ONE-YEAR OUTCOME-BASED ASSESSMENT AT RYERSON UNIVERSITY: LESSONS AND BEST PRACTICES

Said M. Easa

Director of Quality Assurance, Faculty of Engineering, Architecture and Science
Ryerson University, Toronto, Ontario
Email: seasa@ryerson.ca

Abstract – *A plan for assessing CEAB graduate attributes was executed on a pilot basis during 2010-2011 at Ryerson University. Based on the assessment results, improvements to the programs were recommended. The Faculty of Engineering, Architecture and Science (FEAS) at Ryerson University has eight engineering programs and seven science programs. The development of the CEAB assessment system was overseen by the FEAS Quality Assurance Council which includes several working groups. This paper presents the lessons and best practices gained during this one-year assessment. The best practices are related to the leadership structure, assessment elements, assessment methods, assessment data and results, and future program improvements. The presented best practices should be useful to the engineering programs that are planning to start or have already started the assessment process.*

Keywords: Accreditation; Engineering; Graduate attributes; Direct and indirect assessments; Improvements; Best practices.

1. INTRODUCTION

The Canadian Engineering Accreditation Board (CEAB) recently introduced an outcome-based criterion for the accreditation of engineering programs. The criterion includes 12 graduate attributes [1]. According to this criterion, each engineering program in Canada must have a system in place for continuously assessing these attributes and using the assessment results to improve the program. The development of a system for assessing CEAB graduate attributes at Ryerson University started in April 2010. An assessment plan was developed during the summer of 2010, and the plan was executed on a pilot basis during the 2010-2011 academic year [2]. Based on the assessment results, improvements to the program were recommended and are considered for implementation by the departmental and Faculty curriculum committees.

Based on the experience gained during the assessment, this paper presents the best practices related to various aspects of the assessment process.

The following sections present the leadership structure, assessment process (elements, methods, data and results, and future program improvements). The best practices in each of these areas are discussed throughout the sections. A summary of the best practices is then presented, followed by the conclusions.

2. LEADERSHIP STRUCTURE

The Faculty of Engineering, Architecture and Science (FEAS) at Ryerson University has seven accredited engineering programs. The baccalaureate degree programs in Aerospace, Chemical, Civil, Computer, Electrical, Industrial, and Mechanical Engineering are accredited by CEAB. The Faculty also has a Biomedical Engineering program that is currently being considered for accreditation, and is the first standalone undergraduate Biomedical Engineering program in Canada. Engineering students are also required to take courses from the science and mathematics departments.

The leadership structure for the graduate attribute assessment consisted of the following main players: working groups, FEAS Quality Assurance (QA) Council, and QA Director.

2.1. Working Groups

Two types of working groups were established: program working groups and special working groups. There were eight program working groups, one for each of the engineering programs. The special working groups were established for areas that are common to all engineering programs, including the Faculty's science programs, instructors of common engineering courses, NSERC Design Chairs, and FEAS Teaching Chairs. The common engineering courses are CEN 100: *Introduction to Engineering* (First Year) and CEN 800: *Law and Ethics in Engineering Practice* (Fourth Year).

2.2. Quality Assurance Council

The QA Council is composed of the program and special working groups, Dean, QA Director, Associate Dean for Undergraduate Engineering Programs and Student Affairs, Associate Dean for Research Development and Graduate Programs, and representatives from the Faculty and University. The representatives may belong to university library, computing centre, teaching and learning (T&L) office, health and safety office, liberal studies, and undergraduate students. The structure of the QA Council is shown in Fig. 1.

2.3. Quality Assurance Director

It is critical for the success of the graduate assessment process to appoint a QA Director. The Director would lead the process in collaboration with the QA Council, and the program and special working groups. The Director's activities at Ryerson included the following:

- Develop/monitor the assessment process.
- Meet with individual working groups to provide guidance and answer questions (over 40 meetings).
- Meet with QA Council to present initiatives and receive feedback (about once a month)
- Meet with Faculty/University representatives.
- Develop software for data analysis and prepare the learning objectives (LO)-graduate attributes document.
- Prepare common course outline and rubrics for capstone report/oral presentations used by all programs.
- Act as a focal point for contact regarding issues that may arise during the assessment process.

