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Intersecting Roadmaps: Resolving Tension Between Profession-Specific and University-Wide Graduate Attributes

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Article abstract

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INTERSECTING ROADMAPS: RESOLVING TENSION BETWEEN PROFESSION-SPECIFIC AND UNIVERSITY-WIDE GRADUATE ATTRIBUTES

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Abstract

Can we map university-wide graduate attributes to specific program requirements? Can we develop and manage an integrated assessment process? In this article, we present a seven-month long project where we attempted to map generic university graduate attributes (UGAs) to required engineering program graduate attributes in a large Canadian research institution. The purpose of the project was to explore the intersection of the UGAs with engineering graduate attributes, evaluate the accreditation process, develop a mapping process, and examine management strategies for assessing both sets of graduate attributes, all the while keeping the continual improvement process attractive to students, instructors, and administrators. Using a modified dialectical inquiry, two groups worked on the mapping process: one from engineering, the other from social sciences (Education and Arts), to ensure objectivity of comparison. Both forward and backward mapping took place. Results demonstrated that, although generic, UGAs may not necessarily capture specific professional program graduate attributes. The study also highlighted the need for more revisions and updates of UGAs by including various stakeholders who can substantially contribute to the implementation and assessment of UGAs.

Keywords: graduate attributes, engineering education, professional attributes, mapping, learning outcomes

Résumé

Peut-on associer des compétences transversales universitaires, d'ordre général et générique, à des exigences et compétences essentielles propres à un programme de formation particulier? Peut-on mettre au point et gérer un processus cohérent et uni d'évaluation des deux types de compétences au sein du même établissement postsecondaire? Dans cet article, nous présentons un projet qui a duré sept mois et dans lequel nous avons tenté de mettre en correspondance les compétences transversales universitaires et les compétences essentielles requises dans le programme d'ingénierie d'un établissement canadien. Le but de ce projet était d'explorer l'intersection des compétences transversales et de celles requises des diplômés en génie et d'évaluer le processus d'agrément du programme de génie. En gardant en vue l'idée de garder le processus d'amélioration continue attrayant pour les étudiants, les enseignants et les administrateurs du programme, nous visions à mettre au point un processus de schématisation/modélisation pour déterminer des stratégies de gestion afin d'évaluer les deux ensembles de compétences. En utilisant une enquête dialectique, deux équipes se sont penchées sur le travail de schématisation/modélisation : l'une du domaine de l'ingénierie, l'autre de celui des sciences sociales (éducation et arts), afin d'assurer l'objectivité de l'étude comparative. Une schématisation inversée a eu lieu. Les résultats démontrent que, bien que génériques, les compétences transversales universitaires ne capturent pas nécessairement les compétences essentielles particulières aux programmes professionnels. L'étude a également mis en évidence le besoin de réviser et de mettre à jour les compétences transversales universitaires en incluant des parties prenantes qui peuvent contribuer substantiellement à leur mise en œuvre et à leur évaluation.

Mots-clés : compétences transversales, pédagogie du génie, compétences professionnelles, schématisation, résultats d'apprentissage

Introduction

At higher education institutions in Canada, professional engineering programs are accredited by the Canadian Engineering Accreditation Board (CEAB). The aim of the accreditation process is to ensure each student graduating from an accredited engineering program meets the profession's minimum knowledge and skills development required by the principal stakeholders of their education; namely, the profession, society, educational institutions, employers, and graduates themselves. Similar to other professions, such as medicine and law, the governing bodies require strict development and assessment of field-specific technical knowledge, skills, and abilities (Committee on the Accreditation of Canadian Medical Schools [CACMS], 2019; Federation of Law Societies of Canada Standards, 2018; CEAB, 2019). Non-professional university programs do not require an accredited quality assurance assessment of students, programs, and instructor qualifications; however, from employability and career decision-making perspectives, students desire to understand and define the competencies developed as a result of their university experience regardless of the discipline of study (Dew et al., 2013).

