Higher Education Quality Council of Ontario

An agency of the Government of Ontario

Integrating Pedagogy and Technology to Measure Program and Institutional Learning Outcomes at the University of Guelph

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Published by

The Higher Education Quality Council of Ontario

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Cite this publication in the following format:

Desmarais, S., Fach, M. & Lackeyram, D. (2018) *Integrating Pedagogy and Technology to Measure Program and Institutional Learning Outcomes at the University of Guelph.* Toronto: Higher Education Quality Council of Ontario.

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Executive Summary

The University of Guelph was one of the earliest institutions to adopt a statement defining what students would learn by the end of their program of study. This process began with senate-approved learning objective statements in 1987 and evolved to the following list of five institutional learning outcomes developed and approved by senate in 2012:

- Critical and creative thinking
- Literacy
- Global understanding
- Communicating
- Professional and ethical behavior

Building on this work, our next step as an institution was to constructively align and (re)develop course and program learning outcomes and their respective assessments, and then build a cohesive process to assess student achievement of outcomes that would provide meaningful information to all stakeholders. To achieve these goals, the University of Guelph collaborated on a pilot project with D2L (Desire2Learn) to develop a system that would capture and assess learning outcomes and that would report on the achievement of disciplinary, program and institutional outcomes. A pilot was conducted with two degree programs — Bachelor of Arts and Science (BAS) and Bachelor of Engineering (BEng) — using the learning-outcomes assessment tool with the learning management system (LMS) to measure students' skill and ability acquisition over time. The major goals of this project were as follows:

1. Development of an online learning-outcomes capturing and assessment tool
2. Pilot-test its suitability
3. Conduct an initial study using the learning-outcomes assessment tool to measure students' skill and ability acquisition over time

The initial proof of concept conducted with the BAS program involved the use of the D2L rubrics tool within a first-year course across a full semester. The findings from this pilot showed a decrease in the proportion of students not achieving a satisfactory learning-outcomes achievement score as they progressed through their assignments. An authentic assessment approach is supported in the literature as an effective method of measuring outcome achievement. The pilot also confirmed the effectiveness of rubrics within the learning-outcomes tool to provide data that can measure and report achievement. This pilot further validated the need to engage all individuals early in the process to support the cultural, pedagogical, technical and data-management needs of such an initiative.

The next phase of the pilot included the BEng program so that this systematic approach could be tested across an entire program. Approximately 50 courses across seven engineering majors were selected. Based on the lessons learned from the initial pilot, all engineering instructors were engaged in the curriculum preparation process, including alignment, assessment and ultimately, technology engagement. The data derived from this pilot can measure student achievement of learning outcomes at a course level; therefore, a longitudinal analysis will provide important information about student cohort progression over time. Furthermore, focusing on authentic assessments as part of this process will provide a level of complexity that links the learners, assessments and instructors over time, and these assessments can be informed by the longitudinal data.

The lessons learned throughout this project include the importance of faculty engagement in program assessment and pedagogy, as well as the importance of having an assessment tool aligned with these approaches. The complexity of this project influenced both the project design and the way implementation was approached. In addition, the volume of data on student achievement of outcomes has raised issues related to access, security, storage and privacy. These issues require thoughtful consideration from a variety of institutional stakeholders. This project has also become evidence of the importance of professional support when developing, facilitating and guiding the educational and technological tools, processes and policies.

A shared philosophy is necessary to advance work and promote a culture of learning-outcomes assessment. The complexity inherent in assessing student learning is an opportunity to foster collaborative approaches and evidenced-based communication about learning at universities. This work can also help expand the scholarship around teaching and learning research. The relationship between the University of Guelph and D2L has been critical to the success of this effort. It has allowed us to inform the iterative design of the outcomes management tool while also considering workflow implications. Other recommendations based on our experience include the need to put pedagogy first over technology. It is important to align this effort with continuous program improvement processes both formally and informally. It is recommended that the focus be at the program/major level to show evidence of learner progression over time. Finally, it is critical to provide instructors with appropriate support in order to create a culture of ownership and pride with curriculum-based work.

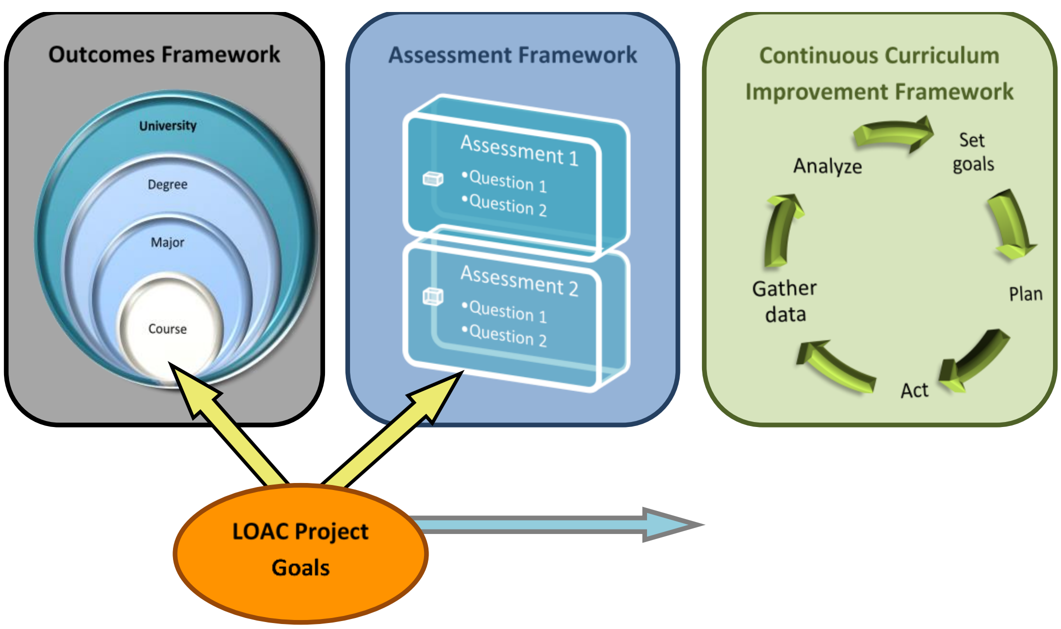
Introduction

Among Canadian institutions, the University of Guelph was one of the earliest to adopt statements defining what students would learn by the end of their program of study. In 1987, the university senate approved 11 learning objective statements to guide educators in the development of courses and programs. As the higher education landscape shifted its focus to learning outcomes, the University of Guelph began an extensive review of learning objectives in 2010 via consultation with students, instructors, staff and many other external stakeholders. This review process led in 2012 to the development and adoption of the following five graduate- and undergraduate-level learning outcomes:

- Critical and creative thinking
- Literacy
- Global understanding
- Communicating
- Professional and ethical behavior

Embedded in the outcome development process was a commitment to learning-outcomes assessment. This project builds on three larger areas of work as outlined in Figure 1.

Figure 1: Context of LOAC Project and Ongoing University of Guelph Outcomes Assessment Initiatives



The first area of work pertains to the development of an outcomes framework at the institution and an alignment between courses, majors, degrees and the university learning outcomes. The next area of work relates to the identification and development of assessments that can be used to assess student achievement of learning outcomes. The last area of work involves the development of processes and the utilization of information to continuously improve curriculum. The main goal of this LOAC project was to establish and align the processes and practices required to develop a sustainable approach to learning-outcomes assessment (as indicated by the yellow arrows in Figure 1). The data gathered was examined for the ability to demonstrate student learning-outcomes achievement, and contribute to ongoing sustainable curriculum improvement (as indicated by the blue arrow in Figure 1).

The Outcomes Framework

For each of the learning outcomes listed above we also engaged the campus in the process of describing what student performance would look like at an introductory level, a developing or reinforced level, and a mastery level. Based on the descriptions, we developed institutional rubrics for each learning outcome. At the broadest level, all courses and programs map to these outcomes and are intentionally aligned. Therefore, at the University of Guelph these learning outcomes serve as a foundational basis to enhance student learning in the following more specific ways:

- Guiding the development of programs, specializations and courses
- Clearly articulating to students what they should know and be able to do at the end of their period of study
- Informing the assessment of student learning so as to enhance continuous curricular improvement processes

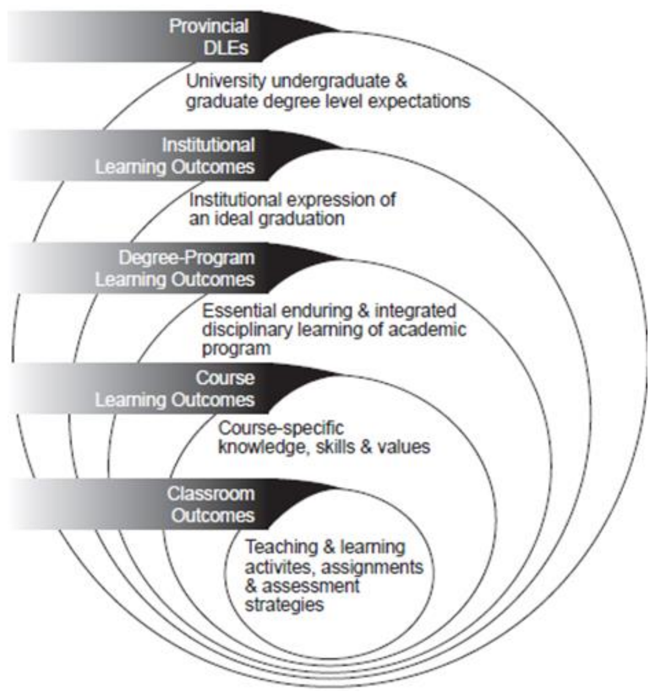
Having developed and adopted learning outcomes at the institutional level, our next phase involved two concurrent areas of work. The first was to continue constructively aligning and (re)developing course and program learning outcomes and their respective assessments. The second was to begin building a cohesive process to assess student learning outcomes in a manner that would provide value for all curriculum stakeholders. In essence, the second step involved the concurrent building of the technological solution within the learning management system (LMS).

At a broad level, assessing student learning involves investigating what is intended in a curriculum, what is perceived by the learner, and what is achieved by the learner as evaluated by the instructors or “experts.” This type of assessment paradigm involves direct and indirect assessment measures and mixed methodologies and approaches to truly understand how a student’s learning is developing. In order to accomplish this type of assessment paradigm, we needed to develop a ubiquitous and usable tool for instructors that would not interrupt the pedagogical flow in the classroom. With these complex needs in mind, we undertook a collaborative pilot project with D2L (Desire2Learn) to develop a learning-outcomes capturing and assessment system within the LMS as part of HEQCO’s Learning Outcomes Assessment Consortium. Although the development of the learning-outcomes assessment tool in this large-scale project is expected to take several years to complete, the current aims of the project are threefold:

1. To develop an online learning-outcomes capturing and assessment tool
2. To pilot-test its suitability
3. To conduct an initial study — using the learning-outcomes assessment tool — to measure students' skill and ability acquisition over time

Underlying the larger objective of this project is the philosophical approach of gathering and using direct assessment measures to understand student achievement of learning outcomes. We started this project with the intention of eventually implementing the approach and the technology across the entire institution. More specifically, this project is expected to influence the regular quality assurance and continuous curriculum improvement processes at the university. From an operational and scalability perspective, partnering with D2L provides the potential for this approach to be adapted across the larger university sector.