Fig. 1. Structure of Quality Assurance Council

- Meet with the assessment instructors at the start of each semester to explain various assessment aspects.
- Develop an assessment report for submission to CEAB before the regular visit.

To promote the effectiveness of the QA Director, it is suggested that resources should be made available for the Director to attend educational workshops and conferences related to graduate attribute assessment. In this regard, a very useful one-week workshop is offered by The Institute for the Development of Excellence in Assessment Leadership (IDEAL) and sponsored by Accreditation Board for Engineering and Technology (ABET).

3. ASSESSMENT PROCESS

3.1. Overall Process

The assessment process included the following tasks:

1. Identify program objectives;
2. Develop the learning objectives for each of the 12 graduate attributes;
3. Map the graduate attributes and LO to all curriculum courses;
4. Determine the assessment schedule;
5. Select courses for assessment;
6. Identify assessment methods (direct and indirect);
7. Develop assessment measures (e.g., rubrics, questions in exams, and surveys);
8. Collect data and analyze the results;
9. Identify strengths and weaknesses of the program;
10. Recommend improvements to the program;
11. Implement recommended improvements;
12. Repeat Tasks 2-11 annually.

The general process is shown in Fig. 2. The blue shaded activities are performed at the Faculty level, while other activities are performed at the program level. The Faculty-level elements that substantially simplify the assessment process are:

- Development of the common LO associated with each graduate attribute.
- Development of a common assessment schedule.
- Development of common indirect assessment methods for all engineering programs, as discussed later.

Note in Fig. 2 the key element of providing feedback for continuous improvements to the program. This is the main objective behind the CEAB graduate attribute assessment. The feedback would normally include program-specific improvements, but also improvements at the faculty or university level (e.g. common engineering courses or liberal studies courses). Note also that program objectives are normally reviewed every three years, where feedback from the constituents and stakeholders is sought, including advisory council and faculty members.

Fig. 2. Assessment process (Faculty-level activities are blue-shaded)

3.2. Assessment Elements

3.2.1. Learning Objectives. The LO (indicators) for each of the 12 graduate attributes were developed for the Faculty as a whole. Each of the eight engineering programs was assigned one or two specific graduate attributes and was asked to develop the respective LO, keeping in mind that the LO would be applicable to all engineering programs. Each graduate attribute had a number of dimensions (e.g. for communication skills, the dimensions include writing skills and oral presentation skills). The developed LO were then circulated to all engineering programs and a final document was prepared after a joint discussion by the working groups.

3.2.2. Curriculum Mapping. The curriculum mapping matrix is a matrix whose rows are program curriculum courses and columns are the 12 CEAB graduate attributes. Table 1 shows such a matrix with a partial list of courses. The curriculum courses include program courses, common engineering courses, and common science courses. Each graduate attribute may be represented by a

single column or by several columns, one for each attribute dimension. The latter is more desirable as it conveys the extent with which each attribute is addressed in the course. For example, in Table 1 Attribute 7 (Communication Skills) has three dimensions *a*, *b*, and *c* that may represent oral, written, and communication tools. The 'x' mark indicates that the attribute dimension is addressed in the course (e.g. CEN 100 addresses dimension *b* of Attribute 7).

To establish this matrix, each faculty member reviews his/her courses and identifies the graduate attributes and their dimensions that are addressed in the course based on its content and materials. Note that it is necessary to ensure that all dimensions of the 12 graduate attributes are addressed in at least one course of the curriculum. That is, each column must have at least one 'x' mark.

3.2.3. Assessment Schedule. The assessment schedule shows the specific CEAB graduate attributes to be assessed each year of the six-year accreditation cycle. It is necessary that each graduate attribute is assessed twice (every three years) during the cycle. Such a scheme allows monitoring the progress associated with graduate attributes during the cycle and in turn developing appropriate improvement measures.

