper research and application to their own projects. For the final capstone reports, the assessment method requires each team to map the public perceptions surrounding their area of innovation. Teams are then asked to demonstrate how their capstone projects respond to these perceptions. Students are then required to identify and describe key moments throughout their design iterations where technical design choices were affected by the knowledge about the non-technical aspects of their technology acquired through the real-time technology assessment process.

<u>Student surveys</u>: the following questions are used to obtain feedback from graduating students.

3.1.8 Professionalism: Survey Questions
I have a good understanding of the roles and responsibilities associated with being a professional computer scientist or engineer.
My program gave me an appreciation of the primary role of the computer scientist or engineer in the protection of the public and of the public interest.

Assessment results:

Professionalism attribute has been measured four times since 2011.

Table 30. Measurement History for Professionalism Attribute in Industrial Engineering

Assessment Cycle	Academic Year	Number of Attributes Assessed	Measure Courses		
			Introductory	Intermediate	Advanced
I	2011-12	4	ENGR 201 ENGR 202		INDU 490
II	2012-13	4	Attribute was not measured		
III	2013-14	4	Attribute was not measured		
IV	2014-15	6	ENGR 201 ENGR 202	-	-
V	2015-16	12	ENGR 201 ENGR 202 INDU 372		INDU 490
VI	2016-17	12	ENGR 201 ENGR 202	INDU 372	INDU 490

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

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

Curriculum maps:
The Impact of Engineering on Society and the Environment attribute is introduced to students via dedicated courses under the leadership of the Centre of Engineers in Society. Later in their programs, students receive opportunities to master their skills in this attribute through courses where open-ended design projects are given.

Table 31. Curriculum Map for Impact of engineering on society and the environment attribute in Industrial Engineering

Indicators	Introductory	Intermediate	Advanced
Awareness of society and environmental impact		ENGR 202 ENGR 392 INDU 342	INDU 421 INDU 490
Sustainability in Design	ENGR 202	ENGR 392 INDU 342 INDU 421	INDU 490

Indicators:
From communication technologies to transportation systems, medicine to urban development, from printing technology to observing deep into outer space, engineers have profoundly changed society and the environment. Increasing awareness of environmental and social justice gives engineers an important role in the process of designing and developing new solutions to world's complex problem in harmony with the environmental and social needs. ENCS has responded to these new expectations from engineers by establishing the Centre for Engineering in Society. As previously discussed, the Centre includes 5 tenured/tenure-track faculty members with expertise ranging from ethics to technology assessment, public policy, and communication. They are equipped with the necessary expertise to develop curriculum to train socially and environmental conscious engineers. Consequently, ENCS defined the Impact of Engineering on Society and the Environment attribute with the following two graduate indicators.

Awareness of society and environmental impact: This indicator focuses on training engineers with a social and environmental conscience. Expected student learning objectives at each learning level are:

- At the introductory level
    - Recognize relevance of societal impact of engineering to improving innovation
    - Demonstrate familiarity with evolution of technologies
- At the intermediate level
    - Categorize wide range of engineering & society relationships, including economic, social, health, safety, legal and cultural aspects
    - Analyze impact of engineering on society and environment
- At the advanced level
    - Diagnose complex social and environmental issues

Sustainability in Design: This indicator aims at training engineers who are sensitive to the limited resources of the world and develop products and services with the minimum environmental footprints. Expected learning objective are:

- At the introductory level
    - Identify social and environmental protection issues
    - Locate challenges to sustainability from technological design
- At the intermediate level
    - Distinguish knowledge gaps and the need for additional data when designing for optimal social and environmental impact
    - Utilize appropriate models in engineering design for optimal social and environmental impact
- At the advanced level
    - Design strategies for incorporating social sustainability

Following list provides the relationship between the student learning objectives and the graduate indicators.

Table 32. Student Learning Objective for Impact of engineering on society and the environment

Indicators	Student Learning Objectives		
	Introductory	**Intermediate**	**Advanced**
Awareness of society and environmental impact	• Recognize relevance of societal impact of engineering to improving innovation • Demonstrate familiarity with evolution of technologies	• Categorize wide range of engineering & society relationships, including economic, social, health, safety, legal and cultural aspects • Analyze impact of engineering on society and environment	• Diagnose complex social and environment al issues
Sustainability in Design	• Identify social and environmental protection issues • Locate challenges to sustainability from technological design	• Distinguish knowledge gaps and the need for additional data when designing for optimal social and environmental impact • Utilize appropriate models in engineering design for optimal social and environmental impact	• Design strategies for incorporating social sustainability

Assessment tools:

The formal training for impact of engineering in society and the environment skills is given in ENGR 392 – Impact of Engineering on Society. The course content is designed in collaboration with the experts from the Centre for Engineering in Society and the course is coordinated by a full-time faculty member from CES. Case studies, assignments and exams are used for measuring student competencies in ENGR 392. Industrial Engineering courses mostly use term projects to measure student performance in impact of engineering on society and the environment.

Student surveys: Annual exit surveys are also utilized as feedback. The following questions on the survey directly focus on the Impact of Engineering on Society and the Environment attribute.

3.1.9 Impact of engineering on society and the environment: Survey Questions
I have had adequate preparation to take into consideration health and safety risks, and to comply with applicable standards, when designing solutions to computer science or engineering problems.
My program has given me an understanding of the environmental, cultural and societal considerations that need to be taken into account while designing solutions to computer science or engineering problems.
My program has given me the ability to analyze both the social and the environmental aspects of computing or engineering activities.

Assessment results:

The impact of engineering on society and the environment attribute has been measured 5 times since 2010. The table below provides the historical evolution of the measurement process.

Table 33. History of Measurement for Impact of Engineering on Society and the Environment in Industrial Engineering

Assessment Cycle	Academic Year	Number of Attributes Assessed	Measure Courses		
			Introductory	Intermediate	Advanced
I	2011-12	4	Attribute was not measured		
II	2012-13	4	Attribute was not measured		
III	2013-14	4	INDU 324 INDU 412	ENGR 392	INDU 324 INDU 412
IV	2014-15	6	Attribute was not measured		
V	2015-16	12		ENGR 202 ENGR 392	INDU 490
VI	2016-17	12	ENGR 202	ENGR 202 ENGR 392	INDU 490

1.6.10 Graduate attribute # 10 Ethics and equity

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

Curriculum maps:
The Ethics and Equity attribute is introduced to students via dedicated courses under the leadership of Centre of Engineers in Society. Later in their programs, students receive opportunities to master their skills in Ethics and Equity through courses where open-ended design projects are given.

Table 34. Curriculum Map for Ethics and Equity in Industrial Engineering

Indicators	Introductory	Intermediate	Advanced
Professional Ethics and Accountability	ENCS 282 ENGR 201 ENGR 202	ENGR 392	INDU 490
Equity	ENCS 282 ENGR 201	ENGR 392 INDU 421	INDU 490

Indicators:
The Ethics and equity attribute has been described in two folds. First, the training of engineering students on professional ethics is tackled under the graduate indicator "Professional Ethics and Accountability". The objective is to ensure all graduating students understand the acceptable behaviors that are governed by the set of rules defined by the regulating bodies in Quebec and Canada. The second aspect of the ethics and equity is described under the graduate indicator "Equity". Today's engineers are responsible for tackling complex problems that effect multicultural, multiethnic, multi-socioeconomic and multi-gender communities. Hence graduating students from ENCS are expected to demonstrate their awareness of such diversity in our society and they are capable of responding to the needs of multi-dimensional communities in engineering projects.

Professional ethics and accountability: This indicator focuses on professional ethics. The following student learning objectives have been introduced to help ENCS to develop and improve the curriculum.

- At the introductory level
  - Identify duties and obligations in the Professional/Engineer's code
- At the intermediate level
  - Apply accountability to professional context
  - Differentiate between ethics, morals, values, and law

    - Define and categorize concepts such as Trust and Loyalty
    - Apply professional ethics in case studies
    - Distinguish professional ethics in Canada and Quebec context
- At the advanced level
    - Adapt ethical reasoning to resolve professional dilemmas

Equity: indicator focuses on increasing the awareness for the presence of diverse communities and their diverse needs. Students are expected to excel in following learning objectives at each learning level

- At the introductory level
    - Describe professional obligations against discrimination
- At the intermediate level
    - Identify economic disparity as a challenge in globalization & sustainability
- At the advanced level
    - Appreciate gender dimensions of equity

Table 35. Student Learning Objectives for Ethics and Equity

Indicators	Student Learning Objectives		
	Introductory	**Intermediate**	**Advanced**
Professional Ethics and Accountability	• Identify duties and obligations in the Professional/Engineer's code	• Apply accountability to professional context • Differentiate between ethics, morals, values, and law • Define and categorize concepts such as Trust and Loyalty • Apply professional ethics in case studies • Distinguish professional ethics in Canada and Quebec context	• Adapt ethical reasoning to resolve professional dilemmas
Equity	• Describe professional obligations against discrimination	• Identify economic disparity as a challenge in globalization & sustainability	• Appreciate gender dimensions of equity

Assessment tools:

At the introductory level we offer ENGR 201 – Professionalism and Responsibility in which students are introduced to the professional system for engineering in Canada with a specific focus on Quebec's professional system. Students are tested on their familiarity with the structure of the OIQ, the Code of Ethics for Engineers, and the "mixed" legal system in Quebec. Students are taught and then tested on their knowledge of the relevant parts of the Quebec Civil Code for engineering practice (legal liability, professional liability, intellectual property, etc.). Students are also given case study scenarios in tutorials that allow them to apply their knowledge about the ethical and legal requirements for engineering in Quebec. These case studies are evaluated for proper understanding and appreciation of the responsibilities of engineers in Quebec.

At the intermediate level we offer ENGR 392 in which we introduce students to the wide spectrum of roles and responsibilities that guide the professional practice of engineers. Many engineers, unlike scientists, practice as professionals. Being a professional entails that individuals adhere to a body of laws called the Code of Engineers or the Professional Code. This code requires the professional to abide by its different provisions that deal with duties and obligations to society. In this class we will understand professionalism, the engineering code and ethical practice of engineers with special reference to Quebec and Canada. This course is particularly important because it will directly address CEAB's graduate attributes on professionalism and ethics by seeking to develop among students 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. In addition this course will also develop an ability to apply professional ethics, accountability and equity.