Figure 2: Nested Outcomes-based Curriculum Alignment from Degree-level Expectations to Course-specific Activities (Kenny & Desmarais, 2012)



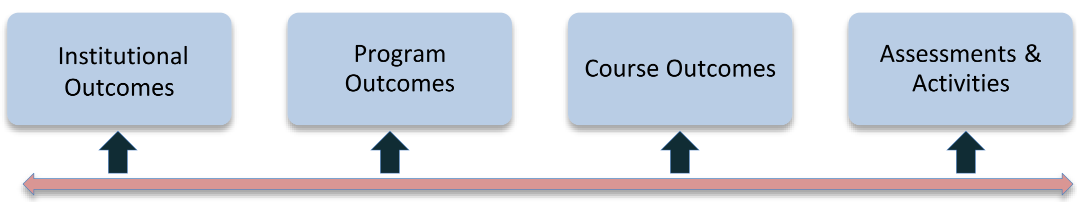
Methodology and Timeline: Establishing the Assessment Framework

Objective 1: Technical Development of a Learning-outcomes Assessment System

The first objective, creating a tool in the LMS, involved a variety of expertise from the university and D2L. The project team consisted of educational developers, instructional technology specialists and LMS internal specialists from the University of Guelph, working in close collaboration with technical specialists and project managers at D2L. The variety of expertise is representative of the complex development process as outlined in more detail by the following two objectives:

- Develop a learning-outcomes assessment strategy that meets the disciplinary program outcomes and university outcomes
- Foster engagement and departmental participation in the piloting and implementation of the online assessment tool

Figure 3: Interrelated Mapping of Outcomes Levels and Assessments



Objective 1.1: Developing a Learning-outcomes Assessment Strategy to Meet Disciplinary and University Outcomes

For each step of the process outlined in Figure 3, our pedagogical experts (educational developers) were involved in liaising with instructors to develop course assessment activities and then align them with course outcomes. Once that alignment was completed, the next step was connecting with our technical experts at D2L to translate the relationship between each assessment and the different levels of outcomes, as shown in Figure 2 and Figure 3. After the technical experts at D2L had completed their first iteration, our instructional technology specialist examined the steps required by instructors and then performed the linking and mapping necessary to design the technical training for instructors. This process was iterative until we moved into our pilot phase.

What was important for us to identify in this strategy was the fluid mapping required between outcomes at all levels with any related assessments and learning activities. For example, Figure 2 shows the nested relationship of outcomes, indicating that there is a link between the variety of outcome levels and the assessment activities. However, translating this multi-mapping functionality into a more linear format for technical development (as in Figure 3) required an iterative approach. At the same time, outside of the related technology work, a clear outline of how course outcomes could be mapped to program and institutional outcomes needed to be established pedagogically before it could be translated technically. For example, a written assessment could contribute to literacy outcomes as well as critical thinking outcomes, and a process to outline that relationship was an intrinsic part of this methodology.

Objective 1.2: Fostering Engagement and Departmental Participation with a New Process and the Online Assessment Tool

The second goal of this project — how to best engage individuals involved in a new process — was based on introducing instructors and our project team to three interrelated functional components of adopting new instructional technology. The first component was to build more intensively on our shared learner-centric outcomes philosophy across the institution with the piloting departments. In this process, we engaged in discussions to develop, refine and align our outcomes statements at all levels (course through program). This allowed the instructors involved in the process to define the pedagogy and the evidence of student learning that could potentially provide evidence of a learner's disciplinary understanding, and the expected course-level and program-level outcomes. Lastly, the project team got together to demonstrate how the tools and technology could work in a complementary manner and essentially identify the improvements needed in the next iteration of development.

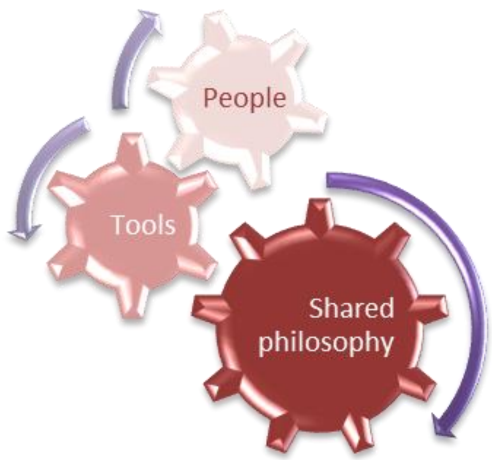
Objective 2: Pilot of Learning-outcomes Assessment System and Measurement of Skill Acquisition

The online assessment tool was tested as a proof of concept in the BAS program as part of the development of our methodology. Based on these findings the approach was applied to a pilot phase in the BEng degrees, which focused on identifying any potential challenges that might occur when dealing with two distinct curriculum types.

Objective 3: Longitudinal Evaluation and Analysis: A Programmatic Approach to Continuous Curriculum Improvement

Using the pilot-derived data that demonstrated student achievement of learning outcomes within the LMS, we developed a longitudinal approach to our data analysis strategy in order to examine how learning-outcomes achievement is taking place for cohorts of learners over time. Operationally, one of our objectives was to investigate the possibility of having the data mapped in the LMS and tied to authentic student assessments in order to provide useful information to program instructors, information that could improve specific elements of the curriculum. This is discussed in more detail in the "Evaluation and Analysis of Longitudinal Data" section of this paper.

Figure 4: Guiding Philosophical Approach



Proof of Concept – The Bachelor of Arts and Science (BAS) Program

In the BAS program, the proof of concept tested the utilization of the D2L rubrics tool within a first-year course across a full academic semester. The course that was used for this proof of concept was an introductory arts and science course that contained multiple writing activities, and which required students to submit three written assignments. A more detailed description of the assignments can be found in Appendix A.

In order to effectively prepare for this project, three key steps needed to be undertaken. The first ensured that the course is constructively aligned as described by Biggs (1996). This involved working with the instructor to confirm that the intended learning outcomes were intentionally aligned with both the assessment methods and criteria, and with the teaching and learning activities in the course. The second step, which was more iterative, involved the creation of rubrics for the assignments (which can be found in Appendix B). Finally, before we introduced technology, the third step involved aligning the rubric assessment criteria with both the program learning outcomes and the University of Guelph's learning outcomes.[1] This is because these alignments define the relationship between the disciplinary assessment intended learning outcomes and how they are connected to the program and institutional learning outcomes as shown in Figure 3. This alignment formed the basis of the logic used for our analysis, which is further discussed in the "Proof of Concept Findings" section.

1 http://www.uoguelph.ca/vpacademic/avpa/outcomes/rubrics.php

While there were many benefits derived during the alignment process for the instructor and the curriculum in this specific course, the key project goals for this proof-of-concept stage included the following:

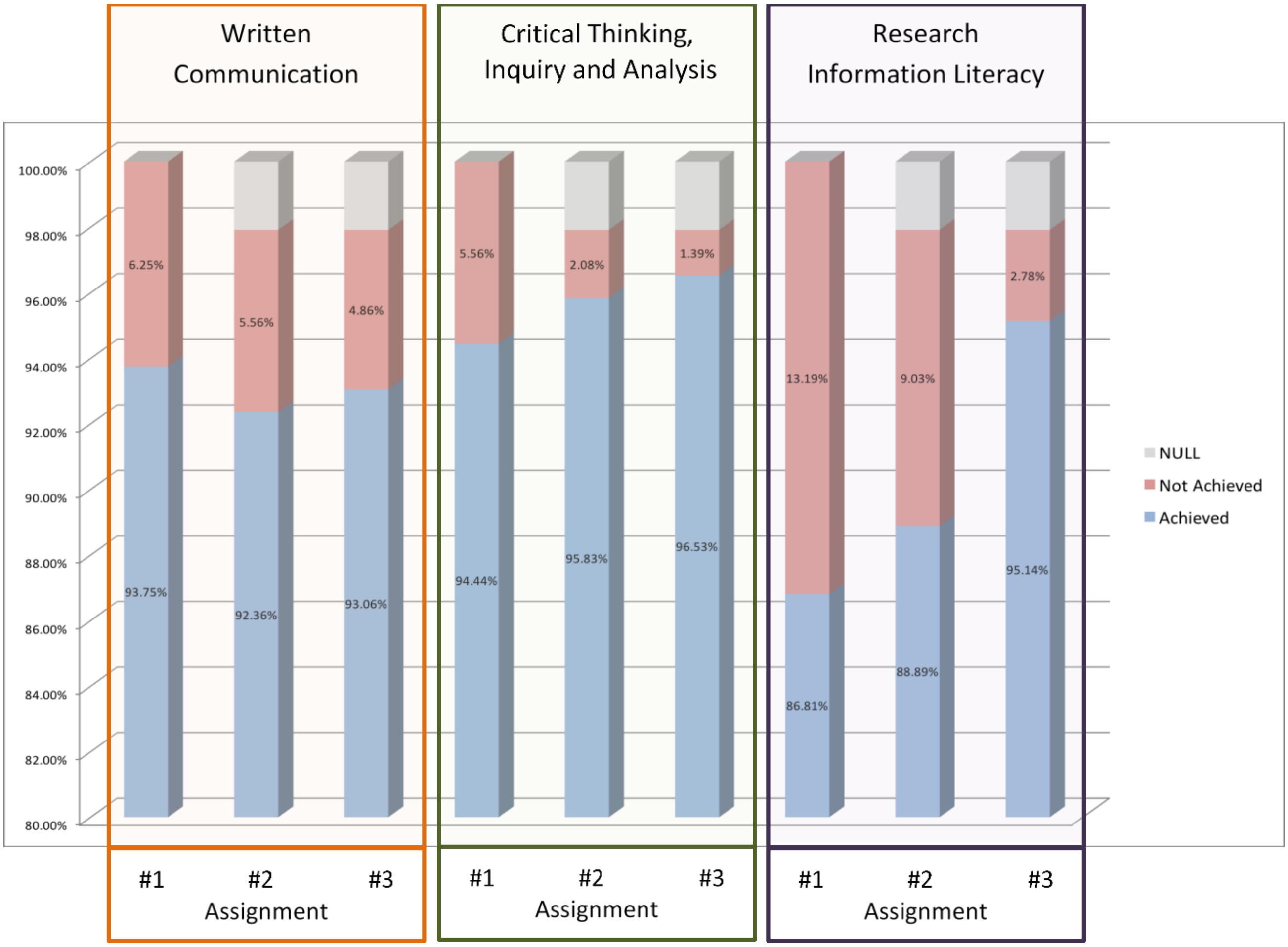
- Use of data and information available to inform continuous curriculum improvement and enhance student achievement of program outcomes (information literacy, inquiry and analysis, and written communication)
- Development of efficient, effective and appropriate practices for the incorporation of D2L analytics into program review processes
- Use of D2L analytics to measure student achievement of learning outcomes

As alluded to in our project philosophy (Figure 4), our next step was working with both faculty members and our in-house instructional technology specialists from the Department of Open Learning and Educational Support (OpenEd) to configure the learning outcomes management tool in the LMS. This interaction was (and still is) a unique feature of our partnership with D2L, since we also shared information from a faculty member's perspective on the technology's setup and ease of use as we were gathering information during this process. Throughout the setup of the course outcomes assessment process, we liaised with D2L in order to allow its technical staff to make the appropriate changes or guide us specifically. Once the course outcomes had been aligned with assessments and set-up in the LMS, the data was extracted and analyzed as discussed in the next section.