To this end, the University of Alberta identified and published a set of seven student attributes to reflect graduate characteristics and the values of the university believed to be developed as a result of course work and extracurricular activities (Dew et al., 2013). The recommended implementation path and assessment of the student attributes was to be accomplished by program planners and instructors. An obstacle to implementation is the perception of whether or not these attributes are linked to program objectives, are developed and/or addressed in the curriculum, would be linked to the curriculum, and could hence be assessed by instructors (Kanuka & Cowley, 2017). The implementation of UGAs as a set of outcomes acquired by students in higher education is a complex, multifaceted project. It requires cooperation and collaboration on many levels, spanning from the classroom and course level, to the program and department level, to the interdisciplinary and administrative levels, and beyond academia to include the multiple stakeholders invested in qualified university graduates, including potential employers, communities of practice, and accreditation and regulatory bodies. It is a complex process that is challenging to undertake (Hamou-Lhadj et al., 2015; Harris et al., 2011; Kaupp et al., 2012; Kaupp & Frank, 2016; Oliver & Jorre de St. Jorre, 2018; Parker et al., 2019; Sepheri, 2013; Stiver, 2011; Watson et al., 2018[1]) given the various and diverse stakeholders involved as shown in Figure 1.

Each professional accrediting body may use different terminology to define what competencies graduates must meet. For example, the Committee on the Accreditation of Canadian Medical Schools (CACMS, 2019) defines in its lexicon, medical education program objectives, which are defined as "statements of what medical students are expected to be able to do at the end of the educational program i.e., exit or graduate level competencies" (p. iv). The Federation of Law Societies of Canada Standards (2018) calls them *skill competencies*. In the Canadian engineering education field, these abilities are called *graduate attributes* (CEAB, 2019); they are demonstrated through institution level-specific and measurable indicators mapped to course learning outcomes (Ivey et al., 2017, 2018). In each of these professions, graduates are required to demonstrate knowledge and skills specific to the profession (e.g., engineering design, clinical skills, knowledge of case law) and skills that are often common (e.g., lifelong learning, communications, ethics). A complete review of accreditation bodies and processes is outside of the scope of this article, but there is clearly significant overlap in professional requirements.

The language used to describe the professional competencies is very different, which underpins the need for a process to map competencies in different fields when implementing and administering a set of graduate attributes relevant to all university graduates, especially those in professional programs governed by accreditation requirements. In this article, we examine the intersection of two sets of graduate attributes at the Faculty of Engineering, University of Alberta: the professional engineering graduate attributes, and the university graduate attributes for the purposes of implementation and administration in a faculty of one university. In engineering, assessment of graduate attributes is part of the required continual improvement process (CIP), a framework each program must develop. There are 12 engineering graduate attributes (GAs) related to student performance of engineering work that must be demonstrated at different levels of ability prior to graduating.

The Faculty of Engineering, University of Alberta framework has been detailed extensively (Parker et al., 2019; Ivey et al., 2018; Watson et al., 2018; Ivey et al., 2017). The seven university graduate attributes are related to skills, characteristics, and values. The necessity for students to demonstrate these attributes is linked to post-graduation marketability and the idea that a university education provides preparation to contribute to the public good (Bendixen & Jacobsen, 2017) rather than demonstrated competence for entry into a profession. Implementation has been slow in professional programs as accreditation-related graduate attribute assessment is already in place and the correspondence of the sets of professional and university graduate attributes is not obvious. In addition, the actual assessment of the UGAs is viewed as an obstacle by academics (Ipperciel & ElAtia, 2014; Kanuka & Cowley, 2017; Maguire & Gibbs, 2013). In non-professional and professional programs alike, there are challenges in implementation as academics do not share common conceptions of student attributes, how they are developed, or the core achievements of higher education.