A proposed assessment schedule is shown in Table 2. Note that the first year of assessment includes soft-skill type of attributes that normally require more attention in academic engineering programs. Also, at Ryerson the design attribute was originally split and addressed in two consecutive years. However, for efficiency it is recommended here to address it in a single year.

3.2.4. Assessment Courses. The courses used for assessment in the 2010-2011 academic year include the following:

- 5-6 Program courses
- 2 Common engineering courses
- 3 Science courses taught to all First-year engineering students

The program courses are selected using the curriculum mapping matrix. For the graduate attributes scheduled for 2010-2011 academic year, the courses that address these

Table 1: Example of curriculum mapping

Course	Title	Graduate Attribute											
		1	2	3	4	5	6	7	8	9	10	11	12
		Knowledge Base	Problem Analysis	Investigation	Design	Engineering Tools	Individual and Teamwork	Communication Skills	Professionalism	Impact on Society and the Envir.	Ethics and Equity	Economics and Project Mgt.	Life-long Learning
CEN 100	Intro to Eng.							a b c	X	X	X		
CHY 102	General Chemistry	X	X										
MTH 140	Calculus I	X	X										

Table 2: Proposed schedule for assessing CEAB graduate attributes for accreditation cycle 2012-2018

Academic Year of Assessment		
2012-2013	2013-2014	2014-2015
2015-2016	2016-2017	2017-2018
- Communication skills	- Individual and teamwork	- Knowledge base for engineering
- Professionalism	- Economics and project management	- Problem analysis
- Impact of engineering on society and the environment	- Lifelong learning	- Investigation
- Ethics and equity	- Design	- Use of eng. tools

attributes are considered for assessment. The common engineering courses include a First-year course (CEN 100) and a Fourth-year course (CEN 800). There are seven science courses offered to First-year engineering students. Of these, three are used for assessment: MTH 140: *Calculus I*, PCS 211: *Physics: Mechanics*, and CPS 125: *Digital Computation and Programming*.

In selecting the program courses for assessment, it is critical to start with the faculty members who are more motivated. Those members not only would help to move the process forward, but also would be beneficial in the following years to train other faculty members.

3.2.5. Standard Items. A good practice for assessment is to develop a standard course outline for all engineering courses. This aids the review of curriculum courses by the CEAB visiting team. In addition, at Ryerson each instructor is asked to list the LO in the standard course outline based on the curriculum mapping matrix. Each LO was listed along with the graduate attribute number and its dimension. The course outline is signed by the course instructor and associate chair.

3.3. Assessment Methods

3.3.1. Direct Assessment. The direct assessment of the graduate attributes is conducted by course instructors. The QA Director meets with the instructors of the selected courses at the beginning of each semester. Rubrics for capstone reports and oral presentations can be found in [3]. These rubrics, with slight modifications, were given to all engineering programs to guide the assessment. The rubrics break down each graduate attribute dimension into characteristics consistent with a student who Does not Meet Expectations, Meets Expectations, or Exceeds Expectations.

An innovative method for assessing graduate attributes using multiple-choice questions that are normally used in large classes has been developed [4]. The method is implemented in the common engineering course (*Law and Ethics in Engineering Practice*). The graduate attributes are assessed for the entire class (446 students) using questions in the midterm and final exams. For each attribute component, a group of 3-7 questions is designed to address the important elements of the LO. The student answers are then classified into three scales: Poor, Average, or Excellent based on the number of questions the student correctly answers.

3.3.2. Indirect Assessment. Surveys for indirect assessment are developed by FEAS Teaching Chairs and used by all engineering programs. The surveys include two student opinion (exist and teamwork) surveys and one faculty member opinion survey. For useful

information on how to develop assessment surveys, see [3] and [5].