Proof of Concept Findings

Using the rubric in Appendix B, student performance was calculated for the three required assignments and categorized for each of the three institutional outcomes as shown in Figure 5.

Figure 5: Student Achievement of Written Communication; Critical Thinking, Inquiry and Analysis; and Research Information Literacy Outcomes over Three Assignments

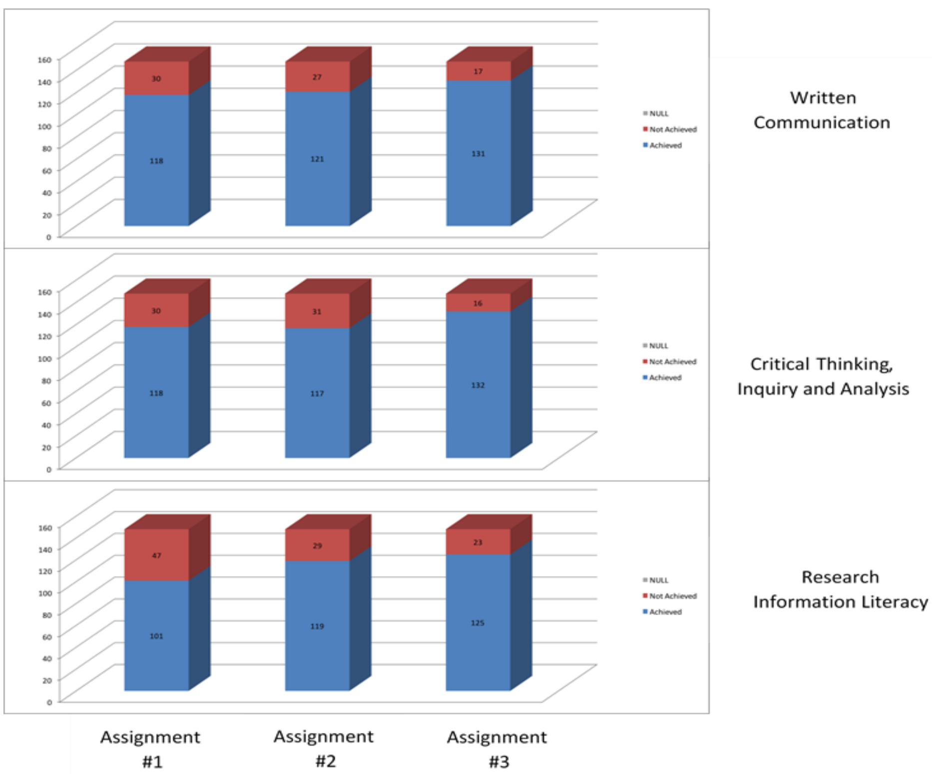


For each institutional outcome being examined, the proportion of students achieving a satisfactory performance level increased. Aligning the teaching, learning and assessment activities in an intentional constructive way, and using clearly defined rubrics linked to outcomes are important facets of developing authentic assessments. Grant Wiggins outlines features of authentic assessments and provides guidance on how this alignment mentioned above happens. For example, consideration should be given to the applicability of the task to transferrable skills in the workplace; whether the task requires multiple knowledge and skill sets being utilized together; and if there are appropriate opportunities to rehearse, practise and utilize feedback in refining final products (Wiggins, 1998). The benefits derived from this type of process are widely reported in the literature as an advantage of using authentic assessments to measure achieved student learning outcomes (Blumberg, 2009; Knight, 2001; Newmaster, Lacroix & Roosenboom, 2006).

The overall findings, demonstrated in Figure 5, addressed our first and second objectives since both the process and the data could be (and were) used to inform continuous curriculum improvement. We were also able to use the rubrics in conjunction with the learning-outcomes tool within the LMS to evaluate student performance on course, program and institutional learning outcomes. Therefore, we were able to partly address our third objective of trying to use D2L analytics to measure student achievement of learning outcomes. Figure 6 includes data derived from D2L that shows the number of students who achieved a proficient level of performance on the three written course assignments as reported for each institutional outcome.

To scale this process from the course to program level, we considered the support needed from both D2L and OpenEd at all stages, such as preparing to on-board with the technology as well as maintenance and data extraction. These observations are discussed further in our “Lessons Learned from the Proof of Concept” section.

Figure 6: Proportion of Students Achieving Specific Institutional Outcomes on Three Written Assignments, n=148 students



Lessons Learned from the Proof of Concept

Overall, the lessons learned throughout the proof-of-concept phase can be briefly categorized into four main areas: cultural, pedagogical, technical and data management. Our reflection on this process indicated a need going forward to engage all individuals earlier with the pilot phase of the larger project.

The discussion about learning outcomes and the perceived “finite” nature of evaluating an outcome represented an opportunity for us as an institution to shift the conversation to continuous improvement. The proof-of-concept process indicated that it was possible to change the culture within the institution. This evolution of the culture around continuous improvement for instructors follows a similar logic of constructive alignment (i.e., define your outcomes, your assessments and how you are going to instruct the subject matter). The next step in this evolution was identifying a course’s limitations (e.g., one assessment in one course may not effectively contribute to a student’s achievement of a learning outcome), and additional courses and instructors may need to be involved. Therefore, we also learned that the process of constructively aligning a curriculum follows naturally from framing learning-outcomes assessment as continuous improvement.

In combining pedagogy and technology however, the alignment also needed to expand to include the alignment of the intended learning outcome, the assessment activities, and the teaching and learning activities, as well as the technical use and pedagogical functionality of the technology. Therefore, from a more technical perspective — and given the scaling support required — we recognize the need to establish clear goals, priorities and effective communication between software vendor, support staff and teaching faculty. To that end, we are developing a more recursive and collaborative working relationship with D2L as we move to the pilot phase.

Lastly, the need to manage, analyze and report on learning-outcomes assessment data, especially at a program level, introduced new considerations for the project team related to data security, data privacy and data management. To this end, discussions with the university’s research ethics board and the assistant university secretary/privacy officer will take place at future stages of the pilot.

Scaling up to a Program Pilot – The Engineering Program

In order to effectively examine how student achievement of learning outcomes was progressing in a variety of curriculum types, we expanded the proof of concept to a larger setting and also a different type of curriculum structure. The proof of concept BAS program has fewer prescribed core course requirements so the different courses provide a greater variety of learning opportunities for students. The BEng pilot program however is much more prescribed at the course level, and comes with a pre-defined accreditor’s list of program learning outcomes from the Canadian Engineering Accreditation Board (2017).

Given our findings about the need to engage more instructors and courses in order to provide a clearer picture of student achievement of learning outcomes, the next step in scaling these activities from one course to an entire program of study flowed naturally. For the program pilot, we chose the School of

Engineering because engineering programs are very structured in terms of their curriculum and course offerings. Another contributing factor was that the majority of students take similar courses — sometimes at the same time — and may behave much like a fixed cohort. This curricular structure made it easier to scale this project and observe the relationship and alignment between intended, course, program and institutional learning outcomes. In addition, we saw an opportunity to integrate both the learning-outcomes process and the results with the accreditation needs of the engineering program as outlined by the Canadian Engineering Accreditation Board (CEAB).[2]

Selecting and Aligning Courses across the Program

In this phase of the project, approximately 50 courses (covering multiple semesters and academic years) across all seven engineering majors were selected. Based on what we learned from the proof of concept course, we engaged all School of Engineering instructors in a course alignment process over a two-day curriculum retreat. During the retreat, we enhanced the process of learning how to write and align outcomes in order to create a ubiquitous understanding of the outcomes assessment project. With this in mind, the main objectives of the retreat were as follows:

- Align course-level learning outcomes and assessment strategies with graduate attributes and indicators
- Design effective assessment strategies to both promote deep learning and evidence student achievement of graduate attributes
- Select evidence of student achievement of the engineering graduate attributes and indicators

The Course Alignment Process

In order to achieve a school-wide understanding of learning outcomes and learning-outcomes assessment, we began by having instructors describe and discuss the context for their courses (see Appendix D). The 12 accreditation graduate attributes — written for all engineering programs to follow — were also included as part of the course context discussion. However, it is important to note that the graduate attributes only describe what is expected at the end of the program; there is very little nuance to guide the level or depth of sophistication required by student learning. Thus, the level of student performance anticipated with any intended learning outcome or graduate attribute was neither defined nor easy to identify. To work around this, we discussed the level of learning sophistication that students would need and how the level relates to the engineering curriculum. We defined the levels as “Introduce,” “Reinforce,” and “Master” (see Appendix E). This way the degree of variability in expected performance between assessments and teaching activities could be better aligned from a pedagogical design perspective.

2 https://engineerscanada.ca/accreditation/accreditation-board

Next, we mapped the intended learning outcomes and graduate attributes using the resource shown in Appendix F. To do this, we provided instructors with guiding questions to consider as they began the mapping process (Appendix G). Table 1 provides a summary of the first round of mapping between course learning outcomes and graduate attributes. This iterative process utilized the data about curricular coverage to help instructors refine all the intended learning outcomes at the course level and address any gaps or redundancies that were occurring in the program. Another benefit of this process is that it allowed individual instructors to revise their assessments and teaching activities in order to support the student learning experience more effectively. Once these steps were completed, we worked with instructors to complete an alignment table for each course in the program. An example of a partially completed alignment table is provided in Appendix H. After completing all these activities, we summarized the data, which shows program-wide learning outcomes coverage and assessment (Appendix I), and program-wide mapping of the sophistication of learning anticipated in the program (Appendix J). Only after this foundational work was completed, and the performance standards widely understood, was the technology introduced to develop program-wide rubrics that evaluate specific course learning outcomes, graduate attributes and program learning outcomes.

