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The Development of Technology-supported Approaches to the LO Process for Accredited Engineering Programs

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Abstract - *Tracking graduate outcomes is a new requirement for engineering education in Canada. Working closely with curriculum developers and educational technologists, the School of Engineering at the University of Guelph developed a curriculum improvement process that combined people, process and learning management technology to collect and analyze the required data. The process began by tracking 12 graduate attributes through 41 indicators in the fourth year capstone course. Tracking was then expanded to common core courses and then finally to all program specific courses. The time to successfully develop and fully implement the process to track and analyze the 12 graduate outcomes was less than six years. To complete in this timeline required engaged and open-minded participants, as well as integrated technologies to collect and report the data. The resulting process provides a sound way for tracking outcomes to satisfy accreditation requirements and internal quality education metrics. Most importantly, all faculty and staff now realize the importance of collecting graduate outcome data and have various support mechanisms at their disposal, leading to the ultimate goal of curriculum improvement.*

Keywords *– accreditation, learning management system, learning outcomes, quality assurance, continuous improvement.*

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1. Introduction

Development and implementation of a curriculum improvement process based on the outcome assessment required by the Canadian Accreditation Board (CEAB), led the School of Engineering (SOE) at the University of Guelph to consult Open Learning and Educational Support processes adopted by the Ontario Veterinary College, which also included an emphasis on learning outcomes. The SOE also looked to the work of a national initiative called the Engineering Graduate Attribute Development (EGAD) Project for guidance [1]. Adopting and tracking graduate attributes (i.e. program level learning outcomes) required the establishment of new processes in the SOE, and all Higher Education Institutes (HEIs) in Canada, and this caused much angst at the institutions. To provide guidance on how to adopt new processes in the academe, this paper presents an overview of a collaborative institutional effort between the SOE and OpenEd implementing a process and describes the infrastructure needed for curriculum improvement based on student learning outcomes. Insight is provided into the importance people have in designing the process and the subsequent implementation of the process. An overview is also provided on the significant role Learning Management System (LMS) technology can have in tracking and managing continuous curriculum improvement.

2. Background

In 2005 the Ontario Ministry of Training, Colleges and Universities formed the Higher Education Quality Council of Ontario,[HEQCO) to advise on improving all aspects of postsecondary education, including quality, access, and accountability. Subsequently, in 2006 HEQCO released a document outlining the five priorities of the ministry, one of which led to the creation of a quality assurance framework for the Ontario post-secondary system [2]. Stemming from this work, in 2010, the Ontario Council of Academic Vice-

Presidents' Quality Assurance Framework [3] required that institutions develop and implement an Institutional Quality Assurance Process (IQAP) that was consistent with their institutional mission and degree level expectations [4]. Part of the framework also required that each individual academic unit articulate learning outcomes that were appropriate to the discipline and aligned to the institutional mission. With Ontario Universities implementing their respective Quality Assurance Frameworks, there is now a commitment to focus on assessing learning outcomes and the continuous improvement of curriculum and student learning across the province.

At the University of Guelph, establishing learning outcomes was a natural extension of reframing institutional learning objectives established in 1987. Beginning in 2010, the University engaged in a two-year consultative process that resulted in the development and Senate approval of five program level learning outcomes, their associated skills, and detailed rubrics designed to provide a consistent approach to their assessment. This resulted in the University's Undergraduate Learning Outcomes (December 5, 2012) and Graduate Learning Outcomes (May 31,2013) [5].

The five approved outcomes for both undergraduate and graduate programs, intended to enhance student learning, are: i) Critical and Creative Thinking, ii) Literacy, iii) Global Understanding, iv) Communicating and v) Professional and Ethical Behaviour [6]. "*These five Senate-approved learning outcomes serve as the basis from which to guide the development of degree programs, specializations and courses; as a framework to ensure outcomes are clear to students and to support their achievement; and to inform the process of assessment of outcomes through institutional quality reviews of programs and departments [6].*" Having clearly defined outcomes ensures that learning objectives in each course are clear, so that students are aware of what is required to be successful with an overall philosophy of student independence as they master the material.

Soon after the University's learning outcomes were approved, Open Learning and Educational Support (OpenEd) took the lead in creating a comprehensive approach to the assessment of learning outcomes. Within the University of Guelph, OpenEd has long worked with faculty and departments to help craft effective learning outcomes at the course and program levels. The aim was to help faculty and programs keep track of their students' progress and track a student's outcomes achievement over the course of their program of studies and add it to other data that was being gathered, as part of Guelph's faculty driven, data-informed, and educational developer supported approach to curriculum development [7].

OpenEd was well placed to provide leadership for Leaning Outcomes Assessment project with the SOE; in addition to assisting with faculty and curriculum development, OpenEd administers and supports the University's learning management system, utilizing Desire2Learn (D2L) technology [8]. The idea was to use D2L's Insights analytics platform, along with their Competency tool to track and assess the learning outcomes of students through course activities, either carried on in the LMS or added to the course grade book. The University became part of Ontario's Learning Outcomes Assessment Consortium and was able to obtain seed funding from the Higher Education Quality Council of Ontario (HEQCO) and the Ministry of Training for Colleges and Universities (MTCU) to investigate the concept and scalability of the project.