At the Advanced level we offer INDU 490 – Capstone. For the last two years, students working in capstone projects have been required to apply "Real-time Technology Assessment" (a technology assessment method introduced in ENGR 392) to their individual projects. Students are assessed through appendices attached to the midterm reports as well as the final capstone reports. For the midterm reports, the assessment method requires each team to write a report on an analogical case study mapping the ethical, social, and legal experiences of their chosen analogue and then applying the lessons learned from those experiences to their own design iterations. Students are then required to map the current R&D activities at regional, national, and international levels within their area of innovation and apply those lessons to their own design iterations. Students are assessed on their ability to demonstrate gained knowledge through proper research and application to their own projects. For the final capstone reports, the assessment method requires each team to map the public perceptions surrounding their area of innovation. Teams are then asked to demonstrate how their capstone projects respond to these perceptions. Students are then required to identify and describe key moments throughout their design iterations where technical design choices were affected by the knowledge about the non-technical aspects of their technology acquired through the real-time technology assessment process.

<u>Student surveys</u>: ENCS conducts a semi-annual survey among graduating students. The forty-six question survey includes 2 questions to provide feedback on Ethics and Equity attribute.

3.1.10 Ethics and equity: Questions
[redacted] had encouraged all students to uphold the highest standards of ethical professional practice.
My university studies have enhanced my understanding of, and my ability to apply professional ethics, accountability, and equity.

Assessment results:

The Ethics and equity attribute has been assessed four times since 2010.

Table 36. Measurement History for the Ethics and Equity Attribute in Industrial Engineering

Assessment Cycle	Academic Year	Number of Attributes Assessed	Measure Courses		
			Introductory	Intermediate	Advanced
I	2011-12	4	ENGR 201	ENGR 392	-
II	2012-13	4	Attribute was not measured		
III	2013-14	4	Attribute was not measured		
IV	2014-15	6	ENGR 202	ENGR 392	
V	2015-16	12	ENGR 202	ENGR 392	INDU 490
VI	2016-17	12	ENGR 201 ENGR 202	ENGR 392	INDU 490

1.6.11 Graduate attribute # 11 Economics and project management

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

Curriculum maps:
The mapping of the Economics and Project Management attribute is shown in Table 37. Students are introduced to this attribute in ENGR 301 -Engineering Management Principles and Economics. ENGR 301 also contains material that covers economics and project management at the intermediate level. In Industrial Engineering, students find opportunities to discuss economics aspects of engineering design in several 3rd and 4th year courses. Finally in the capstone course (INDU 490), students demonstrate their skills in Economics and Project Management as engineers.

Table 37. Curriculum Map for Economics and Project Management in Industrial Engineering

Indicators	Introductory	Intermediate	Advanced
Fundamentals of economics	ENGR 301	INDU 372	INDU 423 INDU 490
Economic evaluation of projects	ENGR 301	INDU 311 INDU 372 INDU 421	INDU 423 INDU 490
Project planning and implementation	ENGR 301 INDU 372	INDU 330	INDU 490

Indicators:
Engineering economics focuses on the systematic application of economics tools and methods on engineering problems. Deriving alternative solutions to problems and evaluating alternatives using economic analysis tools such as cash flow, present and future net value, rate of return on the investment, and purchasing power are some of the main topics covered in engineering economics. Consequently, ENCS defined the Economics and Project Management Attributes under three graduate indicators as follows:
Fundamental of Economics: indicator aims at covering fundamental theory and tools relevant to engineering in the engineering curriculum. Intended student learning objectives are:

- At the introductory level
    - Explain engineering costs
    - Explain interest and equivalence
- At the intermediate level
    - Make economic decisions
    - Prepare and use cash flow diagrams
    - Perform and use various economic analysis techniques
- At the advanced level
    - Adapt fundamentals to specific cases

Economic evaluation of projects: indicator aims at training students on application of economics on engineering projects. Engineering design or problem analysis involves introduction and evaluation of alternative solutions. Economic assessment of alternatives is one of the most important criteria that all graduating engineers must have a good understanding of it. The notion that "economic analysis of projects will be done by management" is no longer acceptable in today's highly competitive marketplace. Consequently, ENCS has defined the following student learning objectives to evaluate and improve the program curriculums that ensure high competency in all its graduating students on the Economic evaluation of projects indicator.

- At the introductory level
    - Aware of tools for project evaluation
- At the intermediated level
    - Perform economic sensitivity analysis
    - Perform economic risk analysis
    - Carry out project cost estimation
- At the advanced level
    - Perform economic assessment of projects
    - Evaluate and select alternative projects

Project Planning and Implementation: indicator focuses on operational excellence during the execution of an engineering project. Students are trained on topics such as time-management, risk assessment, team management, contingency plans, and optimization. Expected student learning objectives are:

- At the introductory level
    - Explain and select organizational structures
    - Identify critical paths
    - Identify root causes of project failure
    - Determine customer satisfaction
- At the intermediate level
    - Develop work breakdown structure
    - Develop project schedules
    - Perform network diagram analysis

  - Perform project risk analysis
- At the advanced level
  - Perform economic assessment of projects
  - Evaluate and select alternative projects

The list below provides the relationship between graduate indicators and student learning objectives at all three learning levels for the Economics and Project Management attribute.

Table 38. Student Learning Objective for Economics and Project Management

Indicators	Student Learning Objectives		
	Introductory	**Intermediate**	**Advanced**
Fundamentals of economics	• Explain engineering costs • Explain interest and equivalence	• Make economic decisions • Prepare and use cash flow diagrams • Perform and use various economic analysis techniques	• Adapt fundamentals to specific cases
Economic evaluation of projects	• Aware of tools for project evaluation	• Perform economic sensitivity analysis • Perform economic risk analysis • Carry out project cost estimation	• Perform economic assessment of projects • Evaluate and select alternative projects
Project planning and implementation	• Explain and select organizational structures • Identify critical paths • Identify root causes of project failure • Determine customer satisfaction	• Develop work breakdown structure • Develop project schedules • Perform network diagram analysis • Perform project risk analysis	• Build teams and manage team dynamics • Prepare contingency plans

Assessment tools:

All Industrial Engineering students take ENGR 301 – *Engineering Management Principles and Economics* in their 2nd year. ENGR 301 provides the fundamentals for engineering economics and project management. Students are mainly assessed by assignments and exams. Later in their studies, students are exposed to economics and project management concepts in core industrial engineering courses through term projects. Most 3rd and 4th year courses include an open-ended term project where students are encouraged to use tools and techniques to conduct economic analysis. Finally, all graduating students must demonstrate their knowledge and expertise in economics and project management during their two term capstone project. As mentioned earlier, CES closely works with the capstone course instructors to reinforce economics and project management skills.

Student Surveys: Student feedback on economics and project management is regularly obtained through following survey questions:

3.1.11 Economics and project management: Questions
I am confident that my studies at [redacted] have given me the necessary skills and knowledge to contribute to project management tasks in real-life applications.
I have gained an understanding of the economic considerations that potentially limit my choices in the design process.

Assessment results:

Since 2010-11 academic year, the Economics and project management attribute has been measured four times as follows.

Table 39. Measurement History for Economics and Project Management in Industrial Engineering

Assessment Cycle	Academic Year	Number of Attributes Assessed	Measure Courses		
			Introductory	Intermediate	Advanced
I	2011-12	4	Attribute was not measured		
II	2012-13	4	ENGR 301	-	-
III	2013-14	4	Attribute was not measured		
IV	2014-15	6	ENGR 301	-	-
V	2015-16	12	ENGR 301 INDU 372	INDU 311 INDU 421	INDU 423 INDU 490
VI	2016-17	12	ENGR 301	INDU 311 INDU 421	INDU 423 INDU 490

1.6.12 Graduate attribute # 12 Life-long learning

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

Curriculum maps:
The Life-long learning attribute is sufficiently covered in the Industrial Engineering program. In the near future, working closely with faculty members and through introduction of innovative methods to measure the student skills, the number of courses that cover this attribute will be increased.

Table 40. Curriculum Map for Life Long Learning in Industrial Engineering

Indicators	Introductory	Intermediate	Advanced
Identifying missing knowledge and learning opportunities		INDU 320	INDU 321 INDU 490
Continuous improvement and self-learning	ENGR 201 ENGR 233 ENGR 301	INDU 321	INDU 490 MECH 311

Indicators:
The goal of the life-long learning attribute is to assist ENCS to develop/improve the curriculum to enhance students' self-assessment and self-learning skills. Engineering is a fast changing discipline. Information technology is now the backbone of all engineering fields. Breakthrough research results are finding their ways to industry applications within very short timeframes. Moreover, highly multidisciplinary teams are the regular working conditions for today's engineers. Hence graduating students must have the skills to be able to continually advance in their fields and adapt to new conditions. ENCS has introduced two graduate indicators to successfully train such engineers who continually excel in their careers as responsible engineers.

Identifying missing knowledge and learning opportunities: indicator focuses on self-assessment. In order to learn, one has to recognize the missing knowledge. Hence, the expected student learning objectives at each learning level are:

- At the introductory level
    - Identify available sources for self-learning
    - Critique him/herself in situations that require engineering skills
- At the intermediate level

    - Able to identify new or advanced fields/opportunities in his engineering discipline
- At the advanced level
    - Knows his/her shortcomings to tackle a challenge
    - Can make educated predictions for the future technological and scientific advancements

Continuous improvement and self-learning: This indicator focuses on self-learning capabilities. Students must be given the necessary tools and guidance to continue learning new knowledge and skills in their field of study. Desired student learning objectives at each learning level are:

- At the introductory level
    - Show awareness of various engineering organizations for training opportunities
- At the intermediate level
    - Self-acquire necessary information from different sources
- At the advanced level
    - Assess a new problem and identify the knowledge necessary to solve it

The following list provides the summary for the relationship between student learning objectives and graduate indicators at each learning level.