Table 1: Summary of Mapped Engineering Graduate Attributes to Course Learning Outcomes

	Semester		Mapped Graduate Attribute Coverage in Curriculum														
Course Name	**F14**	**W15**	**1.1**	**1.2**	**1.3**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Total**
Engineering and Design I	X							/	/	/	/	/	/		/	/	8
Engineering Mechanics I	X				/	/											2
Engineering Mechanics I		X			/	/											2
Engineering Analysis		X	/														1
Engineering and Design II	X	X						/	/	/	/	/	/	/	/	/	9
Material Science	X	X		/			/										2
Fluid Mechanics	X				/	/	/										3
Fluid Mechanics	X	X			/	/	/										3
Engineering Systems Analysis	X		/			/											2
Electric Circuits		X			/	/	/										3
Engineering and Design III		X						/	/	/	/	/	/	/	/	/	9
Engineering Economics	X														/		1
Thermodynamics	X				/												1
Systems and Control Theory		X	/			/	/										3
Heat and Mass Transfer		X	/		/	/			/								4
Engineering Design IV	X	X				/	/	/	/	/	/	/	/	/	/	/	11

X - Course was offered / - attribute was mapped to course Blank cells - course not offered or attribute not mapped

The Assessment Alignment Process

Having established learning outcomes, our next step was to identify specific assessments that could be used to assess student achievement of these outcomes. This involved defining and articulating performance standards in analytic rubrics for the assessments identified in Appendix H. In order to establish a consistent approach, the school adopted the following four performance level benchmarks for all outcomes and graduate attributes:

- Exceeds target – Student performance that goes beyond the standard level expected by instructors for that particular graduate attribute or learning outcome
- Meets target – Student performance standard expected for a particular graduate attribute or learning outcome
- Threshold – Student performance that is approaching the standard (target) performance expected; students in this category demonstrate a reasonable degree of performance and are not failing in the knowledge, skills or ability domains associated with the graduate attribute or learning outcome
- Below threshold – Student performance that may be failing in some or all of the knowledge, skills or ability domains associated with the graduate attribute or learning outcome

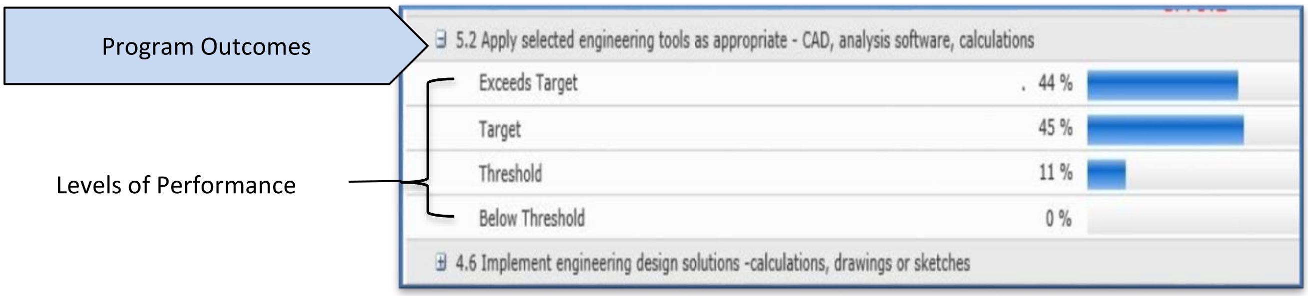
Before these expectations were adopted, they were discussed schoolwide, especially with instructors participating in the pilot. On an ongoing basis, instructors engaged, discussed and reflected upon the standards outlined in the CEAB standards in relation to the assessments they were creating. This type of instructor engagement at the beginning of the outcome assessment process helped to ensure that there was a clear understanding of the type of student performance that qualified at each level. As part of our ongoing curriculum improvement process, educational developers engaged with groups of instructors to help manage instances of inter-rater disagreement whenever required.

Instead of creating a standardized universal rubric, the school worked on developing mapped and aligned analytic rubrics that were created at the appropriate level of mastery and mapped to the graduate attributes (i.e., the program-level outcomes) for each assessment. This allowed for as many assignments as possible to be linked to overall program measures. Example analytic rubrics are provided in Tables 2 and 3 below.

Integrating the Technology into the Learning-outcomes Assessment Process

With the logic of graduate attributes mapped to learning outcomes — and the subsequent alignment of these outcomes with the assessments — the next step was to translate these components into the LMS via our partner, Desire2Learn. This was accomplished by using the outcomes management tool that was being built within the LMS. The tool enables instructors to define student learning outcomes, align them to courses, and ensure they are being achieved. Performance standards are then easily reported back to the instructor to evaluate overall class/cohort performance, as shown in Figure 7 below.

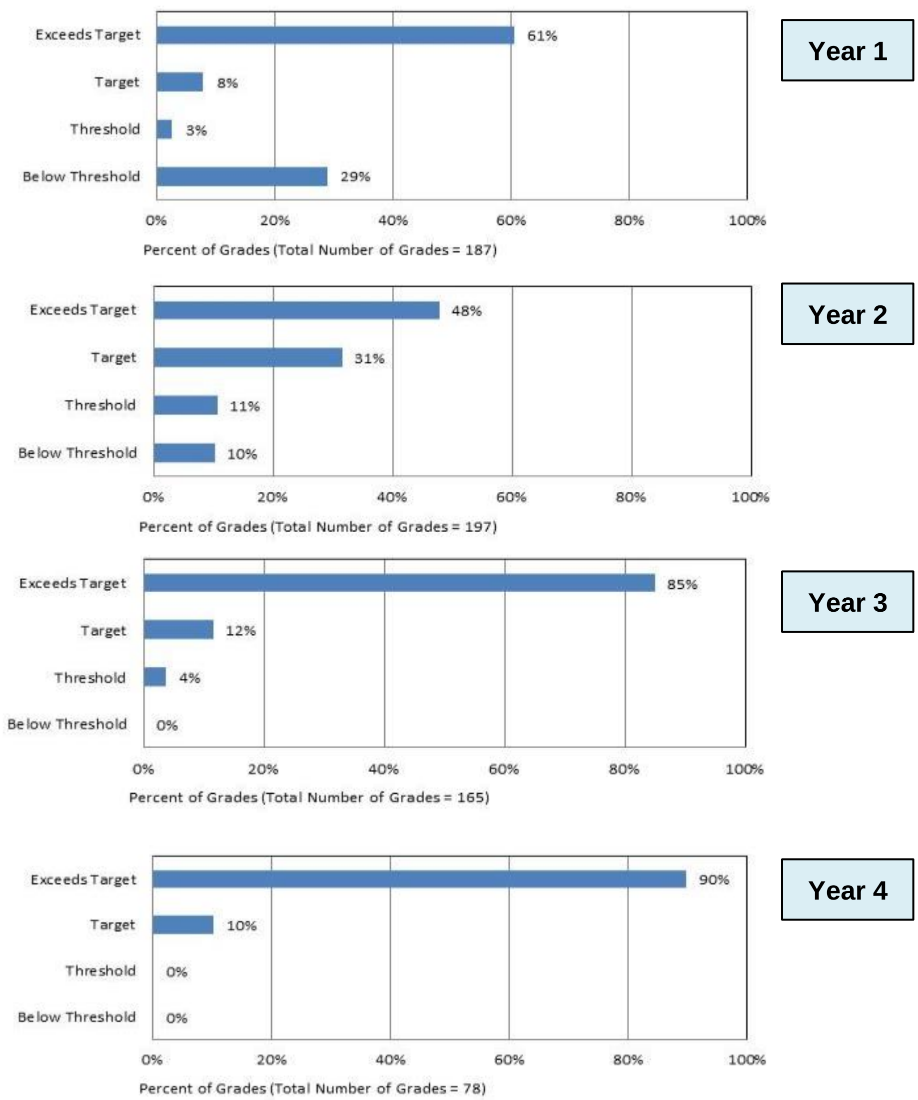
Figure 7: Example of Data from the LMS Showing the Proportion of Students Performing at a Particular Standard of Outcomes Achievement



Mapping student performance to shared outcomes provides valuable understanding of students' skill development as they progress through the School of Engineering. For example, Figure 8 demonstrates how a cohort of students performs in relation to a single program outcome in one learning activity across four years of a program.

Tracking the distribution of the performance levels associated with any outcome is useful for any course or teaching/learning activity; however, this data becomes substantially more powerful when gathered across several years of a program. At the year or course level, this distribution allows both instructors and learners to reflect on performance, and adjust and adapt to improve performance on an outcome. At the program level this adjustment must consider the cumulative element of the curriculum, since each year prepares the student for the subsequent year's teaching, learning and assessment. Since these activities and assessments are mapped to a single program outcome, it becomes more important to investigate if a learning activity (or course) is adequately preparing a learner for the next year's performance expectations. Put another way, from a program perspective we can examine if each year is adequately introducing, reinforcing or promoting mastery for the learners, while also supporting success and progression through their program of study.

Figure 8: Example of Program Learning Outcome (Selecting Appropriate Engineering Tools from Various Alternatives) Performance and Progression across Years 1 through 4



Integrating Metacognitive Development into Learning-outcomes Assessment

Similar types of learning-outcomes assessment data can also be gathered and utilized via evaluating learning portfolio (in this case ePortfolio) submissions. These assessments are most often aligned with learning outcomes in the curriculum related to metacognition. A learning portfolio is defined as an electronic application or physical construct that allows students to track and reflect on the development of their knowledge, skills and values throughout their academic experiences (Brandes & Boskic, 2008). The scope of a learning portfolio is primarily defined by its relationship to specific program outcomes that are aligned to course learning activities. For the purposes of learning outcomes assessment in this project, the intentional use of a learning portfolio within a course curriculum reflects the following principles in design, development and delivery. When used effectively in curriculum, a learning portfolio is able to:

- Utilize technology to both develop a framework that documents the variety of academic learning experiences and allow a student to observe the evolution of their learning
- Capture and provide evidence of student learning so that it can be presented or showcased to audiences in a variety of professional, academic and community contexts
- Bridge a student's academic understanding and/or co-curricular experiences with other relevant areas of interest
- Improve student metacognition and engagement, instill confidence and awareness, and foster self-directed learning
- Benefit from a fully-supported design approach that makes effective use of expertise including pedagogical design, development and delivery support
- Be portable or transferrable so that students can continue to build on it after a specific academic experience

The graduate attributes (program learning outcomes) that were evaluated using portfolios were individual and team work, lifelong learning and project management. In this context, portfolios could create opportunities for students to reflect on their learning while also developing connections between tasks and competency development. The outcomes management tool in the LMS was used to evaluate student achievement of these outcomes. First, however, it was essential to demonstrate the importance and relevance of the portfolio development to the learners themselves. Secondly, a pedagogical framework was needed to guide portfolio instruction and assessment, with a particular focus on strengthening learners' reflective capacities. Building on this, it became easier for instructors to assess student reflection across the various years of their program of study while providing formative feedback within the LMS.