Prior Research on Implementing Graduate Attributes

Since the 1989 Washington Accord (International Engineering Alliance [IEA], 2015), engineering education programs accredited by signatories, such as CEAB and the American Accreditation Board for Engineering and Technology (ABET), are recognized as academically equivalent to support international mobility for professional engineers. In 2009, the Washington Accord accrediting bodies introduced the engineering graduate competency-based outcomes as part of the accreditation process (Easa, 2013; Frank et al., 2011; Gopakumar et al., 2013; Stiver et al., 2010). Subsequently, engineering programs began grappling with how these graduate attributes would become a part of the accreditation process with limited direction from the Canadian Engineering Accreditation Board or Washington Accord signatories. Engineering schools began implementing processes to review curriculum and map the graduate attributes to curriculum content, develop assessment criteria, and then measure graduate achievement of these attributes. Gradually, the 12 CEAB graduate attributes[2] and the associated CIP (IEA[3], 2015) have become a significant part of the accreditation process in Canada (CEAB, 2017, 2018; Kaupp & Frank, 2016). The CEAB Graduate Attributes (CEAB-GAs) have driven changes to the accreditation process, program level assessment, and highlighted the need for a university culture that supports the scholarship of teaching and learning at program and course levels as part of the CIP (Doré, 2019; Jamieson & Shaw, 2019b; Meikleham et al., 2018; Parker et al., 2019). The development of the Washington Accord graduate attributes took nearly a decade (Stiver, 2011; Parker et al., 2019), another decade passed before they were introduced into the Canadian accreditation process (Parker et al., 2019), and it is expected to take another two accreditation cycles for full integration of the graduate attribute continual improvement process (GACIP).

Since 2014, engineering programs in Canada are required to report graduate attribute achievement and demonstrate the use of a CIP to identify program improvement opportunities or justify the status quo (CEAB, 2018) as part of the accreditation process (CEAB, 2017). In Canadian universities, the implementation of the CEAB-GAs framework for assessing the quality of engineering education and graduates is mandated by the national accreditation board and supported by provincial regulators. Consequently, academic program administrators and instructors in engineering faculties are working toward meaningful implementation of these attributes within their curriculum (i.e., Kaupp & Frank, 2016), developing management strategies (i.e., Parker et al., 2019), and writing about their ongoing progress and struggles, including the Engineering Graduate Attribute Development (EGAD, 2018) program inaugurated by several Canadian universities[4]. In addition, some engineering schools associated with the Conceive, Design, Implement, Operate (CDIO) program have investigated how the CEAB accreditation requirements map to CDIO[5] program standards and syllabus (Cloutier et al., 2012; Meikleham et al., 2018; Platanitis & Pop-Iliev, 2011) in order to better manage student and program assessment for two purposes; namely, accreditation and post-graduation marketability.

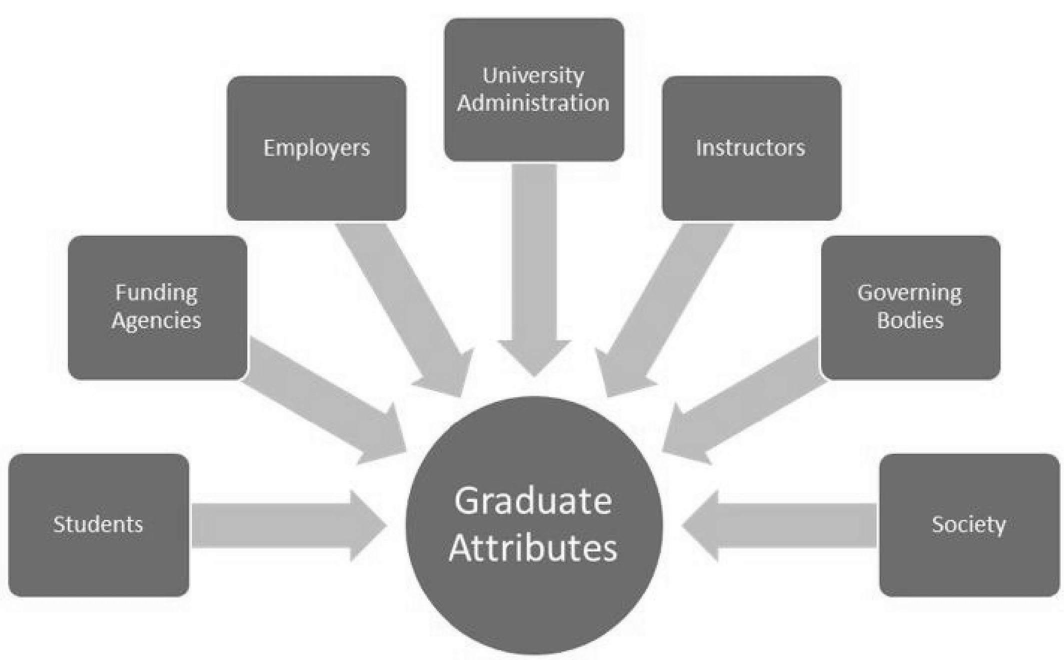
Parallel to this—and triggered by a growing dissatisfaction with higher education outcomes for university graduates (Arum & Roska, 2010), such as job opportunities and graduates' readiness for the job market—the need for a valid and longitudinal assessment that serves the needs of all higher education stakeholders comes to light. University-wide Graduate Attributes (UGAs) are presented as global learning outcomes for students, acquired during their education; they set criteria to assess the transformative influence of higher education on graduates and may link assessment to quality assurance and continual improvement, enhancing accountability of post-secondary institutions (French et al., 2014; Treleaven & Voola, 2008), especially in the eyes of funders. The UGAs model comprises competency-based assessment criteria "which structures learning around competencies defined as fundamental for successful performance" (Stoffle & Pryor, 1980, p. 55). O'Donnell et al. (2017) identify two directions of transferable skill and attribute (TSA) development progression: a vertical progression enabling students to operate within their academic field of study and a horizontal skill development progression that crosses academic disciplines and enables students to "operate successfully within a variety of employment settings" (O'Donnell et al., 2017, p. 21). A goal for professional and non-professional programs is to develop both discipline-specific and generic professional competencies to foster flexibility and resilience in the face of a changing world.