Table 41. Student Learning Objectives for Life Long Learning

Indicators	Student Learning Objectives		
	Introductory	Intermediate	Advanced
Identifying missing knowledge and learning opportunities	• Identify available sources for self-learning • Critique him/herself in situations that require engineering skills	• Able to identify new or advanced fields/opportunities in his engineering discipline	• Know his/her shortcomings to tackle a challenge • Can make educated predictions for the future technological and scientific advancements
Continuous improvement and self-learning	• Show awareness of various engineering organizations for training opportunities	• Self-acquire necessary information from different sources	• Assess a new problem and identify the knowledge necessary to solve it

Assessment tools:

Throughout their studies, industrial engineering students are frequently encouraged to evaluate the limitations of tools and techniques they learn, utilize available research tools to overcome the limitations and self-learn how to create new tools and methods to overcome the limitations. Most course instructors use assignments, case studies and term projects to train and evaluate students.

Student surveys. Annual exit survey conducted among the graduating students include the following questions.

3.1.12 Life-long learning: Questions
I am confident that I have the ability to continue to educate myself throughout my life to maintain my competencies in a fast-changing world.
My computer science or engineering program has enhanced my desire to contribute to the advancement of knowledge.
My university studies have given me the ability to identify and address my own educational needs in a changing world.

Assessment results:

The life-long learning attribute has been assessed 3 times since the 2010-11 academic year as follows.

Table 42. Measurement History for Life Long Learning in Industrial Engineering

Assessment Cycle	Academic Year	Number of Attributes Assessed	Measure Courses		
			Introductory	Intermediate	Advanced
I	2011-12	4	Attribute was not measured		
II	2012-13	4	ENGR 201 ENCS 282		-
III	2013-14	4	Attribute was not measured		
IV	2014-15	6	Attribute was not measured		
V	2015-16	12	ENGR 201 ENGR 233 ENGR 301		MECH 311
VI	2016-17	12	ENGR 201 ENGR 233 ENGR 301		INDU 321 INDU 490 MECH 311

2. Continuous improvement

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

Instructions for criterion 3.2:

Please complete the following information:

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

2.1 [redacted] Vision for the Continuous Improvement Process

2.1.1 CEAB Expectations from Future Engineers

Engineers Canada has identified 12 unique Graduate Attributes (GAs) that all engineering students must master by the time of their graduation from an engineering program in Canada. It is clear from the CEAB guidelines that all 12 GAs are equally important. Therefore, it is the responsibility of the university to offer programs that ensure graduating students can exceed the minimum expectations of all 12 GAs. At first glance, the 12 GAs appear to be commonsense expectations from a responsible engineer. However, the current accreditation criteria set by the CEAB in fact have triggered a major cultural shift in the way traditional engineering programs engage with pedagogy, particularly for training engineering students in non-technical skills. Most notably, the field of “engineering education” has found institutional support, with engineering faculty members becoming more receptive to the introduction of new non-technical skill courses as part of engineering curriculum. These new courses emphasize non-technical aspects of engineering in their technical courses and introduce more open-ended design projects as part of area courses where such non-technical skills can further be reinforced. Finally, the current vision of CEAB has influenced engineering faculties to become more open to ideas for offering non-traditional postgraduate degrees. Engineering in Public Policy, Engineering Education, Innovation, Technology and Society, Sustainability, Multidisciplinary Studies are a few examples currently offered in Canadian engineering schools. ENCS offers a graduate program in Innovation, Technology and Society and an undergraduate certificate in collaboration with Engineers Without Borders in Global Engineering. The Centre for Engineering in Society of ENCS is currently working on a new proposal to offer a graduate program in Engineering in Public Policy. These courses signal new roles for engineering graduates.

2.1.2 Social Expectations from Future Engineers

Engineers are among the most important contributors in shaping today's technology-driven society. Despite all the good intentions of technological innovators, the impact of engineering on society and the environment has a variety of consequences. Engineers play a crucial role in identifying and mitigating technology's negative impact on society and the environment. Beyond their knowledge of how to minimize such negative impacts, engineers' technical skills give them a unique role in governmental and corporate decision making processes. Societies around the world expect to continue enjoying the benefits of technological advances engineers produce, while simultaneously expecting such advances to cause the least harm. When properly managed, the environment is protected, developments are sustainable, cultures are well understood and respected, public money is well spent and economic justice is sustained. In sum, society requires engineers who are equipped with the required skill-sets to become socially responsible practitioners.

2.1.3 [redacted] vision for Future Engineers

While [redacted] ENCS faculty prepares graduates for employment in traditional design and development environments, we also realize that the range of employment for engineers has changed drastically in recent years. From marketing to human resources, engineers are in high demanded due to their technical, teamwork, and problem solving skills.

[redacted] vision for all engineers is to be capable of:

i) taking part in breakthrough design and development projects
ii) understanding the needs of society, environment and business
iii) practicing engineering according to the rules and regulations set by the regulating bodies and governments
iv) working in multidisciplinary, multicultural environments

Such skills can be achieved through a holistic approach. ENCS aims to continually improve the curriculum by:

- emphasizing on fundamentals of science and technology throughout the entire curriculum;
- synthesizing curricular, co-curricular, and experiential opportunities;
- continuously exploring interdisciplinary relationships between engineering, arts, business and sciences;
- cultivating an environment that values integrity, professionalism, transparency, and ethical conduct of the highest standards;

- fostering an inclusive and diverse community in our Faculty, on the campus and in the world beyond our doors, our city and community

These aforementioned ENCS faculty objectives are well aligned with the CEAB graduate attributes. The current accreditation requirements, with its focus on outcomes-based assessment, enable us to develop a continuous improvement process to fine-tune the curriculum to excel in these objectives.

2.2 Continuous Improvement Process (CIP)

Continuous Improvement Process is the ongoing, systematic observation and evaluation of the current system to identify and resolve problems. As is the case in all engineering design and problem analysis methodologies, systems can only be improved if objectives are well defined. Once the organization's objectives are well defined, a continuous improvement process is implemented through intentional steps:

1. the system is continually evaluated
2. problems or opportunities relevant to the defined objectives are identified
3. solutions that may have impact on the objectives are suggested
4. suggestions are evaluated for their compliance and benefits to the objectives
5. best alternatives are selected and implemented
6. the objective of the organization is reviewed and the process is repeated.

In order to develop a sustainable CIP, ENCS has also taken a systematic engineering design process approach and has adopted the following six-step strategy.

1. Define the vision and objectives of ENCS
2. Review of the current state
3. Identify problems or opportunities for improving the current state
4. Evaluate alternatives and suggest action items to improve the current system
5. Implement action-items
6. Re-define the objectives according to changing needs of the society and business

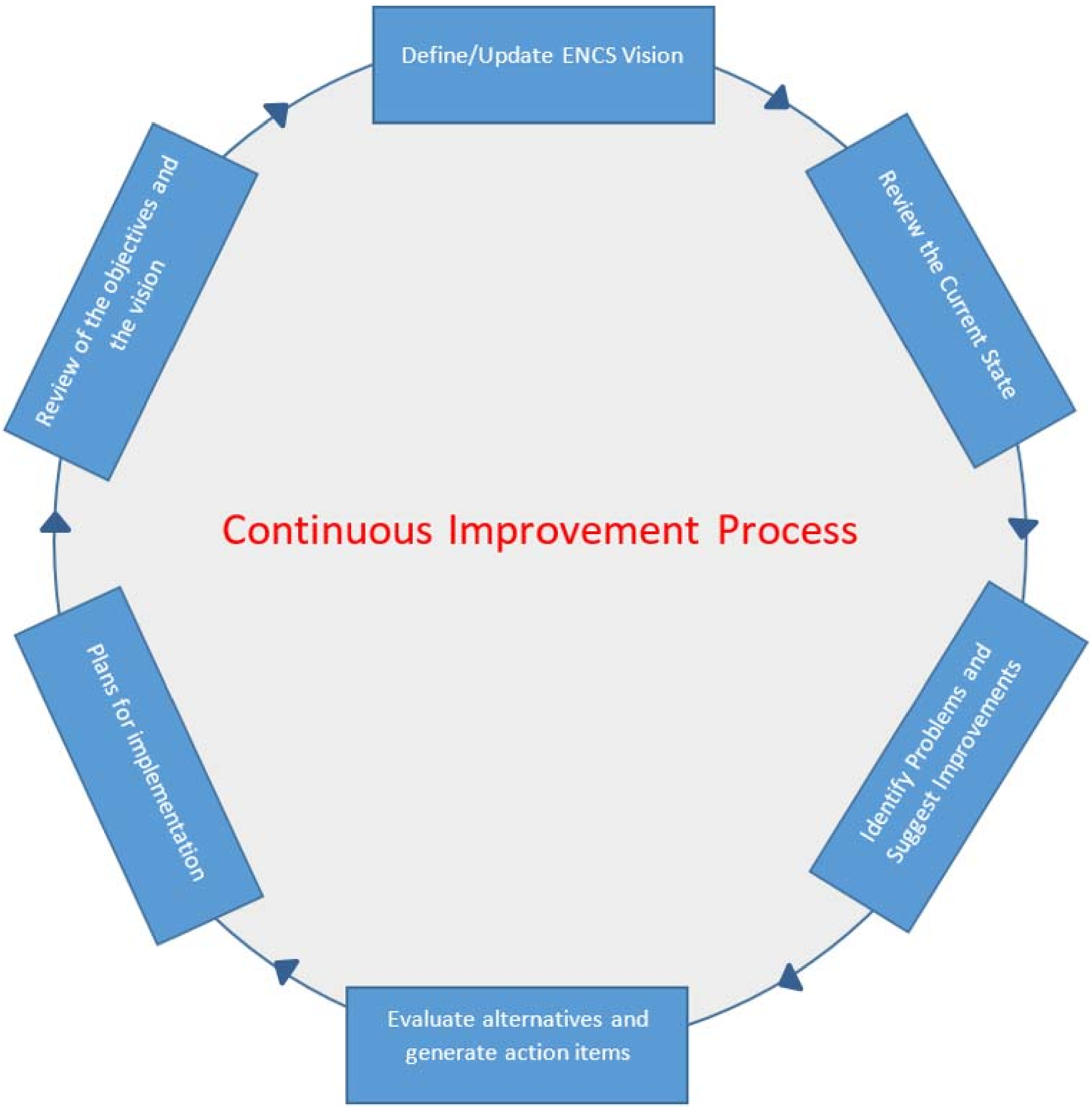

Figure 9. ENCS Continuous Improvement Process

2.2.1 Brief review of 6-step ENCS CIP

Step 1: Define the vision and objectives of ENCS

As stated earlier in this section, the vision and objective of the ENCS faculty is to provide a learning environment for students who become eligible to register as professional engineers in Quebec and are capable of:

- *taking part in breakthrough design and development projects*
- *understanding the needs of society, environment and business*

- *practicing engineering according to the rules and regulations set by the regulating bodies and governments*
- *working in multidisciplinary, multicultural environments*

ENCS continually reviews the current system and makes the necessary modifications in order to support its vision.