Providing the Context for Learners

While many learners struggle with metacognitive and reflective curricular activities in this program, reflection is an important aspect of becoming a professional engineer. The Professional Engineers of Ontario (PEO) asks applicants to complete an "Engineering Experience Record" as part of their application. The complete guide is included in Appendix K and an excerpt is provided below.

How to Create Your Experience Record

- *Describe how the work experience obtained in that position meets each of the five criteria (application of theory, practical experience, management of engineering, communication skills and knowledge of the social implications of engineering).*

When describing your engineering activities:

- *Focus on what you did as it relates to each of the five engineering criteria. Structure the description to include not only WHAT you did, but HOW you did it and WHY you did it. You may use the format: "I did…using…in order to…"*
- *Be specific about what you did as opposed to the work of the team. "I determined the heat load…"*

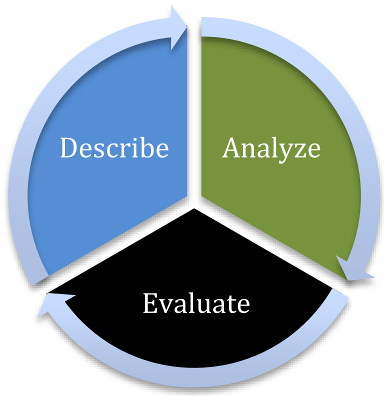
Provide sufficient information about the complexity of the situation.

We were able to utilize the PEO requirements above to provide a clearer context and rationale for learners about the importance of reflection in learning. In essence, we were able to remind learners about the professional requirements, and simultaneously demonstrate why the reflective activities in the curriculum were included. From a curricular design perspective, we integrated these assessments throughout the program in the interdisciplinary design courses, where the student is involved in complex (almost capstone) learning activities. In this way, the portfolio approach provided the repeated opportunities needed for building student capacity with reflective writing across various years of the program.

Developing Aligned Pedagogical Experiences

As part of our effort to assess the metacognitive development of students in relation to the graduate attributes of lifelong learning, individual and team work, and project management, we implemented a taxonomy for reflection, which is further explained in Figure 9 with accompanying rubrics (Clemmer et al., 2015). Briefly explained, this taxonomy of "describe," "analyze" and "evaluate" was adapted from Bloom's revised taxonomy (Bloom, 1956), and identifies the cognitive performance stages that a student should progress through in order to be proficient with reflection.

Figure 9: Taxonomy of Reflection



The results of our efforts to use a learning portfolio approach demonstrated that reflections were successful in instructing and evaluating student performance on metacognitive-related learning outcomes like lifelong learning, team work and project management behaviours. As outlined by Clemmer et al., (2015), instructors observed that students were able to utilize multiple opportunities to reflect on the class learning activities in relation to the graduate attributes, and also demonstrate improvement.

One major success of integrating this portfolio approach within our larger learning-outcomes assessment project was the ability to utilize the data generated by the outcome-assessment tool in affecting curricular improvement. More specifically, our preliminary work has resulted in reflection being integrated into the design sequences of courses across the School of Engineering. In turn, the assessment of these ongoing curricular activities will provide further data to enhance the curriculum and promote student learning and reflective capacity.

Evaluation and Analysis: The Value of Longitudinal Data Analysis

The data derived from the pilot demonstrated that it was possible to measure student achievement of learning outcomes within the LMS at the level of a learning activity within a course. Being able to utilize this data on an ongoing basis allows us to examine learning-outcomes achievement by cohorts of learners over time (as in Figure 8). Meaningful evidence-based questions can be raised when a specific cohort’s performance on a single program outcome is analyzed across multiple courses. For example, at the broadest level it may signal if the courses selected are contributing adequately to the student achievement of that outcome. When examined more closely, it may raise questions about whether the staging of that outcome’s achievement is appropriate (i.e., Is the student going through introduction, reinforcement or mastery of the program outcomes in the appropriate order for the curriculum and for the cohort of learners?).

Having this data mapped in the LMS and tied to authentic student assessments also enables instructors to more closely, and in real time, examine the quality of the assessments in relation to achieving a program learning outcome. For example, if there are questions related to the assessment quality, using the mapped analytic rubrics can help the instructor identify which aspect of the assessment might need improvement. Complete examples of analytic rubrics are provided in Tables 2 and 3, and outline how the focus on improving student learning via assessments can be approached when cohort performance, over time, is linked with performance standards.

Student achievement of each of the program outcomes (graduate attribute indicators) over four different offerings of the same course is illustrated in Figures 10 and 11. In these examples, the rubric in Table 2 was used to evaluate the final design project in the second year of the program written at the “reinforce” level, and the rubric in Table 3 was used to evaluate the final design report in the fourth year of the program written at the “mastery” level of performance.

Table 2: Second-year Materials Identification Project — Analytic Rubric for Graduate Attributes 3.1–3.3

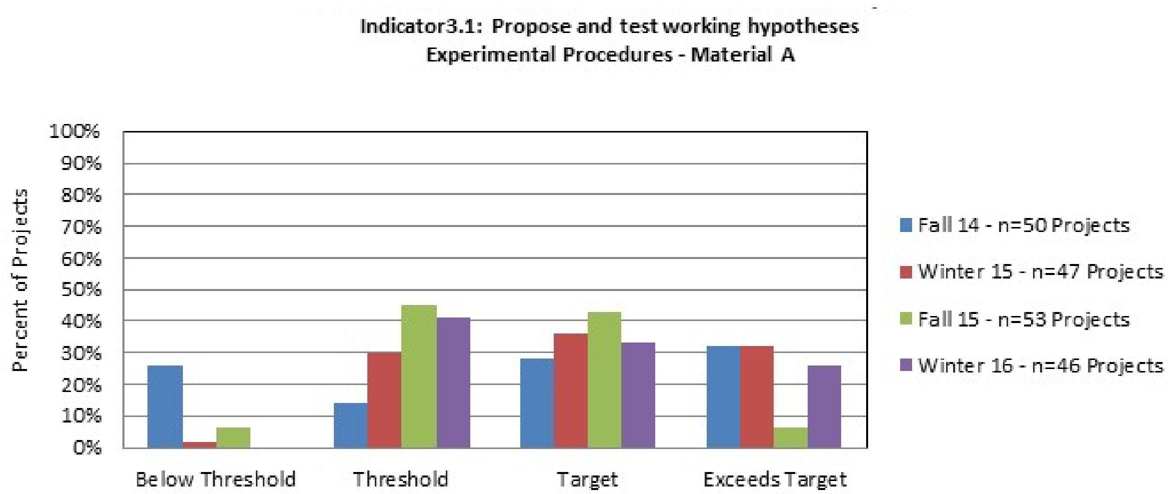
Indicator	Performance Level	Below Threshold	Threshold	Target	Exceeds Target
	Level Descriptor [- Qualifier]	Fails to meet expectations	Minimally meets expectations	Adequately meets expectations	Exceeds expectations
3.1	Propose and test working hypotheses - conclusions	Conclusions are valid but some are not developed from the results and discussion. Or conclusions are invalid or not given.	Conclusions are valid but some key points are missing.	Formulates conclusions that address original problem based on the results and discussion.	Formulates obvious conclusions that address original problem based on the results and discussion. Critical thinking and depth of insight evident.
3.2	Design and apply an investigation plan - experimental apparatus and procedures	Constructs an investigation plan generating data with several errors. Plan is safe. Measurement plan stated but unclear - some tools, considerations missing. Procedures, presentation of proper format are not followed or plan is unsafe! Tests are destructive. Did not follow plan – generated poor quality results.	Constructs an investigation plan from established procedures generating data with some errors. Plan is safe. Measurement methods stated but unclear - some tool considerations missing. Demonstrates basic investigation skills, some gaps in following procedures, presentation of proper format.	Creates investigation plan to generate high-quality data. Plan is safe. Clearly describes a measurement plan including appropriate tools and safety considerations. Demonstrates basic investigation skills, follows procedures, presentation of proper format.	Creates investigation plan with innovative approaches to generate high-quality data. Plan is safe. Clearly describes a detailed measurement plan including appropriate tools and safety considerations. Demonstrates basic calibration skills, follows procedures, presentation of proper format.
3.2	Design and apply an investigation plan - results	Translates raw data into interpretable forms with several errors. Figures and tables are presented poorly – detracts from delivery. Or experimental results are not presented – no evidence of analysis.	Translates raw data into interpretable forms with some errors. Results contradict material identification in some cases. Figures and tables are described and presented using improper format.	Data is analyzed and presented clearly and reliably. Results clearly support material identification. Figures and tables are clearly presented, described and properly formatted.	Data is analyzed and presented clearly and with a high degree of reliability. Results strongly linked and clearly support material identification. Figures and tables are presented and described clearly and enhance delivery.
3.3	Analyze and interpret experimental data - discussion	Material identification based on intuition – not supported by experimental results. Thought process and reasons for material selection are flawed. Or clear contradictions and flawed logic – thought process is unclear.	Results interpreted but logic, insight and judgment are weak. Thought process and reasons for material selection are unclear, logic may be flawed.	Results interpreted with logic, insight and good judgment. Thought process and reasons for material selection are clear, some gaps in logic.	Results interpreted with logic, insight and good judgment. Thought process and reasons for material selection are thorough, clear and concisely stated.

Table 3: Final Design Report Analytic Rubric for Graduate Attributes 4.1–4.6

Indicator	Performance Level	Below Threshold	Threshold	Target	Exceeds Target
	Level Descriptor [- Qualifier]	Fails to meet expectations	Minimally meets expectations	Adequately meets expectations	Exceeds expectations
4.1	Describe the design process	No coherent design plan presented.	Follows a design plan.	Plans the design approach, recognizing time, resources, failures, feedback and iterations.	Plans and discusses the design approach, recognizing time, resources, failures, feedback and iterations.
4.2	Construct design-specific problem statements	Problem identification not consistent with available information.	Constructs a problem identification on components that consider available information.	Constructs a complete problem identification on expected components that are consistent with readily available information.	Constructs a complete problem identification with a thorough discussion of expected components that are consistent with readily available information and beyond.
4.2	Construct design-specific problem statements – literature review	No literature review provided.	Prepares a fair literature review pertaining to the problem.	Prepares a good literature review pertaining to the problem.	Prepares an excellent literature review pertaining to the problem
4.2	Construct design-specific problem statements – supported by constraints, criteria and assumptions	Fails to identify constraints, criteria and assumptions.	Identifies the constraints, criteria and assumptions.	Identifies and discusses the major constraints, criteria and assumptions.	Identifies and discusses all constraints, criteria and assumptions
4.2	Construct design-specific problem statements – supported from a variety of perspectives (e.g., social, environmental, economic, and health and safety)	Fails to support the problem from different perspectives (e.g., social, environmental, economic, and health and safety).	Explains the problem in social, environmental, economic, and health and safety terms.	Anticipates needs and impacts in social, environmental, economic, and health and safety terms for client and users.	Anticipates and explains needs and impacts in social, environmental, economic, and health and safety terms beyond the immediate client and users.
4.3	Create engineering design solutions	Fails to identify the necessary design information and uses a simplistic design approach.	Identifies information necessary for the design process. Proposes a range of ideas using a generation strategy that represents a classical/common/textbook approach.	Identifies the essential information necessary throughout the design process, considers information from diverse sources that are typically considered. Evaluates the quality of the information and proposes a range of ideas that include conventional, risky, innovative and unconventional solutions.	Identifies and discusses the essential information necessary throughout design process, considers information from diverse sources that are both standard and non-standard. Critically evaluates the quality of the information and proposes a diverse range of ideas that include conventional, risky, innovative and unconventional solutions.