Outside the University, professional programs and accrediting bodies also focused on outcomes-based education, such as Human Medicine, Veterinary Medicine, and Engineering. In Canada, Engineering is a regulated profession that is governed at the provincial or territorial level. Graduating from accredited undergraduate engineering programs is the foundation to becoming licensed as a professional engineer in Canada. In order to ensure that Canada's engineering education system is a world leader, the provincial and territorial bodies work with Engineers Canada [9] and have set up the Canadian Engineering Accreditation Board (CEAB). The CEAB sets the national standards for engineering education on behalf of the provincial and territorial regulatory associations. These standards are updated yearly and provide consistency, quality assurance, and mobility with the profession across Canada, as outlined by the Accreditation Criteria and Procedures Report [10].

Currently there are 279 accredited engineering programs at 44 higher education institutions (HEIs) across Canada [9]. Inclusion in the list is only possible after a successful "site visit" by the CEAB. The site visit team reviews the information provided by the institution according to the Accreditation Criteria and Procedures Report [10] and conducts onsite interviews to verify the information provided. Only complete undergraduate engineering programs are accredited and not individuals, courses and institutions. The maximum period of accreditation is six years. Following the site review, and based on quality of the education provided by the institution, the CEAB may require supplemental written reports during the six year period or if needed, more frequent visits.

At an international level the CEAB also signed the Washington Accord in 1989 [11], which acknowledged that the accreditation standards for respective engineering programs were then comparable, and that all graduates satisfy the academic requirements for engineering at the professional level. Outcomes-based education approaches based on Graduate Attributes are a key principle of the Washington Accord.

In response to the focus on outcomes, the CEAB adopted outcomes-based continuous improvement into the site visit process, which occurs every 3-6 years. The CEAB required programs to track and report on graduate attributes in addition to the traditional inputs into the education process that were previously monitored, e.g., contact time in lectures and labs, course content, exam and project grades, quality of instructors [10]. Canadian engineering HEIs were notified of this requirement in (2008) and beginning with the 2017-18

accreditation cycle, the demonstration of an outcome-based Graduate Attribute and Continuous Improvement Process would be a fundamental requirement of accreditation. Within a very short timeframe, the Canadian engineering profession had to respond to an increased focus on outcomes-based education, as both the accreditation and university landscape evolved to adopt graduate attributes and program learning outcomes respectively.

For Guelph's School of Engineering (SOE), developing an accreditation process that involved the tracking of graduate attributes, raised two unique challenges. Firstly, the data and reporting still had to be provided to CEAB to satisfy the official requirements. Secondly, new mechanisms for tracking and reporting learning outcomes (graduate attributes) had to be put in place and demonstrated for upcoming accreditation visits. Complicating matters, there was very little guidance on process expectations, or monitoring and assessment requirements in relation to the 12 graduate attributes put forward by the CEAB: (1) Knowledge Base for Engineering, (2) Problem Analysis, (3) Investigation, (4) Design, (5) Use of Engineering Tools, (6) Individual and Team Work, (7) Communication Skills, (8) Professionalism, (9) Impact of Engineering on Society and the Environment, (10) Ethics and Equity, (11) Economics and Project Management and (12) Life-long Learning [10].

2. Approach/Methodology

Moving from the historical, input-only based approach, to creating and implementing an outcomes framework for program level graduate outcome-based assessment mandated by the CEAB, constituted a significant shift in thinking related to the SOE interaction with the curriculum across its seven programs. There were many challenges in getting started, for example: there was minimal data collection and few outcomes-based processes in place in the School or in the institution. Compounding the situation was the lack of a clear direction or evaluation process from the CEAB. Although faculty generally agreed that an outcome-based evaluation of student performance could be a positive approach, there were diverse opinions on the most appropriate direction. Thus, prior to starting, a significant number of faculty and staff both within and outside the SOE had to get involved in the process.

The first major challenge was getting the faculty to agree on a direction. Initial discussions with SOE faculty regarding the implementation of the new CEAB outcomes-based model were held at a faculty retreat in 2010. This resulted in the appointment of a faculty coordinator for graduate attributes in 2011. Over the next 2 years, workshops were held on topics such as using learning taxonomies [12], and on approaches to and benefits of outcomes-based assessment methodologies, particularly as defined by CEAB within the context of the Washington Accord. By late 2012, using the 12 defined CEAB Graduate Attributes as a starting point, faculty developed over 100 GA elements/sub-elements and over 300 target/threshold statements relevant to the curriculum. Each course instructor then mapped teaching and assessment of these elements at the course level.

In 2013, the SOE received feedback from both OpenEd at the University of Guelph and the CEAB on its early work related to outcome-based graduate attributes. It was apparent, that although much thought had been put into defining the outcome requirement for the program and understanding the graduate attribute process, work had not progressed much beyond the planning stage. This was due to the limited amount of new resources being applied to the process, as well as the large number of defined curriculum elements, which made it difficult to efficiently manage the mapping of outcomes and assessments at the program level. The SOE responded by adding resources to the process, which included a full-time GA coordinator (faculty member), a full-time support staff member dedicated to accreditation, and expanding a project to leverage the University's learning management system with the goal of increasing efficiency and effectiveness in capturing and retaining student performance data for outcome assessment.