Step 2: Review of the current system

i. Review of accreditation requirements

- o *Evaluate the Graduate Attributes*
  - *Definition of indicators*
  - *Definition of Student Learning Objectives at each learning level*
  - *Definition of rubrics*
  - *Review of the curriculum map*
- o *Review of the tools to measure student competencies*

In Section 1, the approach utilized for extracting indicators, student learning objectives, rubrics and the curriculum maps are discussed in full detail. Annually, the definition of indicators, rubrics and curriculum map are reviewed, and changes are made as necessary.

ii. Review of the current student training environment

<u>In-class skill assessment:</u>

✓ *Assign courses to measure student performance at each skill:*
By mid-August of each academic year, departments review the current curriculum map to identify the courses in which to assess graduate indicators. This process was initiated as early as the 2010-2011 academic year during the training phase where a limited number of attributes were assessed. However, starting from the academic year 2015/2016, the Department of Mechanical, Industrial and Aerospace Engineering decided to assess all core courses. The objective was to include the majority of stakeholders in the continuous improvement process and ensure consistency.

✓ *Provide faculty members the necessary tools for measurements*

- <u>Rubrics</u> are available for course instructors to provide reliable feedback on student competencies
- <u>Four level grading scheme (A, B, C and F</u>) enables course instructors to provide compatible measurement results for all ENCS courses.
- <u>Best practice examples</u>: ENCS provides a series of training workshops to publicize best practices for measuring student competencies. Various examples have been distributed to course instructors.
- <u>TA support for data collection and management</u>: Marker salaries have been adjusted as of 2015-16 academic year to compensate for the

additional support given to course instructors for graduate attribute assessments.

✓ *Ensure all faculty members to provide timely feedback:*

- IT Support: [redacted] Graduate Attribute Assessment System (CGAAS) is an in-house developed information management system designed for handling all graduate attribute assessment related activities. CGAAS provides a number of functionalities to faculty members and academic leadership:
  - plan graduate attribute assessment for the given academic year
    By mid-August, departments select courses to assess graduate indicators. Faculty members receive their assignments prior to the beginning of the academic year.
  - collect assessment data
    Course instructors can download a template from CGAAS for grade submission. A single excel file is required to upload grades for a class.
  - provide summary statistics
    Course instructors can view summary statistics for their courses. Curriculum directors, department chairs and other authorized users may access summary statistics for all courses from current and previous academic years. They also have access to grade submission status reports.
  - deposit course outlines and assessment tools
    All faculty members are required to upload the course outlines at the beginning of the academic year. Course instructors are also encouraged to provide their assessment methods in the CGAAS.
  - status report
    Department and faculty administrators can review grade submission status
  - technical support
    One IT technician and a curriculum expert are available to handle any technical issues that course instructors may have during their interaction with the system.

- *Assessment Statistics:* In the 2015 and 2016 academic years, more than 85% of the measurement assignments were completed successfully by the course instructors. ENCS has been collecting student assessment data since 2010. While there was considerable initial resistance from many faculty members during the early years, a significant cultural shift has been achieved. All full-time faculty members and considerable number of part-time faculty members are now completing the assigned measurements on time. ENCS is formulating a plan to improve the engagement of part-time faculty members in the CIP.

<u>Feedback from stakeholders outside of classroom</u>

- *<u>Perform exit surveys on graduating students</u>*
  Until the 2015 academic year, exit surveys were performed annually, among the students graduating in the spring. In 2015, we started surveying students graduating in the winter term as well. Survey questions and the recent results have been provided in the Graduate Attribute Dossier (GAD) Section G
- *<u>Perform surveys on recently graduated students</u>*
  We conducted a survey in 2015 among the alumni who graduated within the last 5 years. (GAD Section H)
- *<u>Review Co-op industry advisor feedback</u>*
  In each department, Co-op program directors receive the industry advisor's reports for all co-op students. Co-op program directors regularly take part in the curriculum committees and CIP committees. (GAD Section J)
- *<u>Review ENCS industry advisory board's feedback</u>*
  ENCS Industry Advisory Board (IAB) meets twice a year. The IAB includes members from a range of industries in North America. ENCS is represented by the Dean, Associate Deans and the Department Chairs. Members from the industry regularly provide their feedback on ENCS graduates in particular, and articulate their general expectations from the newly graduated engineers they hire. The department chairs play a liaison role between the CIPs and ENCS IAB. (Agenda and the relevant documents concerning graduate attributes are provided in GAD Section K)

iii. Develop or update plans to engage stakeholders

The main stakeholders of the continual improvement process are faculty members, students and academic leadership. The external stakeholders are alumni, co-op training, industry advisory boards, government and the community. Currently, ENCS does not have a formal feedback mechanism with the government and the community.

Faculty members: In order to increase the engagement of faculty members, workshops and training sessions have been organized. Most full-time faculty members are or have been members of a CIP Committee (see Table 5). Contributing to the curriculum improvement process through graduate attribute assessment has helped faculty members understand the importance of the current continuous improvement process.

Students: All core course outlines include information concerning the graduate attribute assessment. Students are thus made aware of the skill-sets they will be learning in the course.

Academic leadership: Associate Dean of Academic Programs provides regular updates on CIP during his monthly meetings with the Dean, at the Decanal meetings with the Dean and other Associate Deans, at the Executive meetings with the department chairs and the administrative staff (managers). The Associate Dean also visits department council meetings to provide updates on the CIP and address faculty members' concerns.

Step 3: Identify problems or opportunities to improve the current state

i. Establish ad-hoc CIP Committees for each graduate attribute to analyze the effectiveness of current curriculum for supporting the ENCS objectives

Departments and/or the Faculty establish separate ad-hoc CIP committees for each graduate attribute to evaluate the measurement data and feedback from stakeholders for:

- *assessing problems*
- *generating ideas for improvements*
- *identifying opportunities*

Membership structure of the CIP Committees

- *Chair of CIP Committee:*
  - *For the departmental CIP committees, the chair is assigned by the Department Curriculum Committee*
  - *For the faculty level CIP committees, the Associate Dean of Academic Programs chairs the ad-hoc CIP committees for non-technical graduate attributes*
- *Members*

  Faculty Members in CIP: Faculty members not only measure student performances in their course; they also take part in the CIP sub-committees. *Course instructors who asses the graduate attribute in his/her class are invited to become members of the CIP ad-hoc committee.* For instance, a faculty member who measures communication skill in a course under the Department of Mechanical, Industrial & Aerospace Engineering may be invited to become a member in the faculty-level CIP ad-hoc committee for assessing communication skills. Those faculty members who take part in the CIP ad-hoc committees have become more supportive for the outcome based assessment process as they see the potential benefits of CIP. In turn, these faculty members play a critical role in convincing colleagues of the value of CIP activities.

<u>Technical vs. Non-technical Skills</u>

From the traditional engineering training perspective, 12 graduate attributes are divided into two distinct categories: Technical Skills and Non-technical skills. Technical skills include *A knowledge base for engineering, Problem analysis, Investigation, Design, Use of engineering tools and Lifelong learning.* These attributes are program specific in that they are mostly covered in core courses within the various programs. These technical skills are well aligned with the traditional philosophy of training engineers. On the other hand, non-technical skills that include *Communication skills, Individual and teamwork, Professionalism, Ethics and equity, Impact of engineering on society and the environment and Economics and project management* are more general skills and are expected to be mastered by engineers from all disciplines equally. While programs have their own philosophies to shape their students in the non-technical skills, ENCS believes that fundamental training must be uniform among all ENCS programs. Consequently ENCS has adopted a two-tier system for curriculum improvement.

- Faculty level ad-hoc continuous improvement process committees
    - Communication skills
    - Individual and teamwork
    - Professionalism
    - Ethics and equity
    - Impact of engineering on society and the environment
    - Economics and project management

- Program level ad-hoc continuous improvement process committees
    - A knowledge base for engineering
    - Problem analysis
    - Investigation
    - Design
    - Use of engineering tools
    - Lifelong learning

<u>Impact of two-tier system on the stakeholders' engagement</u>

When it was first introduced by the CEAB, the process of implementing outcome based assessment methods within ENCS has been mainly led by the Faculty Continual Improvement Committee under the leadership of Associate Dean of Academic Programs and Department Curriculum Directors. Establishment of a two tier continual improvement system, involving many more faculty members directly into the CIP was found to be more effective for academic leadership to reach out departments. In the 2010-11 academic year, which was the first official data-collection period, two of the four assessed graduate attributes were non-technical skills (*Communication skills* and *Impact of engineering on society and the environment*). The same two non-technical attributes were measured again in the 2013-14 academic year. The review of these two non-technical graduate attributes was performed by two ad-hoc faculty level CIP committees, chaired by the Associate Dean of Academic Programs. As shown in the committee membership lists for both 2010-11 and 2013-14 academic year assessments (Table 43), the graduate attribute analysis process enabled academic leadership to reach out to wider group of faculty members from all departments. The two tier system has resulted in two unique outcomes:

- Primary benefit:
  - the student competencies on a given graduate attribute are assessed;
  - weaknesses are identified;
  - and solutions to improve student learning experience are proposed.

- Secondary benefit:
  - the opportunity to mobilize faculty level ad-hoc CIP committee members as ambassadors to help curriculum coordinators during the implementation of a continual improvement process in their departments.

Table 43. Attendees of ad-hoc CIP Committees for 2012 and 2014 cycles

Reason: Assessment of Communication Skills Attribute Date: June 5, 2012 **Organized by:** Ali Akgunduz, Associate Dean, Academic Programs	**Reason:** Assessment of Impact of Engineering on Society and the Environment Attribute **Date:** June 1, 2012 **Organized by:** Ali Akgunduz, Associate Dean, Academic Programs

Reason: Assessment of Communication Skills Attribute **Date**: August 28, 2014 **Organized by**: Ali Akgunduz, Associate Dean, Academic Programs	**Reason:** Assessment of Impact of Engineering on Society and the Environment Attribute **Date**: August 28, 2014 **Organized by:** Ali Akgunduz, Associate Dean, Academic Programs

The figure below depicts the current system utilized for graduate attribute assessment in the ENCS.