Indicator	Performance Level	Below Threshold	Threshold	Target	Exceeds Target
	Level Descriptor [- Qualifier]	Fails to meet expectations	Minimally meets expectations	Adequately meets expectations	Exceeds expectations
4.4	Develop engineering design solutions	Fails to investigate and develop each design idea.	Breakdown, investigate and develop a simulation/prototype that advances each design idea.	Breakdown, investigate and develop a simulation/prototype that advances each design idea. Considers advanced tools and experiences of others.	Breakdown, investigate and develop a sophisticated simulation/prototype that iteratively advances each design idea. Integrates advanced tools and experiences of others.
4.4	Develop engineering design solutions – safety	Design fails to consider safety.	Evaluates design ideas using safety performance.	Optimizes and evaluates design ideas with respect to safety performance.	Optimizes, evaluates and critiques design ideas with respect to safety performance.
4.5	Assess engineering design solutions	Design fails to consider constraints, criteria and assumptions.	Evaluates design ideas using constraints, criteria and assumptions.	Evaluates design ideas against major constraints, criteria and assumptions. Defends decisions.	Evaluates and critiques design ideas consistent with all constraints, criteria and assumptions. Critically judges and defends decisions.
4.5	Assess engineering design solutions – sources of error	Design fails to consider the significant sources of error, bias and uncertainty.	Estimates the significant sources of error, bias and uncertainty	Appraises significant sources of error, bias and uncertainty	Appraise and discuss significant sources of error, bias and uncertainty
4.6	Implement engineering design solutions	Design is not validated against the original problem, with limited testing with a prototype or simulation subsystem of an overall solution.	Validates the design within the academic context, by ensuring that it has "meat on the bones" including development of specifications that have been tested through a prototype or simulation. Solution is compared against problem, with the context extended to a single component or single subsystem of an overall solution.	Validates the design within the academic context, by ensuring that it has "meat on the bones" including development of specifications that have been tested through a prototype or simulation. Solution is compared against problem, with the context extended to multiple components of multiple systems.	Validates and discusses the design within the limits of the academic context, by ensuring that it has "meat on the bones" including development of detailed specifications and has been tested through a prototype or simulation. Critique is provided on the finished product with respect to the problem identification. Design solution is elegant with consideration of multiple components or multiple subsystems in an integrated manner.
4.6	Implement engineering design solutions – calculations, drawings or sketches	Design features scattered data, graphs and/or drawings.	Design is supported by good data, graphs and drawings.	Design is supported by very good data, graphs and drawings.	Design is shrewdly supported by excellent data, graphs and drawings.

Figure 10: Student Performance Level in Graduate Attribute Indicators 3.1–3.3 in the Second Year of an Engineering Program



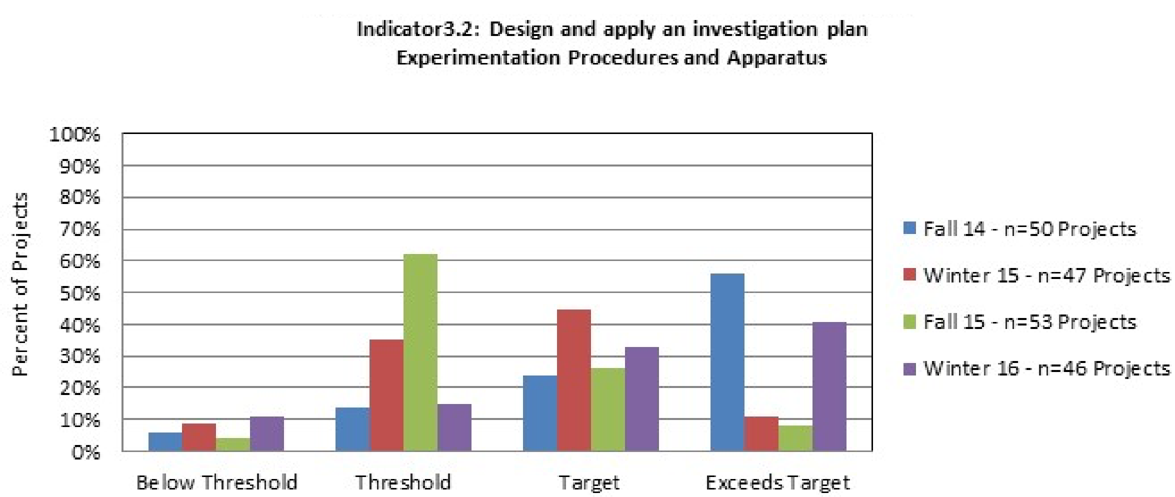
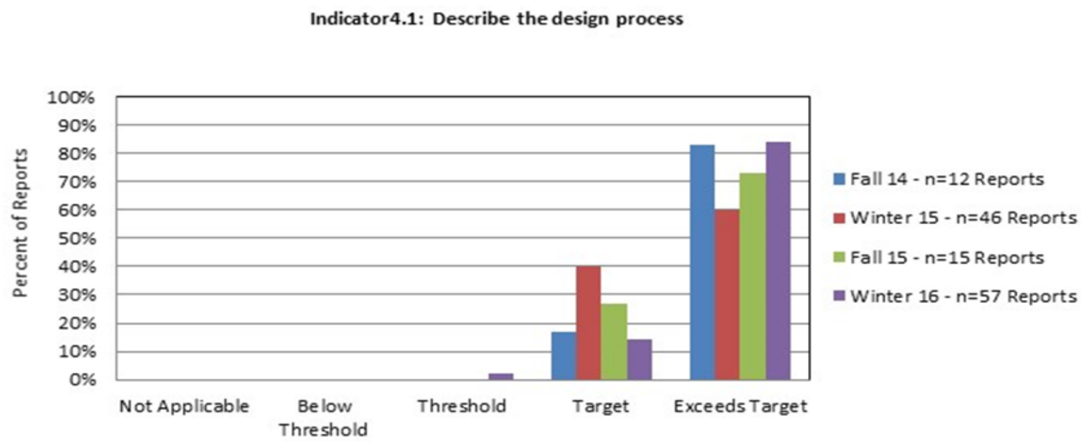
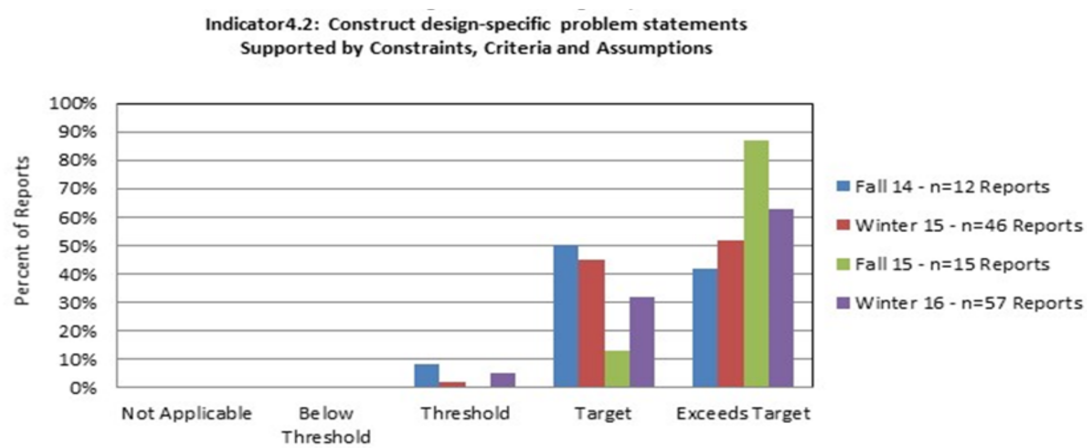
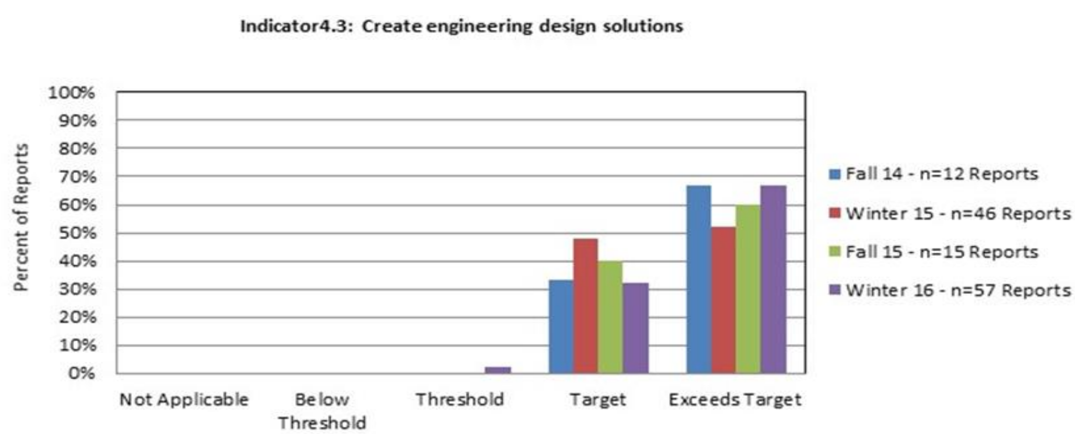