In addition, an expanded Graduate Attribute committee was struck and a 5-step graduate attribute continuous improvement process (GACIP) was adopted and tailored to the programs, processes, and resources that exist at the SOE. This best practice approach to establishing a curriculum improvement cycle was prepared by a National Council of Deans of Engineering and Applied Science (NCDEAS) supported project, referred to as Engineering Graduate Attribute Development (EGAD) Project [1]. The five elements of this process are listed below and illustrated in Figure 1: 1) Program Evaluation, 2) Curriculum Mapping, 3) Identifying and Collecting Data on Student Learning, 4) Analyzing and Interpreting the Data and 5) Data-Informed Curriculum Improvement.

A critical piece of the revised process was consolidating the 100 plus elements and sub-elements to 41 indicator statements. The SOE Graduate Attribute Committee completed this work. Moving from the more than 100 elements to only 41 indicators greatly simplified the mapping processing a variety of ways, including communicating the system to faculty, and applying the outcome framework within the LMS. In addition to reducing the number of indicators, the SOE adopted a standard approach to performance levels for outcome assessment: exceeds expectations, adequately meets expectations, minimally meets expectations, and fails to meet expectations. Quality performance statements were developed to describe the four levels of outcomes. Table 1 gives the proposal rubric for the fourth-year capstone design course, ENGG*41X0 – Engineering & Design IV.

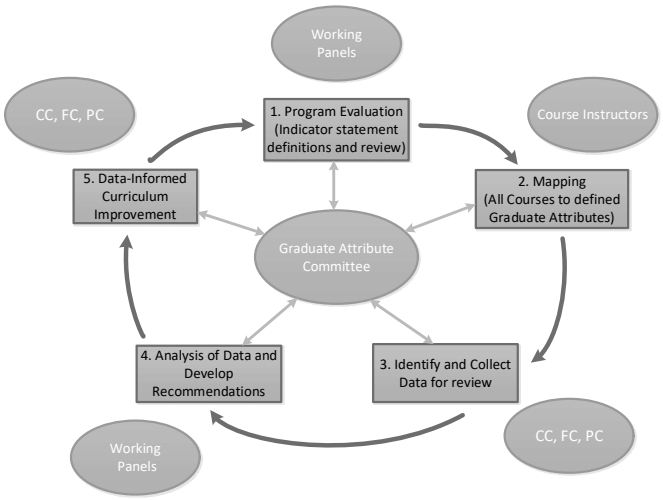

Figure 1: 5-Step Graduate Attribute and Continual Improvement Process (adapted from EGAD [1])

Faculty Council voted 77% in favour in January 2015 of the revised framework, referred to as the "Graduate Attributes and Curriculum Improvement Process 2014-2018 Operational Plan" (2014-2018 GACIP).

4.0 Implementation

4.1 Implementation in the Learning Management System

A key element in implementing the graduate attributes for the SOE was the utilization of the University's Learning Management System, which proceeded over a number of phases.

The first phase involved the technical development of a learning outcomes assessment system (LOA) within the LMS. OpenEd worked directly with D2L to utilize their Competency tool and Insights analytics program to create the suitable environment. Initially, the learning environment was designed to track grades in a single course rather than sets of outcomes within a course and then across an entire program of studies. Moreover, the courses in the LMS are organized according to departments, with students associated with individual courses. Within a course, there could be different students from multiple programs. To track student activity across a program, a second structure had to be developed that would associate students with their programs. The next phase was a proof of concept for the LOA, as well as the measurement of skills acquisition. The learning outcomes assessment tool was used in a limited fashion in the Bachelor of Arts and Science program (BAS) and the Bachelor of Engineering (B.Eng) degrees, although learning outcomes were measured differently in each program to maintain consistency with the disciplines' foci and individual curricular approaches. The team sought to determine whether the online tool could be altered to capture programmatic learning outcomes in multiple ways. The BAS program opted to assess three program outcomes via three assignments within a single course, whereas the B.Eng program chose to assess a single graduate attribute (problem analysis) across multiple courses and across multiple semesters.

After a semester's proof-of-concept LOA phase, the project team evaluated the quality of the data collected, the extent to which students met the established criteria for acquiring or mastering specific learning outcomes, and the changes required to the online capturing system. The team was able to demonstrate that the online tool was able to capture learning outcomes achievement evaluated in different ways, from rubrics, to individual exam questions, to specifically designed assignments. It was also possible to assess the full program of studies (B.Eng), across all of its majors.

The development of Guelph's LOA initiative benefited greatly from key Provincial government funding. The Higher Education Quality Council of Ontario funded the initial pilot phase, while the University was able to further develop the LOA initiative as part of a multi-institutional project funded by Province of Ontario's MTCU through their Priority and Innovation Fund (PIF). With Guelph coordinating, five institutions worked with D2L to develop out the learning outcomes tracking and analyse within their respective LMS.

PIF funding facilitated the next phase, the development within the LMS a program learning outcomes assessment structure that focused on the (B.Eng.) degree and its seven majors. The structure had to track 41 Graduate attributes from year one to year four through various levels of the D2L competency measurement system and to map student achievement from specific individual assessments across an entire program of courses. Figure 2 gives a sample view of the LOA Framework in the LMS.

More specifically the work within the Learning Management System included:

- Alignment of the University's quality assurance approach and curriculum development processes with the appropriate features within the LMS in order to have a systematic method of collecting and assessing achievement results.
- Development of a structure within the LMS that recognized a program's associated courses.
- Creation of a process to automatically populate the LOA structure with student program data from the registrar's office.
- Creation of data extract templates, at both the program and course levels, to enhance evidence-based curricular reporting and development.
- Expansion of the use of the D2L rubric tool, developing protocols and procedures to align rubric criteria with the SOE course learning outcomes and program level graduate attributes.
- Development of an effective data reporting structure at the course and program levels that could be used to inform curricular enhancements for continuous improvement and the accreditation process.