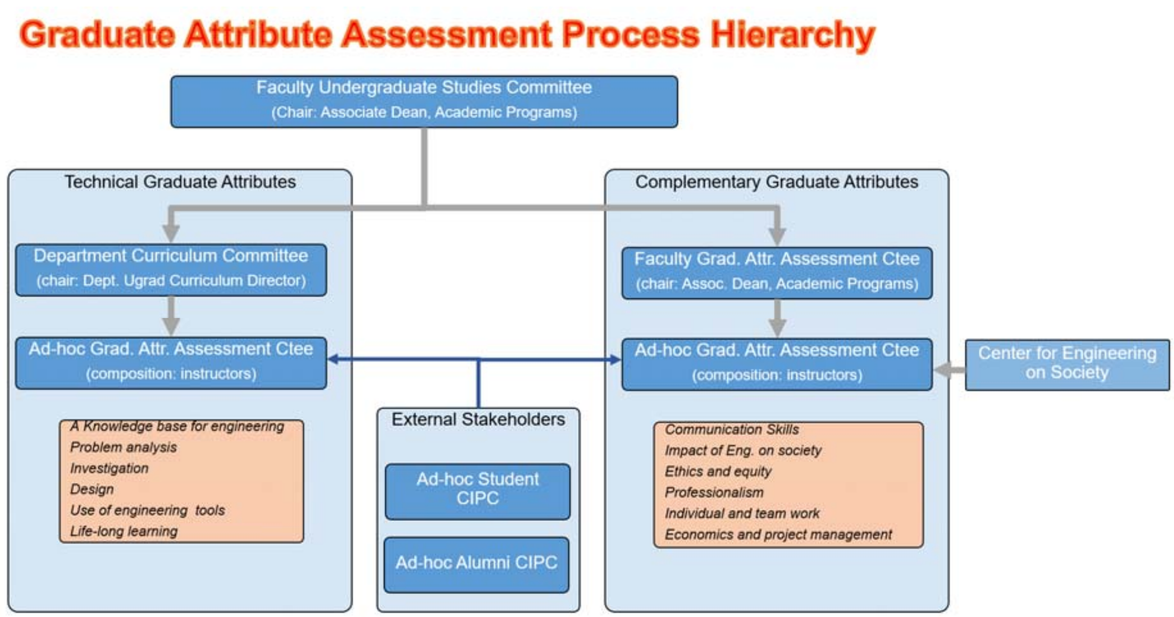

Figure 10. Graduate Attribute Assessment Organizational Structure

ii. Suggestions: Improvements and Opportunities

ENCS has been collecting assessment data from core courses and survey results from graduating students since 2010 and has started forming ad-hoc CIP committees since 2012 with an objective:

- to assess the current engineer training environment
- to identify issues
- to make suggestions for improvements.

Earlier ad-hoc committees served as an experimental setup for the development of the current CIP. The early ad-hoc committees were initiated and chaired by the Associate Dean of Academic Programs to evaluate the status of learning environment for the non-technical skills and design attribute. Building upon this earlier experience, Departmental level sub-committees for evaluating technical skill attributes have been formed. In order, to increase the involvement of faculty members in the Department, the sub-committees are chaired by a faculty member heavily involved in teaching the technical specific skill (see Table 5 for the list of the committee members for each technical skill attribute). The chairs of the sub-committees report their recommendations to all the faculty members during a special yearly meeting for CEAB CIP.

Table 44. History of faculty based ad-hoc CIP committee meetings

Date	Ad-hoc CIP committee	For Measurement data
August 27, 2013	Individual and Teamwork	2012-13
August 27, 2013	Economics and Project Management	2012-13
August 29, 2013	Professionalism	2011-12
August 29, 2013	Ethics and Equity	2011-12
August 28, 2014	Communication Skills	2013-14
August 28, 2014	Impact of Engineering on Society and the Environment	2013-14
February 3, 2016	Design	2013-14 2014-15
February 10, 2016	Ethics and Equity	2014-15
February 10, 2016	Professionalism	2014-15
February 17, 2016	Economics and Project Management	2015-16
February 17, 2016	Impact of Engineering on Society and the Environment	2013-14
March 4, 2016	Communication Skills	2013-14 2014-15
March 4, 2016	Individual and Team Work	2015-16

Below given examples summarize the findings and suggested methods for improvements for the two graduate attributes; Communication Skills (2014) and Professionalism attributes (2016)

Attribute: Communication Skills **Assessment Date: August 28, 2014** **Measurement data from: 2013-14 Academic Year**
Issues Identified: Writing Skills • Group reports do not reflect the performance of all students. Groups usually distribute the responsibilities among members. Project reports may be produced by a limited number of group members. So, assessing writing skills for all students through project report may not be accurate. • While strong emphasis is given on Writing and Presentation skills, research methods and documentation indicators are not well addressed. There should be further emphasis on these two indicators.
Suggestions: **Curriculum Improvements:** • ***Research Methods***: ✓ The term "Research Method" is not perceived same as in communication field. Process improvement should be considered and new term should be proposed as an indicator ✓ Ask students to compare alternative solution methodologies for various engineering problems. Students should provide details about: o Where do they find the information about compared methods o How did they initiate the research o What kind of resources are available to further investigate these methods o Who are the pioneers who first used these methods? What were their purposes? o What are the advantages and disadvantages o Citations At ENCS, best courses to test documentation indicators are Numerical Methods and Probability and Statistics • ***Documentation*** Identify two courses from each program where standards are used or experiments/measurements are performed. Ask student to prepare a document concerning methods, findings, usage, etc.
Other Suggestions: Use exams to test students' writing skills. Short essay questions.

Attribute: Professionalism **Assessment Date**: February 10, 2016 **Measurement data from**: 2014-15 Academic Year
Issues Identified: ✓ *Students should receive feedback concerning their performance on the professionalism attribute* ✓ *BCEE has sufficient coverage on this attribute. Other programs should increase the number of courses assessing Professionalism attribute.* ✓ *ENCS should find innovative ways to assess the attribute.*
Suggestions: ***Curriculum Improvements:*** ✓ *Courses introduce industry norms, government regulations should assess professionalism* ✓ *All team projects should assess professionalism* ✓ *Centre for Engineering in Society (CES) faculty visit core-engineering courses as guest lecturers to introduce a case study to assess students*
Other Suggestions: ✓ *Working closely with CES may help course instructors to accurately assess the attribute.*

Step 4: Evaluate alternatives and suggest action items to improve current system

The dual objective of the CIP of ENCS is to continuously improve both the process and the curriculum. CIP committees produce a report to summarize their findings and suggestions. These reports are provided in the GAD Section F. In this part, we summarize the process and provide samples for process and curriculum improvements.

i. **Process Improvements:**

The existing process is reviewed annually and necessary modifications are performed prior to the beginning of the next academic year. Annual reviews include:

Definition of graduate indicators: Feedback received from students, external stakeholders and faculty members identify weaknesses in graduate indicators as currently described. Accordingly, necessary modifications are proposed to the Faculty Curriculum Committee by the Faculty level Continual Improvement

Process Committee. Once approved, description of indicators are updated in the curriculum map tables.

Curriculum Map Reviews: Two main reasons for proposed modifications to the current curriculum map have been identified.

- Course content/lab/tutorial change: Mostly the result of content changes that are proposed by faculty member(s) to improve the course.
- Reducing the gap in the coverage of skills over the curriculum: As a result of annual review of curriculum map, if the program continuous improvement committees identify a gap between a graduate attribute and its coverage in the curriculum, potential courses to train students on the particular graduate attribute are identified. After consulting with the course instructors, if there are opportunities to cover the graduate attribute, course content is modified accordingly and the course is included in the curriculum map.

Curriculum map reviews must be completed by mid-August.

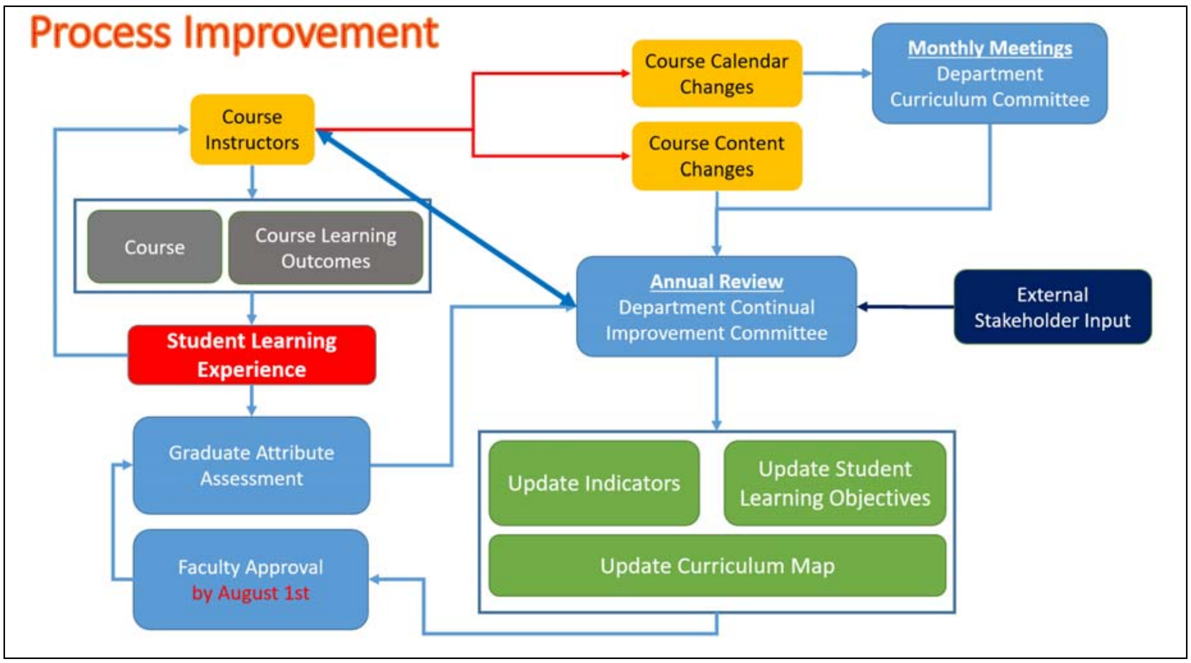

Figure 11. Annual Review of Curriculum Map and Indicator Definitions

ii. Curriculum Improvements:

The majority of suggestions made by the CIP committees are related to curriculum improvements. The outcome based assessment process has made a profound shift in the way curriculums are improved in engineering programs. The current system is attribute focused, hence it provides an opportunity for programs to review their curriculums in a holistic way for each attribute. Consequently, the curriculums are aligned to maximize students learning experiences on each skill from first year to final year courses.