The process of integrating the UGAs model into university professional programs requires integrating this more horizontal transferable skill progression (addressing employability and transformative experience) with discipline-specific and professional program requirements such as the CEAB-GAs, which address discipline competencies, and quality assurance accreditation. As graduates of different professional programs are expected to master skills related to their practical domain, these skills may or may not overlap with the UGAs (Harris et al., 2011; Stiver, 2011).

In order to ensure an effective implementation of a continual improvement program and aligned assessment of graduate attributes, engineering program and curriculum designers now integrate course-level learning outcomes mapped to the CEAB graduate attributes and linked to the overall program objectives (Ivey, 2017; Kaupp & Frank, 2016; Watson et al., 2018). Work and co-op experience, capstone design projects, internships, and extra and co-curricular activities may be included as contributing factors to graduate attribute development (Gwyn, 2017; Gwyn & Gupta, 2015; Jamieson, 2016; Salustri, 2017; Shehata & Schwartz, 2015). The subsequent integration of the UGAs into this process requires the examination of overlap and divergence of the two sets of graduate attributes and the management of the assessment and continual improvement processes.

Figure 1

Stakeholders and Graduate Attributes



The implementation of the UGAs is still evolving and a shared understanding of what the UGAs are and how to implement them is still developing (Kanuka & Cowley, 2017). Administrative questions with respect to coordinated implementation with accredited programs are currently being investigated. This article reflects on the outcomes of the process of mapping the UGAs to the CEAB-GAs within the Faculty of Engineering (F of E) at the University of Alberta (U of A). In addition to the mapping outcomes, the study highlights the methodology of mapping the graduate attributes to distinguish the overlaps and divergences between the two sets of graduate assessment criteria in order to implement the UGAs in a professional program.

Theoretical Frameworks Guiding the Study

As illustrated above, the body of literature on student attributes regarding their higher education purpose, their developmental goals, and their implementation goals are diverse. To guide our work, O'Donnell et al.'s (2017) description of discipline (vertical) and cross-discipline (horizontal) TSA frames the developmental goals of the GA. For the implementation goals Maguire and Gibbs' pragmatic definition of quality assurance best describes the CEAB-GA: "Quality has no intrinsic link with what higher education is; it is simply a measure of how well, effective or efficient an institution is in providing the benefits it claims for itself and its stakeholders" (Maguire & Gibbs, 2013, p. 44). The UGAs are better described by the definition presented: "This definition extends beyond the needs of the institutions and includes societal, economic and political dimensions of what can be taken as higher education" (Maguire & Gibbs, 2013, p. 44). In order to include the UGAs within the Faculty of Engineering GA assessment process for accreditation, an understanding of the congruence and divergence of the two sets of GAs is required. Regarding the overall purpose of student attributes in higher education, we propose a stakeholder framework as noted in Figure 1 to recognize the diverse interests in this process.