- Mapping assessments at the course and program level.
- Establishing an effective working relationship with D2L to inform and influence the continued development of the Learning Outcomes Assessment tool within the learning management system.

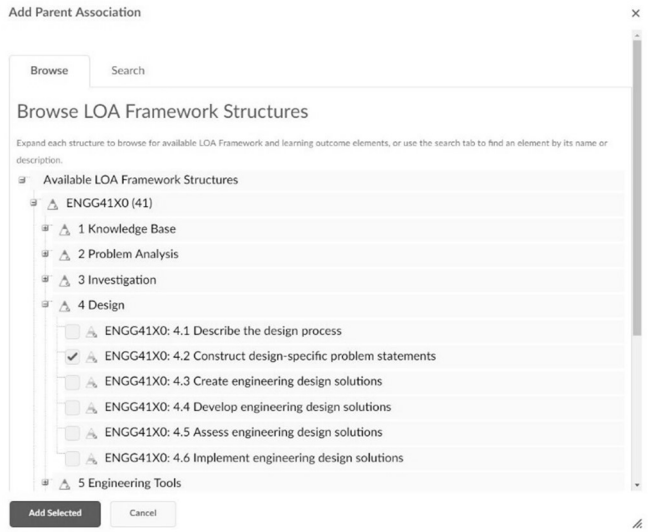

Figure 2 – Example of SOE Learning Outcome Association to CEAB Graduate Attributes in LMS for a specific assessment item

Developing the technology within the LMS for learning outcomes assessment, as well as administration and user support, OpenED was able to fully facilitate SOE's data gathering requirements. Yet, while there was notable success with tracking of graduate attributes and gathering of data within the LMS, there were additional data processing and reporting needs that were not available within the system. This created the impetus to develop tools beyond the LMS.

4.2 Implementation in the SOE

The SOE adopted a three-pronged approach to implementing the GACIP. First, it was adopted in the fourth year capstone design course, followed by the common core courses, and finally program specific courses.

The fourth year capstone design course (ENGG*41X0) is taken by every student in all seven SOE programs, hence the value X in the course code. As the capstone course, ENGG*41X0 could provide data for all twelve graduate attributes. The course instructor, who also was the chair of the Accreditation Committee took the 41 indicators and wrote four quality statements for each one, using the previously prepared target/threshold statements for guidance. These indicators and quality statements were then put into rubrics similar to those in Table 1, covering the following student design project submissions: 1) Proposal, 2) Interim Report, 3) Final Report, 4) Summary Memo, 5) Reflection on Practical Experience and 6) Poster Presentation. ENGG*41X0 also has a final exam to address the law and ethics component of the course consisting of a multiple-choice exam and written essays. Each question is mapped to a specific GA indicator, with the data uploaded to LMS grade book for easy tracking.

The course outline indicates to the students the course learning outcomes and identifies where specific graduate attributes are mapped per University requirements [6].Within the LMS, with the aid of OpenEd, the rubric elements were connected to the specific graduate attributes. Doing so made it possible to continuously collect GA data year after year for the required analysis.

With the success in collecting GA data in the capstone course, the Graduate Attribute committee implemented data collection in the common core. The common core in the SOE consists of 15 courses in math, chemistry, physics and engineering sciences that all seven engineering programs take. In addition, all students take the common four-course design sequence, ENGG*1100, ENGG*2100, ENGG*3100 and ENGG*41X0. By sharing the knowledge gained with the capstone course, faculty teaching these 18 courses (excluding ENGG*41X0) were able to collect GA data. Some of the faculty developed their own rubrics, while some adopted the rubrics created for ENGG*41X0. Others linked the grades of specific assessments. Irrespective of the approach, all the data was collected and managed in the LMS.

Following the success of tracking data in the common core, the remaining "program specific" courses were addressed. Again, best practices were shared with faculty, however, all that was requested was to identify the GA they were tracking in their course and how this was to be assessed. The LMS was used to store the data, whether it was grades from reports, with or without a rubric, or the final exam. The challenge that the Graduate Attribute committee faced was making sure that data for each attribute was collected for all seven programs.

An additional implementation was the use of reflection to gather data for life-long learning. Using the Professional Engineers Ontario guideline for reporting pre-graduation work experience after second year, a questionnaire was developed [13]. The questionnaire focussed on application of theory, practical experience, management of engineering, communication skills, and awareness of social implications in engineering. The students were also asked to reflect on their long-term plans and steps they could take for life-long learning.

5.0 Observations and Discussion

Developing a Graduate Attributes outcomes assessment process and getting faculty and staff on board always needs a focus. Fortunately, the project leaders had two elements they could refer to. First was improvement to the curriculum, which many faculty saw as the driving force, with the objective of continuous improvement. Second, and perhaps most critical, was accreditation itself. Any process needed to satisfy a review by the CEAB. From a timing perspective, the CEAB had established a phase-in schedule and the SOE was able to incorporate the development of the GA process to match with the scheduled CEAB site visits. In doing so, improvements were made to the implementation

plan, providing feedback on whether the approach was heading in the right direction. An overview of the timing to get the process in place is given in Table 2, based on the information provided to the CEAB in the Questionnaire for Evaluation of an Engineering Program – Exhibit 1- Guelph - CORE Document that was submitted September 1, 2017.