The exit survey is distributed to Fourth-year students. The questions focus on learning experiences and skill areas. Students are asked to rate each of the statements on a scale of 1 to 5. In addition, students are given the opportunity to make comments on their educational experience at Ryerson. The teamwork survey involved a rubric that is used to provide feedback on student opinion on teamwork. Scantron sheets are used for both surveys

The faculty member opinion survey asks for the perception of the faculty member on student performance. For each of the graduate attributes assessed, the faculty member indicates the percentage of students in the course who had achieved that graduate attribute for each performance scale (Poor, Average, and Excellent). Note that for simplicity only three scales were used.

3.4. Assessment Data and Results

3.4.1. Data Collection. In collecting assessment data, a few tips may be noted. First, for a particular graduate attribute being assessed, use a few learning objectives and focus on assessing the most important ones. Make sure what is being collected will yield information, not just data. One of the common mistakes in assessment is that programs tend to collect huge amounts of data, much of which are not useful. Second, since the graduate attribute assessment is an evaluation of the program, sampling is acceptable, especially in large classes. However, ensure that the sample is representative of all students.

Third, although CEAB requires that a program demonstrates that students achieve the graduate attributes at the time of graduation, the courses selected for assessment should span across all four years of the program. Such earlier (formative) assessments allow monitoring the progress of graduate attributes and help identify where improvements should be made.

3.4.2. Analysis of Results. An example of the analysis results for a learning objective is shown in Fig. 3.

Fig. 3. Example of student performance for a learning objective (LO1)

The results show that the percentages of students achieving poor, average, and excellent performance are 25%, 26%, and 49%, respectively. That is, the percentage of poor plus excellent performance is 75%. The threshold (TH) and target (T) for this learning objective are selected as 80% and 95%, respectively. Improvements to this learning objective are clearly needed.

One best practice for analyzing assessment data should be noted. During the first year of assessment at Ryerson University, the original intent was to use software like the Blackboard. However, it was found to be much simpler to analyze the results using a spreadsheet. A common spreadsheet was developed and used by all engineering programs to enter the data which were automatically analyzed. The spreadsheet calculates statistics for the learning objectives from the data entered by the course instructors.

As assessment data/information accumulates over time, it would be necessary to develop or acquire a Faculty-wide database management system. Such a system can provide different levels of access to various levels of administration. It should also include analysis tools to monitor progress of the graduate attributes over the four years of the program and over time. Other features may include the relationships among different courses of the curriculum (e.g. pre-requisites).

3.5. Future Program Improvements

Program improvements can be identified based on the assessment results and the selected target and threshold levels. These levels may vary among graduate attributes and through the four years of the program. At Ryerson, each program identified program-related improvements and Faculty-level improvements (common engineering courses, science courses, and some liberal studies courses) were discussed by the QA Council.

In the early stages of graduate attribute assessment, the improvements should focus not only on student performance, but also on the tools used to assess them. These include revision and fine-tuning of learning objectives, curriculum mapping matrix, scoring rubrics used for assessment, direct and indirect methods, data analysis, and training of instructors.

4. SUMMARY OF BEST PRACTICES

A summary of the best practices for graduate attribute assessment is presented in Table 3. These practices are mostly based on the experience gained during the pilot assessment at Ryerson University. They are related to leadership issues, assessment elements, assessment methods, assessment data and results, program improvements, assessment report, and other aspects.