Dialectical Approach to Mapping

We employed a dialectical approach to mapping the UGA to the CEAB-GA. In mathematics, mapping is synonymous with transformation and is defined as "any prescribed way of assigning to each object in one set [emphasis added] a particular object in another (or the same) set" (Osserman, 2006, para. 2). In this project, we embarked on a structured qualitative approach to carrying out the mapping process between two sets of graduate attributes from the university: one is mandated by an accreditation body, while the other is more of a guide to generically define what students acquire in a university beyond the classroom experience.

Using Dialectical Inquiry (DI), we proceeded to the mapping process within a qualitative research methodology. Berniker and McNabb (2006) define DI as "a useful structured qualitative research method for studying organizational sense making processes as they are understood by participants.… Its focus is on the content and meaning of models and theories in use" (pp. 644–645)

Dialectical inquiry requires debate and building arguments by experts on a subject or matter that requires opposite views. Hence, we organized our DI through an adapted Hegelian model of: thesis, antithesis, synthesis. We approach both sets of graduate attributes, the university, and the CEAB as thesis and antithesis, and the mapping process was the final synthesis of both forward mapping (thesis) from CEAB to UAB, and backward mapping (synthesis) from UGA to CEAB. The final results that contributed to the mathematical range is the synthesis of our work. Our aim was to answer these questions: Are the CEAB and UGAs equivalent/overlapping? And how can we read these similarities and/or dissimilarities within the wider scope of quality assurance in higher education?

Back in 1969, Mason found utility of the dialectical modeling for effective decision support system: the constructive debate between experts leads to better outcomes—a synthesis of new ideas and findings. The mapping process that we undertook was directly founded on this model for decision making.

Research Design

The overarching objective of this interdisciplinary study at the U of A is to advance the scholarship in understanding, use, implementation, and management of related graduate attribute competency-based continual improvement processes. This article addresses the following questions:

- What are the challenges of aligning the UGAs with program-specific requirements (the CEAB-GAs in our case study) to facilitate efficient implementation?
- How does mapping for implementation contribute to evolving the UGAs as a universal assessment criterion to include vertical and horizontal TSA development aspects?
- How does the dialectical method of one-to-many and many-to-one relationship expose the blindsided areas in the UGAs and in any assessment criteria in general?

The aim of this study is to identify the main areas of divergence between the two GA assessment models, along with identifying the main challenges of the actual enactment of the UGAs in curriculum design more broadly. The outcomes of this article will be valuable to those who seek to integrate UGAs with professional practice programs governed by external graduate attributes. This model is proposed for use in different faculties and disciplines and toward a cross-disciplinary standardization of the UGAs assessment process.

Case Description: Integration of the CEAB-GA and UGA Management Systems

The initial development of two separate systems to assess graduate attributes for engineering undergraduate students was identified as redundant, overlapping, an undue burden for both students and instructors, and potentially difficult to manage by program administration. The UGAs are structured as knowledge, skills, and attitudes (KSA) indications of the attribute and were intended to demonstrate student and program quality assessment of higher education programs. From a preliminary review, the CEAB graduate attributes and those of the U of A did not match as listed in Table 1. From a professional program perspective, the priority of the Faculty of Engineering is to maintain accreditation, meet the governing body's requirements, and train undergraduate students to ensure the safety of the public whom engineers serve; notwithstanding U of A requirements for demonstrating graduate competencies.