Table 1: Excerpt from Proposal Rubric ENGG*41X0

	Exceeds expectations	**Adequately meets expectations**	**Minimally meets expectations**	**Fails to meet expectations**
	Points: 4	**Points: 3**	**Points: 2**	**Points: 1**
Indicator	**STATEMENTS**			
4 - Design: An ability to design solutions for complex, open-ended engineering problems and to design systems, components or processes that meet specified needs with appropriate attention to health and safety risks, applicable standards, and economic, environmental, cultural and societal considerations.				
Construct design-specific problem statements	Constructs a complete problem identification with a thorough discussion on the expected design components that is consistent with the readily available information.	Constructs a complete problem identification with a light discussion on the expected design components that is consistent with readily available information.	Constructs a problem identification with no discussion and does not consider all available information.	Problem identification not consistent with available information.
Construct design-specific problem statements - **Literature Review**	Prepares an excellent literature review pertaining to the problem	Prepares a good literature review pertaining to the problem	Prepares a fair literature review pertaining to the problem	No literature review provided
Construct design-specific problem statements - **supported by constraints, criteria and assumptions**	Identifies and discusses the all constraints, criteria and assumptions	Identifies and discusses the major constraints, criteria and assumptions	Identifies the constraints, criteria and assumptions	Fails to identify and constraints, criteria and assumptions
Construct design-specific problem statements - **supported from a social, environmental and economic, health and safety perspective**	Anticipate and explain needs and impacts in social, environmental and economic, health and safety terms beyond the immediate client and users.	Anticipate needs and impacts in social, environmental and economic, health and safety terms for client and users.	Explain the problem in social, environmental, economic, health and safety terms	Fails to consider the problem in social, environmental, economic, health and safety terms

Table 2: SOE GACIP Activity Timeline – 2011-17

Year	Activity/Development
2010	Faculty Retreat – Plan CEAB Outcomes based approach - Summer
2011	Appoint Graduate Attribute Coordinator faculty member
2012	Develop SOE curriculum framework aligned to CEAB Graduate Attributes (GAs)(300 outcomes)
2013	CEAB accreditation visit (Mechanical) – feedback to SOE on GA progress
2013	Adopt standard SOE course outline
2013	Establish Graduate Attribute Committee (GAC)
2013	Create consolidated SOE GA-Indicator Framework – 41 indicators common to all 7 programs
2013	Create Student Exit Survey – Administer to all students in capstone design course, ENGG*41x0
2013	Initiate Learning Outcome Assessment (LOA) project. Use the Learning Management System to collect GA-based student performance data, course alignment workshop.
2013	Develop GA Based rubrics for use in Capstone Project course ENGG*41x0, and integrate into the LMS
2013-14	LOA Project (Phase 1) – GA 2 – Problem Analysis 7 courses.
2013-14	Establish "Below Target, Threshold, Target, Exceeds Target" for assessing GA performance.
2013-14	Faculty Panels - 12 Common CORE GA Faculty Review Panels (1st cycle of GA reviews)
2014	CEAB Accreditation – Computer Engineering, Biomedical Engineering – positive feedback on SOE GACIP.
2014	Faculty Retreat – Curriculum alignment: Knowledge Base & Design Common Core- May.
2014	Integrating reflective practice into Design Sequence Courses (ePortfolio Project)
2014-16	LOA Project (Phase 2)– Common CORE – Expand to all 12 GA's, 20 courses
2014-17	Faculty Panels - 12 Common CORE GA Faculty Review Panels (2nd cycle of GA reviews)
2015-16	ePortfolio Pilots – ENGG*3100 & ENGG*41x0 – Focus on reflection and life-long learning
2015	GA Recommendation Tracking System Development – RT Tracker - Summer
2015	Faculty GACIP Retreat (June) – Data Collection Process, Prioritization of Recommendations, Assignment of GA assessments to Courses.
2015	Approve SOE 2014-2018 Operational Plan – January
2015	Faculty Learning Outcome Alignment Workshop – Using the LMS for GAs - September
2015	Fall - SOE Accreditation Data Collection Planning Form – GA Assessments
2016-17	LOA Project (Phase 3) - Expand to all ENGG – 50+ courses - Common CORE & Program Specific
2016	Alumni – Employer GA Survey – March
2016	SOE – Learning Outcomes Report Manager development
2016	Course Outline Manager Development – integrates much of the GACIP process data requirements into an electronic data repository
2017	Student GA Focus Group Initiative - February
2017	Industry GA Focus Group Initiative – April
2017	Faculty GACIP Workshop – SOE GACIP - Start-Stop-Continue Reflection - June
2016	Establish Coop Work term performance rating process – GA related feedback
2017	Assign program-specific Graduate Attribute Officers (GAOs) - February
2017	GAO's use SOE Learning Outcomes Report Manager generate student performance GA data.
2017	Program-specific Faculty Panels – 7 Programs (continuation of 2nd cycle of GA reviews)
2017	Course Outline Manager Pilot - Fall

Even though the CEAB gave advanced notice of the changing accreditation system in Fall 2008, things took time to get going. At Guelph, establishing the learning outcomes curriculum improvement process was an important step in maintaining accreditation for the four established programs and getting accreditation for the three new programs. The initial push to identify the graduate attributes that should be tracked was successful in developing some foundational material. However, initial feedback from the CEAB review of a new program in Winter 2013 and the input from OpenEd, quickly showed that the development of the learning outcomes process at Guelph was falling behind. This resulted in a short timeline of about six months to have a process in place when CEAB was on campus to review two new engineering programs in Winter 2014, with a full review required for all programs in Fall 2017.