The CIP committees established at ENCS are particularly efficient as they include both faculty members who measure the given attribute in their courses and members from curriculum committees (department chair, curriculum director or Associate Dean). Measurement data from several courses and faculty members' own experiences with students on the given graduate attribute enables the committee to objectively analyze the graduate attribute. Moreover, the department chair, curriculum director and Associate Dean's direct involvement in the CIP committees brings an opportunity for members to review both course measurement data and external feedback such as the results of exit interviews, co-op reports, ENCS industry advisor and alumni feedback. Consequently, CIP committees utilize course measurement data, faculty members' experiences with students and feedback from external stakeholders and perform a thorough analysis on the current state of the student learning environment. Such a holistic approach gives an opportunity for the engineering programs to identify weaknesses and suggest the most effective curriculum improvements.

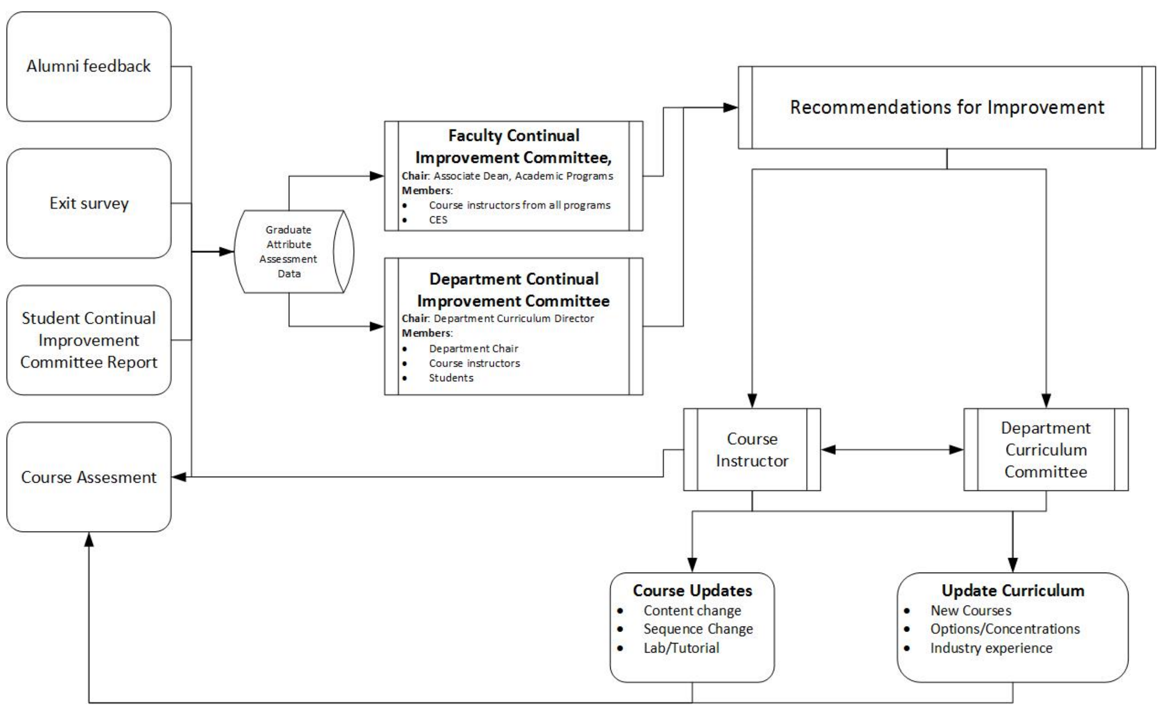

Figure 12. Curriculum Improvement Process

Table 45. Examples for Curriculum Improvements

<table>
<tr><th>Implementation Date</th><th>Reason</th><th>Nature of improvement</th></tr>
<tr><td>2015-16 Academic Year</td><td>Reinforce complementary skills in Capstone courses</td><td>CES Involvement in Capstone Courses: [redacted] work with capstone course instructors to train and reinforce non-technical skills of graduating students. [redacted] is responsible for providing in-class training to all engineering students and helping the course instructors to evaluate students’ competencies</td></tr>
<tr><td>2013-14 Academic Year</td><td>Improve writing skills</td><td>An ENCS technical document writing guidelines has been officially adopted in department councils of all departments.</td></tr>
<tr><td>2013-14 Academic Year</td><td>Improve non-technical skill training through open-ended projects</td><td>Introduce more open-ended projects as part of the core-courses:
Term projects are effective ways to introduce and utilize non-technical skills. ENCS aims at increasing number of courses include term projects.
<table>
<tr><th>Course</th><th>Project Scope</th></tr>
<tr><td>INDU 311</td><td>Build a hospital that effectively serves a local community with 100 doctors.
Build a profitable railway company that operates on a single-track rail-network in Canada</td></tr>
<tr><td>INDU 421</td><td>Build a profitable facility to produce bike-racks of your design
Build a profitable facility that produces hockey gear of your design.</td></tr>
</table></td></tr>
<tr><td>2015-16</td><td>Improve the use of engineering tool</td><td>Introduce labs to reinforce operations research solver usage</td></tr>
</table>

Step 5: Implement action-items

Once CIP committees review the current status of engineering programs and propose changes to address identified issues, department curriculum coordinators, department chairs and the Associate Dean of Academic Program take leadership in evaluating the suggestions and realizing them in a timely fashion. The following 4 step approach is adopted in all programs at ENCS.

i. Review the suggested improvement proposals
ii. Prioritize improvement proposals
iii. Develop an implementation plan
iv. Monitor the implementation process

Step 6: Re-define the objectives according to changing needs of the society and business
Organizations must periodically review their objectives to align with the changing expectations of society and business, reflecting research and technology trends and awareness of the environment. Both [redacted] and ENCS review the vision and goals and release the university and faculty visions in the University Strategic Plan and ENCS Faculty Strategic Plans. While the ENCS strategic plan plays a fundamental role for the current CIP, the result of the CIP is a significant input to the definition of the faculty vision.

Once the ENCS vision and goals are reviewed and updated, the CIP continues from Step 2.

2.2.2 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 main stakeholders of the continual improvement process are faculty members, students and academic leadership. The external stakeholders are alumni, co-op training, industry advisory boards, government and the society. Currently, ENCS does not have a formal feedback mechanism with the government and civil society.

Faculty Members (including Part-time Instructors):

Faculty members not only provide measurement data, but also serve on the CIP committees as discussed in the previous sections.

Student Engagement:

Students have been involved in the CIP in various ways. The Faculty Undergraduate Studies Committee has student representation. Students can provide their feedback on important decisions discussed during the meetings. Exit and alumni surveys are designed to capture the students' feedback on graduate attributes. MIAE has already established two Student CIP committees to review the Industrial Engineering and Mechanical Engineering curriculums from graduate attribute perspectives. The mandate of these committees is to obtain continuous feedback from students on graduate attributes. ENCS has decided to form a student CIP committee in all engineering programs starting from the 2017-2018 academic year.

To increase awareness of the CIP in ENCS among the student population, faculty members are encouraged to provide a short overview of graduate attributes to students at the beginning of each semester. The graduate attributes are explicitly included in the course outlines. Exams and assignments are also designed to better evaluate students on the types of skills that are covered in a course. This way, students are made aware of the skills that are covered in the courses.

Undergraduate Student Committee for Continuous Improvement

MIAE has established two student committees to analyze Mechanical Engineering and Industrial Engineering curriculums from graduate attribute assessment perspectives. Students are given clear directions to review the current state of industrial engineering program and provide a feedback on:

- Strengths of the program
- Weaknesses of the program
- Opportunities and suggestions to improve

Composition of members in 2016-17 academic year is provided in Table 46.

Table 46. Undergraduate Student Committee for Continual Improvement in Industrial Engineering

Name	Level	Role in the committee
Francis Therrien	Fourth Year	Member
Andrew Tianshi Feng	Fourth Year	Member
Céline Paquet	Fourth Year	Member
Emmanuelle Le Brasseur	Fourth Year	Member
Piero Matos Quintana	Fourth Year	Member

The details of their report can be found in GAD Section I.

Academic Leadership:

The academic leadership is demonstrated through the various committees that have been introduced to steer the Continual Improvement Process at ENCS. These committees are presented in Section 1 – Graduate Attributes.

The Center for Engineering in Society:

Both CEAB requirements and the objectives of ENCS have clearly stated that future engineers in Canada and in the world are expected to be well-rounded through blending social skills and awareness with the state-of-the-art technical training. In order to best serve the needs of the students, ENCS has taken an unconventional approach; instead of relying on external experts to integrate the social skills in the traditional engineering training, ENCS has established a permanent department, "The Centre for Engineering in Society" (CES) within the Faculty of Engineering and Computer Science. This Centre, with 5 tenured/tenure-track faculty members and 3 full-time teaching stream faculty members with expertise from public policy to philosophy, works closely with departments and faculty members to develop new pedagogies to blend traditional engineering training with the current expectations of the society and industry. Having such complementary expertise in-house enables ENCS to naturally develop curriculums that blends non-technical skills into the traditional core-engineering courses. Since 2015, a member from CES, [redacted] has been working with the capstone (senior year design project) course coordinators to provide better pedagogical training for students on complementary skills. CES is currently working with departments to extend this collaboration to the 3rd year design courses. Moreover, through collaboration with CES, several core courses have introduced open-ended term projects where non-technical skills are blended into traditional teachings of engineering fundamentals. These changes enable students to relate theory with applications. CES has a regular member in Faculty Undergraduate Studies Committee (curriculum committee) and Faculty Design Committee.