Table 1

University and CEAB Graduate Attributes

UGA (7)	CEAB-GA (12)
1. Ethical Responsibility (ER)	1. Knowledge base in engineering (KB)
2. Scholarship (SC)	2. Problem analysis (PA)
3. Critical Thinking (CT)	3. Investigation (IN)
4. Communication (CM)	4. Design (DE)
5. Collaboration (CL)	5. Use of Engineering tools (ET)
6. Creativity (CR)	6. Individual and team work (TW)
7. Confidence (CF)	7. Communication skills (CS)
	8. Professionalism (PR)
	9. Impact of engineering on society and environment (IS)
	10. Ethics and equity (EE)
	11. Economics and project Management (EP)
	12. Lifelong learning (LL)

Accreditation and Graduate Attribute Implementation in Engineering Programs

The accreditation process of engineering undergraduate programs is multifaceted. Competency-based assessment, curriculum content, and quality inputs are seen as complementary aspects of a program and its accreditation. If an institution can deploy resources for collaborative implementation at the administrative, program, and course level, a cultural shift that explicitly makes learning a priority can happen. Students, instructors, administrators, and stakeholders must recognize the value in the implementation and believe that developing the graduate attributes is a worthwhile activity for the graduate attributes to become *embedded* at the program and course levels (Hamou-Lhadj et al., 2015; Jamieson & Shaw, 2016, 2018a, 2019a; Kaupp & Frank, 2016; Oliver & Jorre de St. Jorre, 2018; Parker et al., 2019).

To achieve the objective of embedding the UGAs into the course and program levels of the curriculum, three levels of implementation and cultural change are targeted. The first is the institutional level, where a collaborative administrative team allocates resources, develops an implementation vision, and executes a strategy to support a learning-focused team that develops and monitors the implementation process as shown in Figure 2. At this level, a collaborative effort aimed at integrating the goals of the professional program(s) and the university graduation requirements is required. The second is a program-level approach that focuses on mapping the graduate attributes to the curriculum, the developmental trajectory of the graduate attributes on the learning pathway (Meikleham et al., 2018) over the program years, and integrating the goals of the professional program and the university graduation requirements into the program and course objectives. The third level targets specific course design coordinated with the developmental trajectory of the graduate attributes on the learning path for the program. Figure 3 shows an integrated approach to managing CEAB-GA implementation and continual improvement at the program and course levels focusing on constructivist and outcome-based learning approaches (Hattie, 2009). Course instructors can embed GAs at the course level given an institutional learning culture, but the learning trajectories must be managed at the program level across multiple courses that allow the student to progress on a learning pathway that scaffolds graduate attribute development through the program progression.

The initial institutional level work done at the U of A in the Faculty of Engineering to implement a management structure for the CEAB-GA is discussed in this case. At the time of investigating how UGA integration might occur, the U of A, Faculty of Engineering had already developed a management structure, mapped the curriculum, and was starting to move into Stage 3 as described in Figure 2. This study identified the first step toward integration as mapping the UGAs to the CEAB-GAs to outline the overlap as well as the divergence between the two frameworks, and potentially provide a management strategy to reduce assessment loading at the program and course levels while satisfying the professional program requirements and the university requirements concurrently.