To meet the timeline, available resources were leveraged, including: OpenEd, similar exercises on campus, input from EGAD, and perhaps most importantly, the use of software systems and technology. Having access to the D2L learning management system with the competency framework made it possible to start collecting data and storing for subsequent analysis.

Connected with the continuous improvement process was the development of a shared philosophy that would develop and mobilize a process that was pedagogy-forward driven. For example, while there was limited outcome assessment in the SOE, the Provost's Office wanted to see learning outcome development across campus. An important contribution by SOE to the institution would be the development of rubrics and other outcomes assessment processes that could be shared by faculty in courses and programs across campus.

Developing a new process for curriculum improvement requires a leadership group and one or more champions to lead the process. Once the CEAB indicated that graduate attributes were required for future accreditation reviews, the SOE quickly formed a Graduate attributes committee(GAC). The GAC held consultative meetings with faculty to decide how the framework should be structured. Over a two year period, meetings were held and the 100 plus elements and sub-elements were developed along with the 300 quality statements. Faculty were then asked to map their courses to the 100 elements and sub-elements.

As can be expected with any new system, concerns were raised that the proposed new approach did not apply to a specific course and that it was too complicated. They were concerned with the extra workload and not sure if the process would generate the required data. Faculty meetings were held to answer questions and provide guidance. They were reassured that the goal was to improve the quality of engineering education at Guelph, not increase their work load. To help with the transition, faculty panels were held to review some of the courses to ensure their alignment with the appropriate graduate attributes.

At the time that the SOE was developing its GA process, three new engineering programs were being developed. As part of the typical process, the CEAB sent a visiting team to complete a review of the new program. The SOE was also notified that at the same time, the SOE GA process would be reviewed. This GA review would have no impact on the actual accreditation outcome, but rather evaluate where the GA process was, as in three years the GA Process would impact the accreditation result. The new program was successfully accredited by the CEAB as expected. However, there were concerns raised about the GA Process. In essence, the visiting team felt that the GA process was not sufficiently developed. They liked the faculty review panels, but felt that the 100 plus elements and sub-elements was too complicated, with a major concern that the GA process was not sustainable.

Once the SOE reviewed the results, an action plan was developed as the CEAB was scheduled to be on-site in less than a year as noted earlier. This action included the regular turnover of faculty sitting on the GAC, with a new chair assigned referred to as the Accreditation Coordinator who had oversight for all accreditation issues, including the graduate attributes activities. The new chair was also the instructor of the capstone design course. To support these efforts, the SOE also hired a contractually limited faculty member who was the chair of the GAC, with responsibility of focussing on graduate attribute activities. Three other faculty and one staff member were appointed, including the SOE Associate Director of Undergraduate Studies. In addition, there was a range of support from OpenEd. Our experience shows that significant human resources are needed to rollout a new process.

The first actions of the GAC were to meet with OpenEd. OpenEd was involved in a learning outcome assessment (LOA) project that involved a consortium of Ontario universities and the LMS provider Desire2Learn. OpenEd also assists the Ontario Veterinary College (OVC) with their accreditation activities that include outcome assessments. The discussions suggested that the first step should be the reduction of the 100 plus elements and sub-elements of the graduate attributes. The streamlining resulted in 41 indicators that to describe the 12 graduate attributes.

The next step was data for these indicators. Since the chair of the Accreditation Committee also taught the ENGG*41X0 design course, this capstone design course was the logical place to start collecting data for these 41 indicators. The first step was for the instructor was developing quality statements for each indicator. Using the 300 plus quality statements previously developed by the GAC committee, the instructor was able to develop a rubric that had 41 indicator statements, with four quality statements as outlined in the approach section.

Setting the levels for the four quality statements had some challenges. For example, how would they relate to the existing numerical grading system? In the end, "exceeds expectations" translates to grades above 80%, "adequately meets expectations" for grades above 70%, "minimally meets expectations" for grades above 60% and "fails to meet expectations" for grades below 60%. The 60% threshold for "fails to meet expectations" was selected as a benchmark as it matched the "continuation of study" threshold for the Engineering program, since Engineering is an honours program.

One of the issues that arose was whether the rubric results for outcomes should also be used to provide the student grade. The committee and faculty were split, and arguments were made on both sides. The main argument for a common rubric was that we do not have the resources to grade each report twice. The main argument against a common rubric was that academic grade assigned in a course may be different than that for an assessment of outcomes. To test the rubric and make a decision, the design panel re-graded some previously graded capstone reports. Doing so would also give feedback on possible improvements to the rubric. The results of the regrading

showed that some of the quality statements needed refinement, from both the marker and student perspective. Since the rubrics were meant to provide feedback to the student, they needed to be clear. Likewise, with different faculty using the rubric, if the statements were not clear enough, there would be no consistency in the grading. All these comments were received and incorporated in the second-generation rubrics for ENGG*41X0.