Table 3: Best practices for graduate attribute assessment

Aspect	Best Practices
Leadership Aspects	<ul style="list-style-type: none"> - Designate a person to lead the process. - Establish program and special working groups and use local university resources. - Ensure faculty buy-in through clear communication. Acquire facilitation basics.
Assess. Elements	<ul style="list-style-type: none"> - Keep the process simple (e.g. common LO and assessment schedule). - Review the LO annually and the curriculum mapping every three years. - In first year, assess the graduate attributes related to soft skills. - Develop a common course outline that includes the LO related to the course. - Focus on few LO for each graduate attribute dimension. - In selecting courses to be assessed, start with motivated faculty members. - Stress that the process does not assess the instructors, but the program.
Assess. Methods	<ul style="list-style-type: none"> - Must use direct methods. Indirect methods are supplementary. - Don't use advanced assessment methods (e.g. triangulation) early in the process. - Develop scoring rubrics for only complex attributes and pilot test them before use. - Ensure you collect information, not data.
Assess. Data and Results	<ul style="list-style-type: none"> - Develop a template spreadsheet for the analysis of assessment data. - Use three performance scales for data analysis (e.g. poor, average, excellent). - Use both target and threshold for each LO.
Program Improve.	<ul style="list-style-type: none"> - Involve curriculum committee/advisory council/QAC to develop improvements. - Monitor effect of improvements to graduate attributes every three years.
Assess. Report	<ul style="list-style-type: none"> - Prepare a report of the assessment effort and include it with CEAB questionnaire. - Keep the report simple and focused. - Include a clear flow chart of the process. - QA Director writes the report's common parts, program parts are then added. - Remember that a main complaint of CEAB visitors is quality of documentation.
Other	<ul style="list-style-type: none"> - Acquire a useful assessment book, such as [3], for use by engineering programs. - Collaborate with other universities that have gone through the process. - Develop or acquire a Faculty-wide database management system (long-term) - Organize retreats/workshops at the program and Faculty levels.

5. CONCLUSIONS

The key ingredients that have contributed to the success of the assessment process are: (a) continuous interaction between the QA Director and individual working groups and representatives, (b) frequent general meetings for engineering chairs and course instructors who conduct the assessments, (c) appointment of a coordinator/working group for the science courses taught to engineering students, and (d) several retreats at both the program and Faculty levels.

During the 2012-2013 academic year, the following tasks will be undertaken at Ryerson University:

- Implement program and Faculty-level improvements that have been identified.
- Review and revise the learning objectives of the graduate attributes.
- Review and revise the curriculum mapping matrix.
- Select the courses to be assessed.
- Assess specific graduate attributes according to the assessment schedule.
- Validate the scoring rubrics used for oral presentations and capstone reports.
- Conduct triangulated assessments.
- Establish a database management system to store yearly assessment data.

Acknowledgements

The author is grateful to all the individuals who have contributed to the assessment process at Ryerson University during the past two years. These include the dean, associate deans, engineering chairs, associate chairs/program directors, NSERC design chairs, FEAS teaching chairs, science coordinator and chairs, Faculty/university representatives, and course instructors. In particular, the author acknowledges the following: D. Androutsos, T. Antimirova, K. Behdinan, P. Chan, M. Colasuonno, L. Fang, J. Friedman, M. Jaseemuddin, D. Joksimovic, M. Kassam, G. Khan, M. Lachemi, M. Mehrvar, H. Marzouk, R. Nagendra, D. Opasinis, M. Reed, K. Sennah, J. Smith, F. Stewart, S. Upreti, P. Walsh, F. Yuan, and S. Zolfaghari.

References

- [1] Canadian Engineering Accreditation Board. *Accreditation Criteria and Procedures*. CEAB, Ottawa, Ontario, 2010, 87 pp. {ISSN 1708-8054}.
- [2] Ryerson University. *Assessment of CEAB Graduate Attributes: Plan and Results (2010-2011)*. Faculty of Engineering, Architecture and Science, Toronto, Ontario (Note: there are eight reports, one for each of the engineering programs).
- [3] Joni Spurlin, Sara A. Rajala, and Jerome P. Lavelle (eds.), *Designing better engineering education through assessment*. Stylus Publishing, Sterling, Virginia, 2008, 360 pp. {ISBN 978-1-37932-212-3}
- [4] Said M. Easa, Marc A. Rosen, and D. Robert Beaumont, Innovative assessment of CEAB graduate attributes in large class: Law and ethics in engineering practice. *Proc., Canadian Engineering Education Association (CEEAA12) Conf.*, 2012 (Paper 106).
- [5] Linda A. Suskie, *Questionnaire survey research: What works*. Association for Institutional Research, 1999, 206 pp. {ISBN 1-882393-05-8}