Figure 2

Graduate Attributes Implementation Stages

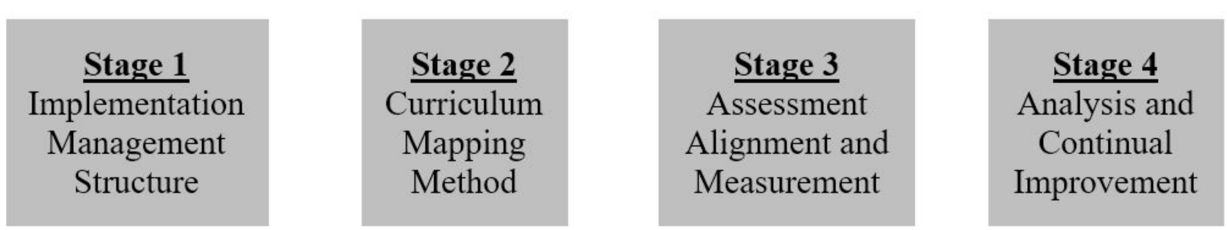
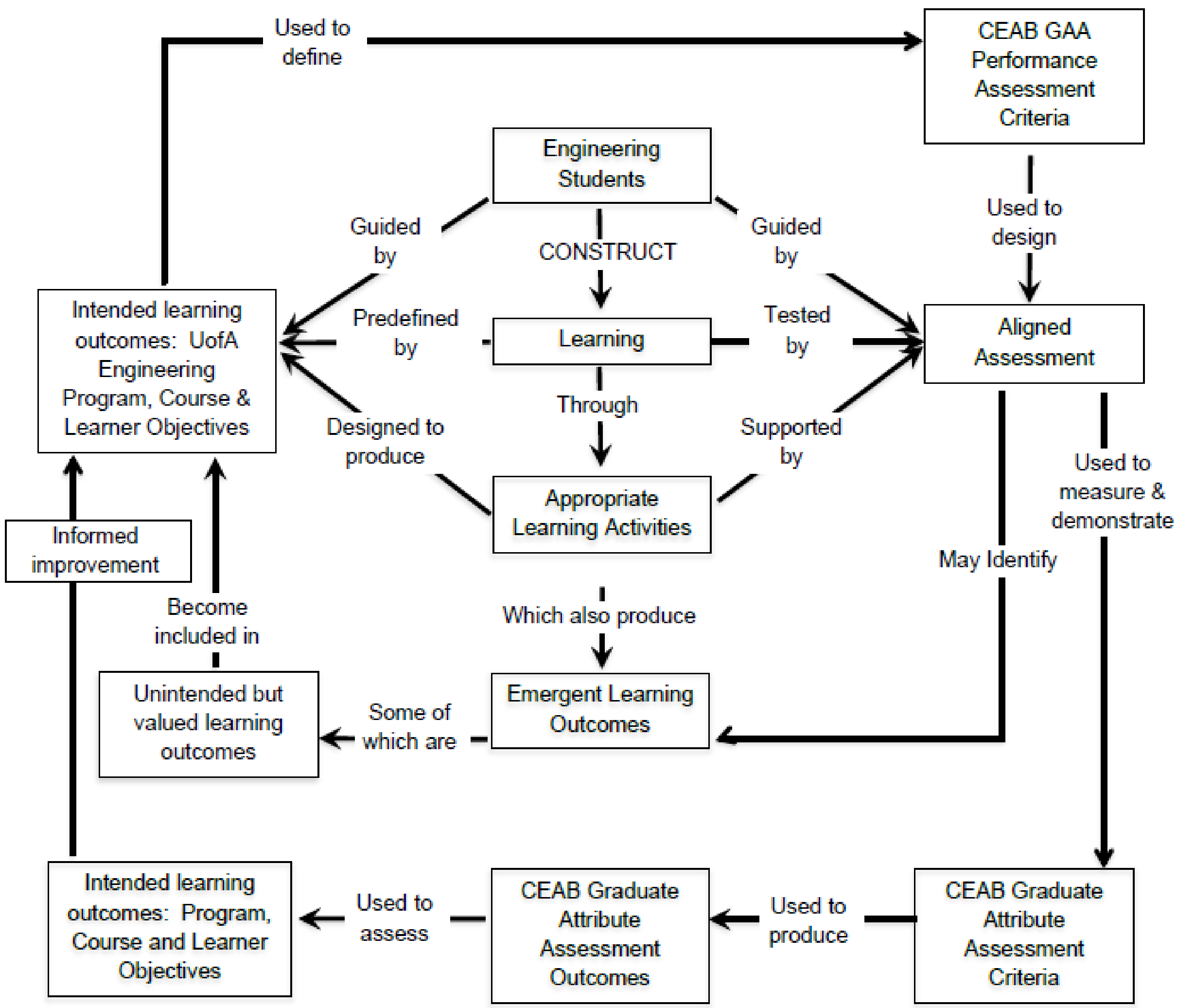


Figure 3

Continual Improvement Process Algorithm for the University of Alberta[6]