Comparison of the regrading "grades" and the original "grades" showed that the rubric grades were about 10% higher than the original grades. The committee had no concern with this as it had been mentioned over the past few years that the capstone grades were on the lower side, which potentially could impact scholarship opportunities for graduates looking at graduate school. In the end, the committee decided to us a single rubric to assess grades and outcomes, and to expand the implementation to the Winter 2014 offering of ENGG*41X0, which had approximately 165 students in 25 groups. There were also about 20 different faculty members grading the reports so there would be different perspectives on how the rubrics could be interpreted. Overall, the GAC felt that the grading of the capstone projects would become more consistent as everyone would use the same rubric, and more importantly, students would get improved feedback. From a curriculum improvement perspective, it would also allow faculty not on the SOE GAC to experience the practice of implementing the graduate attribute process.

One of the challenges implementing the rubrics to a relatively large class with many faculty members, was the need to implement consistency and grade in a timely manner. Based on discussions with OpenEd, it was determined that the D2L technology could be leveraged by uploading the indicator statement framework to the LMS, along with the rubrics. Each faculty member could than access an electronic copy of the capstone report and record the rubric results on-line. The LMS would then store the results for each student, graduate attribute and indicator, making it easier for the Graduate Attributes Coordinator to access the data and analyse trends. Storing the data in the LMS would also make it easier to track trends over time. ENGG*41X0 is taught twice a year, so after 5 years, the GAC would have 10 data points on each graduate attribute / indicator, allowing the Graduate Attributes Coordinator to make informed comments and recommendations.

As can be expected, these comments and recommendations are only as good as the input data. Some faculty had concerns that some of the indicators did not apply to the projects they were advising. However, other faculty felt relieved that the grading process for the capstone report had improved as everyone was using a common, predefined rubric. The students' comments were also positive. Instead of just getting a grade on their report with minimal feedback, the quality statements associated with each indicator were now the basis of the feedback. Overall, the initial implementation went smoothly, and faculty could see how assessing graduate attributes could make a positive contribution. Yes, improvements were needed, but it was a start.

While faculty and students accepted the graduate attribute process that was put in place, the concern remained as to what CEAB would say based on the comments from their last visit. The Graduate Attributes Coordinator put together an entire supporting package for the new process for the visit that took place in early 2014. Supplemental meetings with the CEAB Visiting Team helped explain the process. In the end, the CEAB was very impressed with the progress made and the foundation put in place. As a result, the SOE adopted the 2014-2018 GACIP plan and implemented further changes.

Following the adoption of the 2014-2018 GACIP plan, refinements were made to the rubrics. The system was then first rolled to the common core, followed to the rest of the courses with support provided by the GAC, Accreditation Coordinator, Graduate Attribute Coordinator and OpenEd. Some challenges were seen, which included new faculty continuously being hired due to the rapid growth going on in the SOE, naysayers saying it was still too complicated, and some faculty suggesting that the not all the right data was being collected. However, the GAC with the support of most faculty, leadership in the SOE and OpenEd, noted that the 2014-2018 GACIP plan would continue until the next scheduled visit in Fall 2017. Completing this review would be a good external review of the system, after which further adjustments could be made.

During the CEAB accreditation visit in Fall 2017, all seven programs were reviewed. This was an important review as for the first time the graduate attribute process could directly impact the accreditation results. The review went well with all 7 programs maintaining their accreditation status, and the SOE graduate attribute process receiving positive feedback. The feedback received, and the on-going continuous improvement is now reflected in a new 2018-2024 GACIP plan. The foundation of the process stays the same, with GA data collected on the D2L learning management system. Proposed changes included sampling of GA data from various courses, instead of courses providing data on all graduate attributes and the establishing a lead faculty member from each program, called a GA officer, to manage/develop the process as part of the central GAC. It should be noted that faculty GA officers were introduced for each program prior to the Fall 2017 visit to help with data collection and interpretation of program specific courses, and the modification worked well. The benefit was a further expansion of "GA Experts" in the SOE which helped with the rolling out / expansion of the process.

5.1 Technology

Utilizing the University's LMS made developing a process that tracked LO data much easier. Since the technology was part of the LMS, its use did not affect faculty in their daily activities substantially, which made it easier to get people on board and to have strong engagement in the project. The system was able to store data for every course for every

graduate attribute indicator statement. This data could come from specially developed rubrics, aggregate data from exams, or specific exam questions that were linked to specific indicators. The data could then be extracted from the LMS using software-reporting tools developed by the SOE computer services unit. Extracted data could be analyzed and shared with faculty, staff and CEAB visiting team members to show trends. The data was extremely helpful to the graduate attribute panels established by the SOE to evaluate the data and suggest improvement to the curriculum.

Monitoring of the quality improvement data was done using Request Tracker (RT). RT is an open source issue tracking program that was configured by the SOE computer staff to monitor possible improvements to the curriculum and curriculum process and could easily be shared with faculty and staff [14].

Like all software implementations, there are always challenges and need for changes. Two issues stood out with using the LMS for GA assessment. One is the desire for more flexibility in using rubrics. For example, where optional categories for indicator statements is desired, using optional indicator statements requires a manual process whereby a faculty member must adjust the grade before submitting. While not overly difficult, for some faculty it is an undesired complexity. Not having this flexibility option makes it difficult to develop a universal rubric that could be used in all courses. Faculty need the option of turning off and not grading certain attributes. Another challenge were the delays in processing while saving data, particularly once a large number of outcomes are being tracked, which was the case with design rubrics. These delays can be frustrating and can cause faculty to become frustrated with the overall GA data collection process.D2L was apprised of this issue and developed a batch-oriented solution that was transparent to users, and eliminating the frustrating delays, and demonstrating the need for a strong vendor relationship.