<u>External Advisory Committees</u>

Alumni Engagement Committee on Continual Improvement

The department benefits from two industry advisory boards (ENCS Industry Advisory Board and MIAE Industry Advisory Board). The ENCS Industry Advisory Board meets semiannually. Each meeting provides an opportunity for the advisory board to review the progress in the faculty and provide feedback on the gap between academics and industry. Each meeting has a particular theme specific to graduate attributes. Past meetings included expert presentations on:

- Design
- Entrepreneurship
- Communication
- Leadership

Similarly, the Department Industry Advisory Board provides feedback on industry expectations for engineering qualifications from general engineering essentials to specific topics only relevant to MIAE programs. The advisory board is composed from mechanical engineering, industrial engineering and aerospace experts. In 2016-17 academic year, a pilot study was conducted by two separate ad-hoc group (Alumni Committee for Mechanical Engineering and Alumni Committee for Industrial Engineering). Mandates of the committees was to evaluate how their training at [redacted] shaped their careers. More specifically, the committee members were asked to evaluate their programs for each specific attribute and identify:

1. Strengths of the program
2. Weaknesses of the program
3. Suggestions to improve the student experience

Co-Op and [redacted] International Placement: Feedback from employers

[redacted] has been offering Co-Op training for those students who wish to have formal industry training. [redacted] International Placement focuses on identifying industry experience in overseas for students. Both programs provides individual industry supervisor reports on engaged students concerning their engineering skills. The focus of these reports (GAD Section J) align well with the graduate attributes. Hence, the feedback received from the Co-Op and international placement experiences were incorporated in the development of indicators and are being used in the continual improvement process. Co-op program directors take part in the ad-hoc CIP committees.

2.2.3 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 at the program level. Please list all program-level actions that have been recommended to date. In each case briefly discuss the specific rationale for change and the accountability and timelines for full implementation.

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

Following the two-tier system for curriculum improvement described in step 3, the improvement actions regarding the non-technical attributes are discussed at the faculty level and forwarded to the Departments. Technical attributes are analyzed at the Department level based on the data collection and the CIP sub-committee reports. Each faculty member attending a CIP sub-committee meeting is asked to fill up a CIP form commenting on student performance in the specific technical attribute and suggest improvement items with an implementation deadline. The details of CIP reports are provided in the GAD Section I. Below, a sample list of improvements for all 12 graduate attributes is provided.

Table 47. The sample list of improvement actions in Industrial Engineering

GRADUATE ATTRIBUTE	ISSUE IDENTIFIED	IMPROVEMENT ACTIONS	IMPLEMENTATION
YEAR ASSESSED WINTER 2016			
A KNOWLEDGE BASE FOR ENGINEERING	Some students do not remember important basic concepts needed for more advanced 300/400 level courses.	Develop an online library of fundamental math and natural science topics for students to review when needed.	*This initiative is currently in progress led by the associate dean of academic services.*
YEAR ASSESSED WINTER 2017			
A KNOWLEDGE BASE FOR ENGINEERING	In spite of what is indicated on incoming students' records, we seem to have a number of students who are	- Implement a diagnostic test upon admission. Review admission requirements.	*Admission requirements have been raised (CRC scores for CEGEP students) in order to improve the*

	not adequately prepared in math/natural science topics.		*quality of the entering students* *Associate Dean* [redacted] *is leading a project to improve math training of year zero and first year students*
YEAR ASSESSED WINTER 2016			
PROBLEM ANALYSIS	Mathematical and physical modeling courses should be introduced earlier in the program.	Change Modelling and Analysis of Physical Systems from a 300-level course back to a 200-level course?	*INDU 411-Computer Integrated Manufacturing and INDU 421 –Facilities Planning and Material Handling courses can be moved to earlier in the curriculum. INDU 421 requires strong background in production planning and operations research. It may be difficult to move earlier. Curriculum committee for IE will study the feasibility of these suggestions*
YEAR ASSESSED WINTER 2017			
PROBLEM ANALYSIS	Relying on the final exam as a tool to evaluate problem analysis may be not optimal since the students are not given a chance to improve their understanding.	Bring awareness to the faculty members	*Midterm and projects are utilized to measure the attribute. Industrial Engineering program includes several courses with term projects. CIP committee will work with course instructors to use projects to assess problem analysis skill in open-ended projects.*
YEAR ASSESSED WINTER 2016			

USE OF ENGINEERING TOOLS	Students should be exposed to Matlab earlier in the program	Introduce Matlab earlier in 200-level courses	*Industrial Engineering students are not exposed to Matlab. It is a powerful tool from operations research to statistical analysis. An introduction to Matlab is now covered in MECH 215*
	Despite mastering different engineering tools, the students seem having a difficulty making good decisions regarding the most appropriate tool to be used.	Each teacher of this attribute must include questions (during term and final) where students have to select tools and this must be measured in the next round of attribute assessment.	*INDU 311 and INDU 421 have implemented the suggestion in the 2016-17 academic year.*
	INDU students need a better exposure to CPLEX in order to solve integer, binary-integer, and mixed-integer programming models.	Add a laboratory component to INDU 323 and INDU 324	Laboratories have been added to INDU 323 and INDU 324 and the number of credits have been increased to 3.5.
YEAR ASSESSED WINTER 2017			
USE OF ENGINEERING TOOLS	Co-Op reports and Undergraduate students committee suggest that, advanced knowledge in Excel is essential	Identify a course in INDU to cover Excel	[redacted] has agreed to include Excel training in the INDU 423. However, the Excel knowledge is required earlier in the program. The CIP is looking for other options.
	In INDU 323/324 CPLEX was introduced as an engineering tool. This showed that the students have deficiencies in programming skills.	The Curriculum committee should look into adding MECH 215 as a pre-requisite to INDU 323/324	In progress. ENCS should also find creative ways to improve students programming skills.
YEAR ASSESSED WINTER 2016			
INVESTIGATION	There is not a sufficient number of open-ended experiments.	Introduce more open-ended experiments	*A new project using Arduino has been implemented in MECH 215*

			Some other labs can introduce similar experiments. CIP is looking for other options
	Content for designing experiments/tests is limited.	Introduce design of experiments/tests.	*This has been already been implemented in MECH 321 and INDU 311. However, more has to be done in the upcoming years.*
YEAR ASSESSED WINTER 2017			
INVESTIGATION	Further introduce open-ended projects in the program	INDU program has sufficient number of open-ended projects in core courses. Faculty members should find creative ways to teach and measure investigation attribute.	*CIP will work with the faculty members. INDU 311 already measure investigation as part of the project.*
	Data analysis is a part of this attribute which should be assessed in more than one course.	Change labs to focus more on data analysis, comparison of sample and hypothesis tests.	*In progress. CIP has not met to identify candidate courses yet.*
YEAR ASSESSED WINTER 2016			
DESIGN	The committee feels the need for introducing design earlier in the program.	Add a simple design project *Introduce a "micro capstone" like project course in 2nd year with open ended design and competition -- Autonomous robot drag racing competition.*	*NSERC Design Chairs are working with departments to introduce a formal design course in 1st or 2nd year.* *ENCS has been investigation the possibility of* creating a mentorship system by linking capstone groups with first and second year students. Pairing final year student with new students will enable:

			• new students to better understand design issues • capstone students to improve their managerial skills
YEAR ASSESSED WINTER 2017			
DESIGN	Students mostly design a single design solution. Alternative design is not well understood and students do not have the formal knowledge to compare alternatives	Work with the capstone instructors and courses with term projects	*In INDU 421, the concept of "evaluation of alternative designs" is introduced. In INDU 311, statistical comparisons of alternative designs is given. Both MECH and AERO students should be encouraged to take the technical elective course INDU 440:* Product Design and Development
YEAR ASSESSED FALL 2016			
LIFE-LONG LEARNING	There is a need for more appropriate tools in order to evaluate this attribute.	*WeBWork should be used to help assess this attribute*	*In INDU 321, the term project was modified to better reflect this attribute. Students were asked to analyze three different case studies. In these case studies, students were encouraged to apply INDU 321 knowledge to other areas such as business and healthcare.*
	Life-long learning is not measured sufficiently throughout the program	*Increase the coverage of LLL in all programs*	*Select elective courses to assess LLL* *OIQ training to ENCS students should include 2 hours coverage of LLL*

YEAR ASSESSED FALL 2013			
INDIVIDUAL AND TEAMWORK	Not all students find opportunity to express their leadership skills	Engineers need more exposure to university level student societies	ENCS sponsored engineering students to initiate • Engineering and Commerce Case Competition • Management and Consulting Club • CES worked with the "reflective practice" workshops in Coop • CES offered leadership skills workshop in FALL 2015.
	Term projects are mostly given in technical elective courses. Most core courses do not have term project	Departments should encourage all programs to introduce term projects in the core courses	INDU 421-Design a facility for hockey equipment manufacturing INDU 311-Design a hospital MECH 351-Steam car competition ENCS 282 – Technical Communication ENGR 392 – Impact of Engineering on Technology
	Measuring individual student's contribution is difficult	Use Peer Evaluation Use log books	Capstone courses use logbooks JMSB is using a peer evaluation system. ENCS was first given access through collaboration with JMSB. Starting 2014 academic year, the system has been moved to Moodle. All faculty members have access to the peer evaluation system.