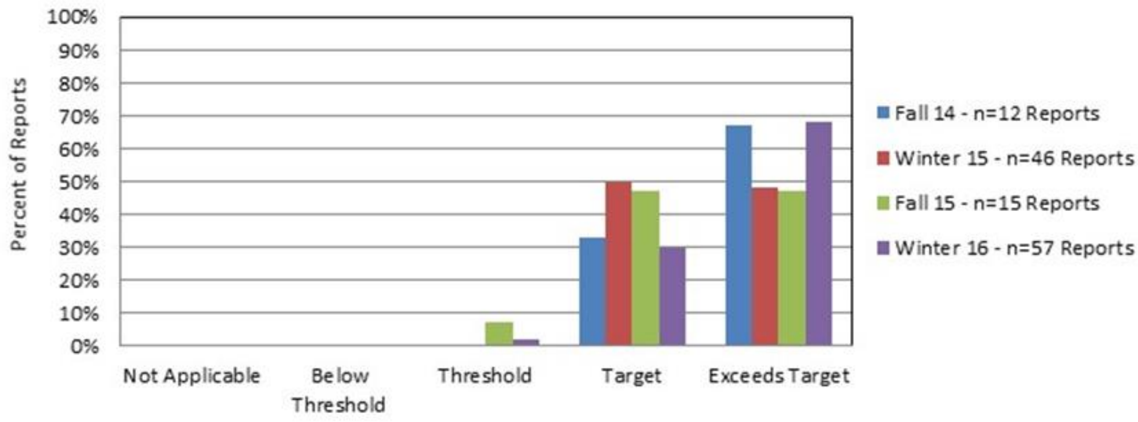
Figure 11: Student Performance Level in Graduate Attribute Indicators 4.1–4.6 in the Fourth Year of an Engineering Program



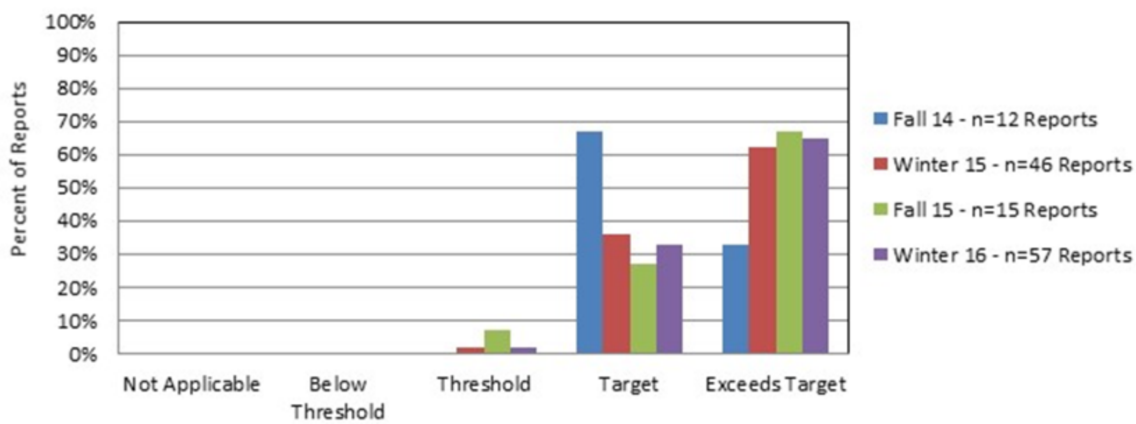




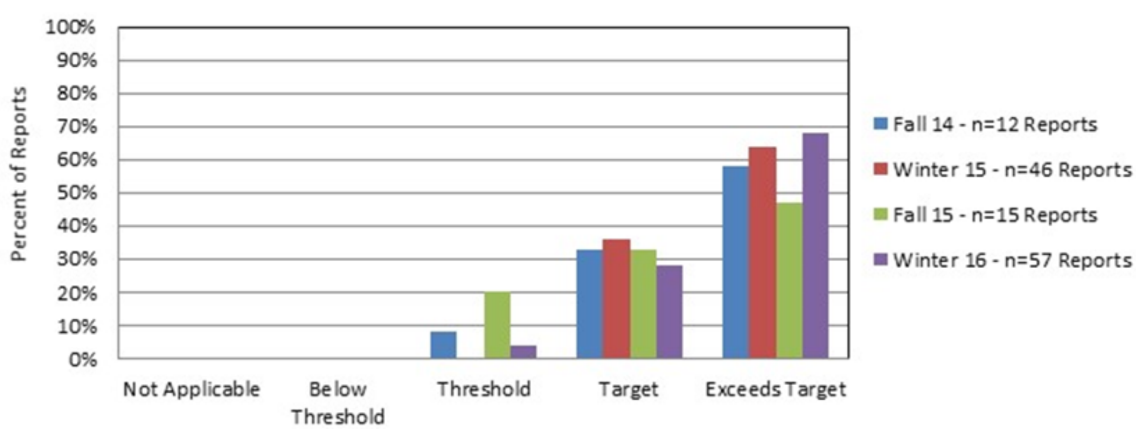
Indicator4.4: Develop engineering design solutions



Indicator4.5: Assess engineering design solutions



Indicator4.6: Implement engineering design solutions



The examples in Tables 2 and 3 — analytic rubrics tied to authentic assessments and linked via the learning-outcomes management tool to the program learning outcomes — provide a sustainable and consistent method of examining student proficiency in associated graduate attributes.

Why Focus on Authentic Assessments?

The answer to whether or not to use authentic assessments must take into consideration that our learners are not static; they change and evolve including their level of disciplinary preparation and metacognitive awareness. Similarly, each continuous improvement cycle associated with a curriculum provides an opportunity to incorporate a variety of factors that shape the way that our students learn. In essence, the use of data from authentic assessments allows us to examine the depth, richness and complexity that links the learners, assessments and instructors over time, as shown by the longitudinal data in Figures 10 and 11. Additionally, the feedback process of authentic assessments provides transparency between the outcome and the assessment as well as the relevance and contexts of the assessments.

When program groups come together to discuss data gathered from authentic assessments, they are able to discuss and revisit what is valued in their discipline and what their programs are trying to accomplish. This type of program view and discussion helps to unravel any uncertainty associated with what the program is trying to accomplish, and begins to unravel the aspects of the formal curriculum that learners might be struggling with (Alsubaie, 2015; Nami, Marsooli & Ashouri, 2014). In a similar manner, longitudinal evaluation of authentic assessments provides a richer understanding of how each learner, and each cohort of learners might experience the curriculum over time and allows us the opportunity to identify and investigate questions at a variety of levels. It also allows us to examine outcome achievement at all levels including program, course, whole assessment or component of the assessment.

For example, a comparison of student performance in second versus fourth year (Figure 10 versus Figure 11), shows a greater proportion of students from multiple cohorts performing at or above target (the anticipated outcome performance level) in the fourth year. While overall the results may confirm that this could be in line with what the program is trying to achieve, this data raises the question (among others) of how we work with the students who pass but are not at our target performance level (i.e., the learning outcome is not achieved). In essence, it also allows us an evidence-informed opportunity to closely examine how we utilize curricular resources to best support students who are performing at or below threshold and the specific kind of intended outcome that the curriculum might need to focus on.

Going from Learning-outcomes Assessment Data to Curriculum Improvement

In the previous sections, we discussed how we identify what is ***intended*** by a curriculum at the course and program levels, as well as how it relates to learning outcomes (e.g., Appendix I and J). Using the learning-outcomes management tool in the LMS, we gathered student performance data on these outcomes, specifically data on what was ***achieved*** in the course and through the program curriculum. Analyzing the gap between what is intended and what is achieved is crucial to continuously improving a curriculum. Moving from data analysis to recommendation to action involves a number of additional steps that we elaborate on below. For the purposes of this report, however, we have excluded what is ***perceived*** in the curriculum as part of this discussion. How multiple stakeholders (e.g., learners, society, professionals, instructors, etc.) perceive a curriculum and curricular learning outcome achievement levels provides another important data set that allows for the triangulated analysis of curriculum data to inform action. However, this data was outside the scope of the current project and will be included in future analyses. (See Robley et al., 2005 and Ghrayeb, Damodaran & Vohra, 2011 for more information on this concept.)

In Figures 10 and 11, the act of comparing student achievement of learning outcomes serves as an opportunity to inform the context for potential curricular improvements. This information can also guide the management of resources when considered with larger program-level data and mapping data for curriculum improvement at the program level. For example, mapped curricular data that demonstrates whether a program learning outcome is taught and/or assessed as well as the intended level of learning (Appendices I and J). This information can help administrators identify and prioritize areas in a curriculum needing improvement. In addition, when this data is used with program-level assessment performance data on specific program outcomes (as in Table 4 below), it can help pinpoint courses and key aspects of courses that might benefit from curriculum improvement. Generating this level of program information is critical to continuous curriculum improvement and is only made possible by the mapped learning-outcomes data gathered from the learning-outcomes management tool in the LMS. These early successes have prompted the School of Engineering and the University of Guelph to invest in new educational data warehousing capacity and expertise to best support this process.

Table 4: Summary of Winter 2017 Performance Level in Graduate Attribute 1.1 (Recall, describe and apply fundamental mathematical principles and concepts)

Course	Activity	% Below Threshold	% At Threshold	% At Target	% Above Target
Course 1	Term test 2	61%	15%	14%	9%
Course 2	Midterm	67%	16%	11%	6%
Course 3	Midterm	22%	17%	28%	33%
Course 3	Final question 1	24%	27%	17%	32%
Course 3	Final question 2	37%	18%	15%	29%
Course 3	Final question 3	40%	16%	16%	27%
Course 3	Final question 4	16%	9%	10%	64%
Course 3	Final question 5	58%	6%	12%	25%
Course 3	Midterm question 1	1%	5%	10%	84%
Course 3	Midterm question 2	29%	16%	10%	45%
Course 3	Midterm question 3	61%	19%	6%	13%
Course 3	Midterm question 4	9%	3%	9%	79%
Course 4	Midterm question 15	45%	30%	0%	20%

As illustrated in Table 4, summaries of student achievement of learning outcomes over multiple assessments in a course allow instructors the opportunity to review the alignment between the intended learning outcome and the assessment. At the program level, this type of summary also provides an opportunity to review the alignment of the assessments with outcomes as shown in the series of interrelated tables in Appendix L.