5.2 Focusing on People

The overall guiding philosophy for educational technologies at OpenEd is pedagogy-forward. This is particularly important for new technology-enhanced processes. Although this may seem resource intensive, OpenEd's experiences confirm that this approach is extremely valuable and results in more sustainable approaches over time.

At the broadest level, OpenEd first engaged in discussions to develop, refine and align outcomes statements with the graduate attributes as a shared philosophy. Next OpenEd engaged instructors to define the pedagogy and the evidence of student learning that could potentially provide evidence of a learner's understanding. Finally, the project team got together with faculty to demonstrate how the tools and technology could work in a complementary manner.

More specifically, there has always been a close working relationship within OpenEd between staff administering and supporting technology and staff supporting curriculum and faculty development. Applying this collaborative philosophy with the SOE, there was an appreciation of the different needs, requirements, and perspectives across all participants in the LOA project. This working synergy increased the ability of the development team to identify what the technology needs were and facilitated the interpreting back and forth between pedagogical and technical perspectives. Engagement with technical staff and developers throughout the process, meant that stakeholder needs were translated into the appropriate technology support needs required for the project, allowing for a more effective and efficient way to gather, manage, and analyze SOE's data.

On the SOE side, embracing the use of technology is a cultural attribute of the department and this worked to the advantage of the project when it came to applying new technology to support the work. Within both SOE and OpenEd a guiding philosophical approach to technology is to "get under the hood" and adapt and improve existing technology in conjunction with the needs of the stakeholders. This results in an overall willingness to invest (people, time, expertise, etc.) and to evolve an approach that would lead to identifying the best practices. Within the SOE, there was an existing ability to use technology and software to manage the outcomes in a constructively aligned manner by all parties involved. The SOE invested in developing this expertise in conjunction with the introduction of the technology that was utilized.

5.3 A Model for Learning Outcomes Assessment

The processes covered in this paper were also guided by a foundational model of triangulation Learning Outcomes Assessment as outlined in Figure 3 [15]. Biggs noted ".... high level engagement ought not to be left to serendipity, or to individual student brilliance, but should be actively encouraged by the teacher." (p. 353) OpenEd adapted this from Mathison [16] and Ghrayeb et al., [12], and model integrates three elements across a curriculum. The three elements are:

- What is intended in a curriculum at the course and program levels as it relates to learning outcomes
- What was achieved in the course and the program curriculum i.e. gathered student performance data on these outcomes from individual assessment to graduate attribute across a program, and
- What is perceived in a curriculum by multiple stakeholders such as learners, society, professionals, instructors, etc.

The embedded nature of the triangulation model acknowledges how outcomes assessment is localized within a curriculum and intentionally links assessments across courses to other elements of the course and the program, for example, the course learning outcomes and the Graduate Attributes respectively. Another key feature of this model is the suitability to perform and to confirm curricular gap analyses. For example, consistent

approaches to examining what is intended and what is achieved can provide simple and effective strategies to continuously improving assessment and overall achievement of graduate attributes in a larger curriculum. When this approach is conducted in relation to the larger curriculum graduate attributes, the process of moving from data analysis to recommendation is likely to be better aligned between assessments and across courses.

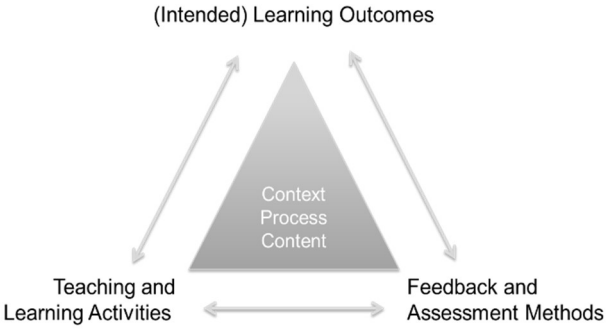

Figure 3 – Constructive Alignment (after Biggs, [14])

6.0 Conclusion

The SOE and OpenEd experience has shown it is possible to put in place a state-of-the-art system that collects and analyses learning outcomes data with the ultimate goal of curriculum improvement. Many new initiatives were implemented over the 6-year period, which involved significant changes to processes, technology and practices that affected the faculty and staff of the SOE. Key points of the experience are as follows:

- Commitment is needed from a core group of people in the beginning to help with sorting out the initial challenges. Without this commitment, there will be challenges with the quick adoption of the developed process. This core group can then explain and assist with process development to the remaining staff and faculty during rollout.
- Resources need to be dedicated to the process, and in particular staff, who can provide faculty with support.
- Key factor in the success can be attributed to adopting a suitable learning management system for collection and storage of data to provide efficiencies
- Data collection and analysis can satisfy internal requirements and the external accreditation requirements for a professional program and
- Faculty and staff now realize the importance of collecting GA data, which helps improve the quality of engineering education provided.

Developing a new process needs to keep in mind the culture and character of the unit desiring to implement a new curriculum improvement system. Consultation is key as observed in the SOE and OpenEd experience. One recommendation for future development is the use of more one on one meetings to help facilitate adoption of the system. Grouping meetings with faculty and staff are not always the best conduit.

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