			CES (Deborah Dysart-Gale) met with students in several core courses to discuss teamwork and the individual.
YEAR ASSESSED WINTER 2016			
INDIVIDUAL AND TEAMWORK	Contribution of an individual is difficult to assess in group works.	Use the peer evaluation system (PES) developed by JMSB	An online peer-evaluation solution is available in Moodle. As part of the current [redacted] Graduate Attribute Assessment System, a dedicated, graduate attribute focused peer-assessment solution is considered to be developed.
	Students with high GPAs often face obstacles due to lack of communication skills which may have an impact on their leadership and career development.	Provide leadership opportunities for the high GPA students.	Will have meeting with ECA executive team.
		Create a mentorship program where senior students mentor first year students: Shadow Capstone Teams supervised by actual capstone groups.	The item was discussed in the Decanal and Executive meetings but it's difficult to implement.
YEAR ASSESSED FALL 2013			
COMMUNICATION SKILLS	Based on the assessment results, the committee concluded that students are not followed-up on their writing skills between the ENCS 282 course which is the formal communication course and final year courses such as Capstone. The faculty members believe that in addition to the formal training of students in writing skills, sustainability is equally important. Hence	A standardized lab-report format that encourages students to excel their formal technical writing skills will be developed. All courses with lab component will adapt the standard lab-report format.	A standardized lab-report format is introduced. *CES developed and implemented the "ENCS Form and Style Guidelines"*

	further emphasis should be given towards fostering writing habit (cultural adaptation/change).		
	Group reports do not reflect the performance of all students. Groups usually distribute the responsibilities among members. Project report may be produced by limited number of group members. So, assessing writing skills for all students through project report may not be accurate.	Use different assessment tools such as essay questions, report had been embedded in the courses ENCS 282 and ENGR 392 in order to assess the writing skills of individual students.	Starting September 2014, more responsive assessment tools are used in ENCS 282 and ENGR 392. Both courses now include more individual writing assignments. Also, developed the ENCS Form and Style Guidelines, introducing a specific and shared rubric for individual contributions.
	While strong emphasis is given to writing and presentation skills, research methods and documentation indicators are neglected. There should be further emphasis on these two indicators.	In terms of research methods, ask students to compare alternative solution methodologies to solve/tackle engineering problems. Students should provide details about: • Where do they find the information about alternative methodologies • How did they initiate the research • What kind of resources available to further investigate these methods • Who were the pioneers first used these methods? What were their purposes? • What are the advantages and disadvantages • Citations ….	CES (Brandiff Caron) assesses documentation in Capstone projects. ENCS 282 introduces “research methods” and “documentation” for formal lab reports. There is still a need for identifying program courses where the research methods indicator can be covered better. ENGR 390-Numerical method courses may be an alternative, CIP committee has not discussed this with the courses coordinators yet.

YEAR ASSESSED WINTER 2016			
COMMUNICATION SKILLS	While the collected data shows mainly satisfactory results, there seems to be some misunderstanding about the “Research methods” indicators	Redefine the indicator “Research Methods”	The name of the indicator has been changed to "Information Gathering".
	Assessments are mostly done through projects where the contribution of individual is not always clear.	Use lab reports	Discussions concerning modifying some of the labs has started. CIP has not started working with course instructors.
	The lab report preparation format which was developed in 2014 has not been fully adapted. Department chairs and curriculum directors should encourage course instructors to use the suggested lab report format.	Develop a library of good technical report examples and make them accessible by the students • Technical report • Lab Reports • PowerPoint presentations	Samples are available in the AAS system.
	When evaluating technical writing, students should be made aware of the importance of writing quality.	A workshop on communication skills should be organized. Invite industry reps as speakers.	CES is officially involved in the capstone courses. Introducing new group/term projects in program courses should further enhance the students’ technical writing skills.
	Students should continuously practice their formal communication skills throughout the entire program	Introduce more open-ended projects in program core-courses for students to practice their writing and oral skills.	Work with Design Chairs to introduce more open-ended projects and to organize workshops.
		Lab work should encourage documentation.	This may also help to improve investigation skill. Departments should identify candidate courses with labs. Dean’s office will lead in the 2017-18 academic year.

		Introduce a new course: *Communicating with Clients for Engineers*	Proposed in the Executive Committee meeting. A more concrete proposal is expected. It may be difficult to introduce as a core course but it can be an elective course.
		3rd year Seminar course to all students who must conduct research on a given topic from multiple sources (or small project requires self-learning); provide a written report; and perform an oral presentations in front of faculty members and other students. This can also be used to assess the attribute life-long learning.	In progress. Some faculty members think that this is an extra work for students. It may be considered as a for credit course. Yet, this may be difficult to implement as it would require to remove a course from the core. This topic will continue to be discussed in the Faculty Curriculum Committee during the 2017-18 academic year.
YEAR ASSESSED Fall 2013			
PROFESSIONALISM	ENGR 201 alone is not sufficient to prepare students for the capstone and real-life	The center for engineering and society should help departments to reinforce student training in Professionalism.	[redacted] has been assigned to help with the Capstone courses in all programs. [redacted] has started to work with some 390 (mini-capstone) course instructors to provide better coverage of the professionalism attribute.
	Students should be exposed to more real-life scenarios that reflect professionalism attribute.	Introduce more open-ended projects based on real-life scenarios.	Faculty has been working with the department curriculum directors to increase the term projects in engineering core courses. Open-ended term projects are providing opportunities to reinforce the professionalism attribute. CES has access to a variety of case studies. Our goal is to introduce these case studies as part

			of engineering core courses.
YEAR ASSESSED Winter 2016			
PROFESSIONALISM	Professionalism is covered in many courses with project components. However, some course instructors still do not evaluate this particular attribute in their courses. ENCS should work with the faculty members to introduce new ways of evaluating professionalism component of course projects.	Professionalism should be assessed in courses which introduce industry norms and government regulations.	In progress ENGR 301, AERO 417, INDU 412, SOEN 384, BCE 451 and ELEC 331 are candidate courses. Currently, only SOEN 384 and BCEE 451 are used for assessing professionalism. CIP and CES will work with course instructors of these courses during 2017-18 academic year.
		CES members act as guest lecturers with the aim of introducing case studies in engineering core courses.	[redacted] is working with capstone instructors to better assess professionalism. In the future, we plan to expand this collaboration to 390 and other project based courses.
	Students should receive feedback concerning their performance on the professionalism attribute.	An official record of a student's performance on graduate attributes.	The AAS system provides the statistics for individual students, however, ENCS has not adopted a policy to provide a transcript that shows the performance of students on specific attributes.
YEAR ASSESSED FALL 2014			
IMPACT OF TECHNOLOGY ON SOCIETY AND THE ENVIRONMENT	The course on Impact of Technology on Society (ENGR 392) is offered to students too late in the program. Students should have a good foundation at the beginning of their studies before they	Move ENGR 392 to 1st year in the sequence.	Due to the complexity of course sequencing, it turned out to be challenging to move ENGR 392 to first year. To address this recommendation, CES has

	start tackling open ended projects that require an understanding of the impact of the technology on society.		been working with different programs to better integrate the attribute in the core courses. In addition, ENGR 201 (Professionalism and Responsibility) and ENGR 202 (Sustainable Development and Environmental Stewardship) have introduced materials that cover this attribute. Both of these are already mandatory first year core courses.
	Engineering courses do not include sufficient coverage of this attribute.	Prepare workshops for faculty members to increase the awareness.	Completed: A workshop was given to faculty members on August 26, 2015 and August 31, 2016 to provide best practice examples.
YEAR ASSESSED WINTER 2016			
IMPACT OF TECHNOLOGY ON SOCIETY AND THE ENVIRONMENT	Instructors of core engineering courses should be further encouraged to reinforce these skills. ENGR 392 and design courses (390 and 490) are covering this attribute. Yet, all programs have potentials to bring Impact of Technology on Society and the Environment discussions in courses that are focusing on energy, manufacturing, material usage, automation, artificial intelligence.	Introduce open ended projects in non-design courses	In progress. In recent years, more core courses included term projects.
		Work with Center for Engineering in Society to discuss strategies to introduce impact of technology discussions in engineering core courses	In progress. ENCS is a champion member of Engineering Change Lab. The core mandate of the lab is to promote engineering profession as part of the society and environment as a holistic way. Moreover, CES is helping departments to increase awareness for impact of engineering on society and the environment.

YEAR ASSESSED FALL 2013			
ETHICS AND EQUITY	Continue providing training on academic integrity and ethics on campus	Work with the university and student success center to better train students for: • Professional ethics • Academic ethics	Student success center provides annual workshops as part of engineering core courses on ethical conduct. In addition, effort has been made to train students on proper referencing in technical writing. Furthermore, CES provides formal training on ethics and equity in capstone projects.
	Capstone projects should contain a component of equity	Students must demonstrate how equity is handled in their projects.	CES is working with capstone instructors to better integrate equity in the project
	Students need more exposure to scenarios that reflect ethics and equity in real-life.	Introduce more real-life case studies	CES has provided case studies and literature as part of the capstone courses
YEAR ASSESSED WINTER 2016			
ETHICS AND EQUITY	Assessment of equity is particularly a challenge for engineering programs. ENCS should continue working with departments/faculty members to increase the awareness.	Mandatory non-credit exams similar to OIQ in 3rd and 4th year.	Not a popular option for both students and faculty members. OIQ gave lectures that 392 students attended on Ethics and Professionalism, Winter 2017. CES worked with local chapter of Engineers Without Borders to develop workshops in ethical practice (each Winter semester).

		Open-ended projects in engineering core courses.	In progress. Programs are offering more and more term projects as part of the core courses.
YEAR ASSESSED FALL 2013			
ECONOMICS AND PROJECT MANAGEMENT	Project management is well covered in the capstone courses. More emphasis should be given to other courses.	Update ENGR 301 to focus more on project management	ENGR 301 has been modified. Now the course has better coverage of project management
YEAR ASSESSED WINTER 2016			
ECONOMICS AND PROJECT MANAGEMENT	Departments are encouraged to find ways to apply engineering economics and project management skills in various 300 and 400 level courses along with 390 and 490.	Core courses that include term projects should find new ways to discuss elements of engineering economics.	Cultural shift is needed. Topics such as “life-cycle assessment” has started to be discussed among engineering faculty members. We expect significant improvements on the way economics and feasibility aspects of design is discussed as part of design projects. ENCS will continue promoting the topics. Currently, CES is involved in all 490 (capstone) courses in the faculty. CES is reinforcing the fundamentals of complementary skills and also encouraging students to incorporate social and industry expectations in their capstone projects. We aim at expanding this collaboration to 390 mini-capstone projects in the near future

References

Canadian Engineering Accreditation Board, "A guide to Outcomes-based Criteria-For Visiting Team-Chairs and Program Visitors", Version 1.25, 1 March, 2015.

B.S. Bloom, Taxonomy of educational objectives. Handbook 1: Cognitive domain, David McKay Company, Inc, London, 1956.

M.B.L. Donia, T. A. O'Neill and S. Brutus, (under review). *Peer feedback increases team member performance, confidence, and work outcomes: A longitudinal study. On Proceedings of* Academy of Management, Vancouver, British Columbia, Canada, 2015.

S. Brutus and M.B.L. Donia, "Improving the Effectiveness of Students in Groups with a Centralized Peer Evaluation System" Academy of Management: Learning and Education, 9(4): 652-662, 2010

S. Brutus, M. London, J Martineau, "The impact of 360-degree feedback on planning for career development", Journal of Management Development, 18(8):676-693, 1999.