Making Outcomes Assessment Sustainable for Courses

Making outcome assessment sustainable is a key feature of moving from data gathering via learning outcomes assessment to actionable curriculum improvement. In order to achieve this, we needed to ensure that the data is reliable, responsive and relatable. To make our data gathering processes more reliable, we created learning outcomes and aligned the assessment instruments used to evaluate them. Similarly, the use of well-supported ubiquitous technology such as the LMS and data warehousing environments provides opportunities for instructors to contribute to, and access meaningful information from, the outcomes data. The ease of access to data via the LMS makes instructors more responsive to using data about student learning, especially when these instructors are involved in the curriculum improvement process in a course or program. Sustainability in this process can be achieved by synthesizing and supporting the use of relatable information from the gathered data. Furthermore, engaging with data on learning outcomes and curriculum mapping has not commonly been part of the average instructor’s daily activities. However, that does not necessarily mean that instructors are unwilling or unable to engage with this type of data. For the project team at University of Guelph, this meant the data had to be presented in a relatable manner and be broadly applicable; a feat that can be accomplished by communicating our logic of outcomes assessment (Figure 2) to all instructors. To go a step further, we also provided instructors and curriculum committees with data that followed a similar logic, spanning from the course level to the larger program level (as seen in Figures 10 and 11 and in Table 4). In Table 5, a summary of the number of mapped assessment points that are included in evaluating a learner's achievement of a particular graduate attribute (e.g., 132 for knowledge base) is also produced from the gathered data. Table 6 expands on this summary to demonstrate the number of specific learning outcomes (indicators) utilized in evaluating achievement on a particular learning outcome, and the origin of that assessment point (be it numeric or rubric-based) from the learning-outcomes management tool. This overview allowed instructors to see how their efforts contributed to both the intended learning outcomes and the assessment within their program. Collectively this data provides programs, committees and instructors with more precise information on how they might go about improving a curriculum.

Table 5: Summary of Number of Assessments Mapped to Graduate Attributes Across 45 Courses in the Engineering Program Curriculum

Indicator	Total number of mapped assessments
Knowledge base	132
Problem analysis	184
Investigation	105
Design	122
Use of engineering tools	119
Individual and team work	7
Communication skills	86
Professionalism	9
Impact of engineering on society and environment	43
Ethics and equity	5
Economics and project management	78
Lifelong learning	19

Making Outcomes Assessment Sustainable for Programs and the University

In order for our outcomes assessment work to be sustainable, the data gathered should allow both programs and the institution to easily report on student achievement of learning outcomes at a variety of the nested levels shown in Figure 2. This concept of sustainability of the learning-outcomes assessment process resonated strongly with our institutional objective — to examine student achievement of program and university learning outcomes and how multiple courses within a program curriculum mapped to learning activities are contributing to that achievement. As part of the learning-outcomes assessment work at the university, we implemented a similar approach in the Doctor of Veterinary Medicine (DVM) Program. In this example (as with our proof of concept and pilot programs), we mapped specific authentic assessments to course and program outcomes and the university-level learning outcomes prior to the development of the learning-outcomes management tool. Using the principles of nested learning outcomes and aligned assessments, we were able to examine data that has been gathered from developmental rubrics, and that could be related to student achievement of institutional learning outcomes. In the case of the DVM program, the course-assessment data collection was based on a validated analytic curriculum-wide rubric that was mapped to the program competencies (program-level outcomes) and used to evaluate a variety of assessment strategies. By adopting a program-wide approach to aligning and evaluating learning outcomes with a validated analytic rubric, we were able to utilize authentic direct assessments of student performance to report on the student achievement of institutional-level outcomes as summarized below in Table 6.

Table 6: Mapped Summary of DVM Program Student Learning-outcome Achievement, OVC Clinical Competencies and University of Guelph Institutional-level Learning Outcomes

Summary of OVC DVM program student proficiency measured as a direct assessment of student performance during the final year of the DVM program					
Mapped to U of Guelph Outcomes	OVC Clinical Competencies	Proficiency of students expressed **as a percent (%)** of students assessed. Class n = 118			
		Significant improvement needed	Approaching graduating expectations	Meets graduating expectations	Exceeds graduating expectations
Critical and Creative Thinking	Veterinary factual knowledge, acquisition of case history, consideration of animal welfare, problem solving and clinical judgement, occupational and public health	0	0	99	1
Literacy	Diagnostic ability, technical and procedural skills, case ownership and continuity of care, written communication, presentation skills	0	0	100	0
Global Understanding	Veterinary factual knowledge, communication skills with the client, consideration of animal welfare, problem solving and clinical judgement, case ownership and continuity of care, communication skills with professionals, participation	0	0	100	0
Communicating	Acquisition of case history, communication skills with the client, conducting a physical examination, handling animals safely and humanely, consideration of animal welfare, case ownership, written communication, communication skills with professionals, participation, professional conduct and collegiality, presentation skills	0	0	100	0
Professional and Ethical Behaviour	Professional conduct and collegiality, occupational and public health, communication skills with professionals, written communication, technical and procedural skills, diagnostic ability, problem solving and clinical judgement, consideration of animal welfare	0	0	100	0

In the School of Engineering pilot, we extended the general approach used in OVC to include integration with the LMS. In a similar manner for the scalable pilot, we also mapped and aligned the program-level outcomes (i.e., the engineering graduate attributes) and the institution-level learning outcomes (see Table 7). As you will observe, and as is usually the case, mapping outcomes is usually a one-to-many mapping relationship at the program and university level. This complexity increases as students progress through programs that require more course variability. Therefore, the sustainability that using the learning-outcomes management tool lends to this project and process is invaluable.

Table 7: Mapped CEAB Graduate Attributes and University of Guelph Learning Outcomes

CEAB Graduate Attribute	Mapped U of G University-level Outcome
Knowledge base for engineering	Literacy
Problem analysis	Critical and creative thinking
Investigation	Critical and creative thinking, communicating, literacy
Design	Critical and creative thinking, literacy, global understanding
Use of engineering tools	Literacy, critical and creative thinking
Individual and team work	Professional and ethical behaviour
Communication skills	Communicating
Professionalism	Professional and ethical behaviour
Impact of engineering on society and the environment	Global understanding
Ethics and equity	Professional and ethical behaviour
Economics and project management	Professional and ethical behaviour
Lifelong learning	Global understanding

Based on what we have learned from the School of Engineering pilot we have started developing nested learning-outcomes frameworks for other undergraduate programs. In Fall 2017, the simultaneous learning-outcomes alignment process was started with over 20 different majors at the bachelor's level.

Lessons Learned

In order to make this pilot scalable and sustainable throughout the university, the project team is evaluating the successes and challenges associated with the implementation strategy, and the quality of the data acquired. More specifically, our ongoing work related to learning-outcomes assessment will focus on refining the following elements related to this project:

- Supporting the institutional continuous improvement processes by accurately aligning institutional outcomes, program outcomes and quality-assurance processes
- Developing an iterative design process with D2L to stage the technical development of the learning-outcomes assessment tool
- Fostering a culture of deep engagement with assessing learning outcomes among faculty and departmental committees
- Creating mechanisms to ensure sound data management, security and privacy

This project, funded through HEQCO's Learning Outcomes Assessment Consortium, enabled the University of Guelph to move toward its goal of capturing and assessing learning outcomes in all programs. The results of this project demonstrate that the online learning-outcomes assessment tool is able to capture learning-outcomes achievement data from a variety of mapped assignments. But aside from the obvious benefit of capturing this data within a course and across a program of study, this project has deepened faculty engagement in program assessment and pedagogy. This engagement has been established in three ways:

1. Providing the instructors with the data
2. Providing a focused opportunity to debrief and discuss the data (i.e., make it relatable)
3. Facilitating practical solutions and approaches that can be implemented incrementally

The program-wide implementation of a learning portfolio in the School of Engineering is an example of this deep faculty engagement that was not originally an explicit objective of this project.

While there were clear benefits of the project, as expected some challenges did arise. From a technical perspective, D2L's LMS has to be adjusted from a tool that captures individual grades in a course to a tool that captures broad outcomes acquired throughout a student's program of study. The complexity involved in this alteration has resulted in our adopting an iterative project design and implementation approach.

Another key lesson from our project is that faculty engagement is critical to success. As this project expands to other programs at the university, faculty engagement remains a high implementation priority. Therefore, an ongoing goal is to align outcome-assessment needs with continuous curriculum improvement and also contribute to existing quality-assurance processes at both the institutional and program levels.

Additionally, we learned that the volume of data related to student achievement of learning outcomes raises issues around data access, security, storage and privacy. This has resulted in thoughtful discussions and planning by a variety of stakeholders at the university (e.g., the privacy officer, research ethics board, deans, associate deans, and our office of institutional analysis and research). From a technical perspective, the University of Guelph is working closely with Desire2Learn on the next version of the Insights software, while senior staff are exploring ways of managing, processing and manipulating the data.

Finally, from a staffing and expertise perspective, it has also become clear that substantial professional staff support is required. The Open Learning and Educational Support department continues to guide the best pedagogical use of educational and technological tools, processes and policies around learning-outcomes assessment. New capacity has been committed from the department to achieve the deep instructor engagement that is critical to ensuring that appropriate and useful data can be extricated for continuous curriculum improvement.

Recommendations

The following are some key recommendations for other institutions:

- From the practical level of utilizing a technical solution, we strongly recommend being pedagogy forward — consider the pedagogical need before the technical need.
- If possible, align this effort with the continuous program improvement processes and conversations at your institution both formally and informally.
- Given that delivery of an outcome usually spans multiple courses, efforts should be focused at the program and major level as well as at the course level; learners require time to demonstrate their evolving levels of achievement of learning outcomes.
- Support and involve instructors in all your processes; each discipline brings with it a valued and rich perspective to assessing learning in the respective curriculum. This approach creates a culture of ownership and pride with curricular work.

Why this Approach Works at the University of Guelph

Above all else, a shared philosophy is foundational to why we continue to make progress in learning-outcomes assessment. The University of Guelph prides itself on being a learner-centric institution and learning-outcomes assessment extends naturally from this philosophy. Our partnerships with D2L, faculty, staff and students focus us on keeping these processes sustainable and beneficial to everyone involved in the curriculum.

Our findings reaffirm the complex nature of learning-outcomes assessment. For the process to be successful, it requires numerous direct and indirect assessment approaches, and novel methods of documenting the experiences and contributions of students, instructors, employers and other stakeholders. This process is rich with collaborative opportunities for instructors, professional staff, educational researchers and learners to work together to improve both the curriculum and the learning environment. We believe that the willingness to engage with learning-outcomes assessment data and to collaborate on the findings is another key reason why this approach is successful.

Our collaboration with Desire2Learn has been beneficial as it continues to develop the learning-outcomes management tool for this project. Rather than building the entire functionality of the tool independently, D2L engaged us in an iterative design process that included feedback and user testing throughout. This approach ensured alignment between the needs of the institution and the functionality of the tool. It also gave the project team the opportunity to use the tool during development, and allowed us to test and revise workflow strategies.

The University of Guelph was one of the first institutions in Canada to propose the concept of learning objectives, and in essence, articulate a clear commitment to the quality of what we expect graduates of the university to know and do. This commitment continued with senate-approved institutional learning outcomes and the development of program- and course-learning outcomes in our undergraduate programs. The findings of this project highlight the importance of shared philosophies in support of student learning; authentic engagement with faculty, staff and students; and the development of innovative partnerships to keep processes sustainable. Most importantly, the culture of learning-outcomes assessment signals the next step in the university’s commitment to keeping our learners at the centre of what we do.

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Higher Education Quality Council of Ontario

An agency of the Government of Ontario