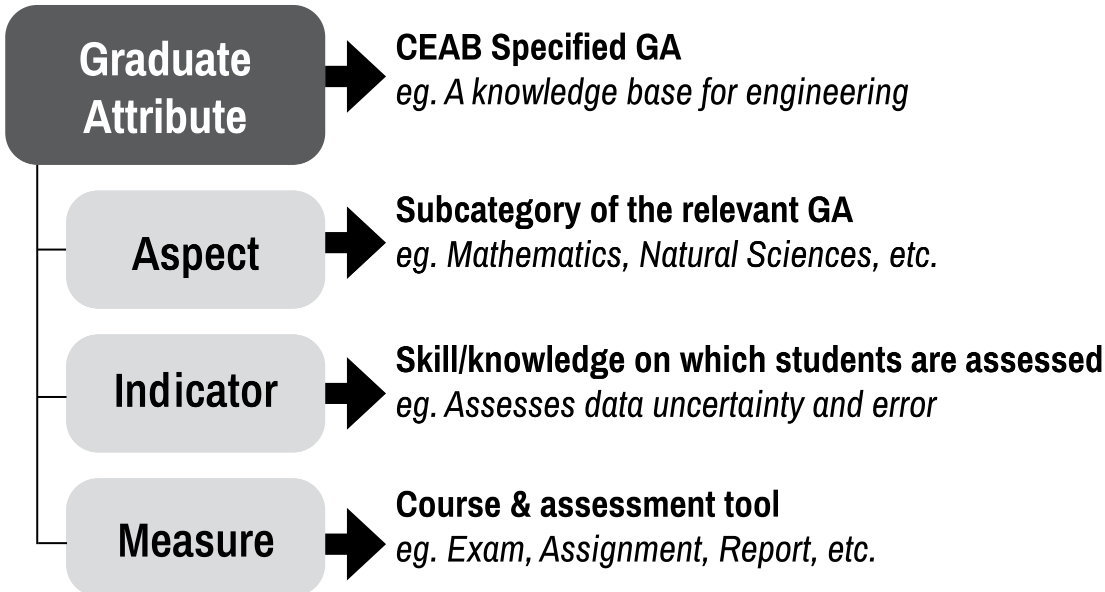
Developing the CEAB-GA Management Structure

In accordance with the internationally agreed-upon Washington Accord (IEA 2015), accreditation of Canadian engineering undergraduate programs requires students demonstrate a satisfactory level of competence commensurate with the professional expectations of an engineer in training at the time of graduation (CEAB, 2017). The development of these competencies should progress over the course of the engineering program. The CEAB-GAs are structured as competency or performance-based outcomes (Hattie, 2009) and intended to assure graduate and program quality. The U of A, Faculty of Engineering assessment model includes aspects, indicators, and measurements for each of the CEAB-GA. The 12 CEAB graduate attributes listed in Table 2 are defined in Appendix A, Table A.

For the U of A, Faculty of Engineering GACIP management process, a hierarchy was developed for each CEAB-GA as shown in Figure 4. For each of the 12 CEAB-GAs, the faculty academic planning committee identified a number of *aspects* (sub-attributes) that elaborated or characterized that CEAB-GA to provide a better

Figure 4

Graduate Attribute Hierarchy (CEAB, 2017)



understanding of how many different dimensions had to be considered and assessed within the curriculum. The aspects developed for the engineering programs are presented in Appendix B, Table B, where the mechanical engineering program is used as the example. With exceptions of CEAB-GA (1), Knowledge Base for Engineering, and CEAB-GA (5), Engineering Tools, which were largely discipline-specific, a common set of aspects was developed for all engineering programs at the U of A. This supported the deployment of a standardized management approach across the different engineering programs. For each aspect, at least one indicator was identified. These indicators describe some assessable skill and/or ability that an engineering student can demonstrate developmental competency in. The total number of indicators for all U of A engineering programs ranges from 82 to 90, depending on the program. In our programs, the number of indicators per graduate attribute ranges from four to 19. In mechanical engineering there are 82 indicators. Those highlighted in grey are discipline-specific. With this level of detail, mapping the U of A graduate attributes to the Faculty of Engineering CEAB-GA sub attributes was possible.

University-Mandated Graduate Attributes at the University of Alberta

In 2007, the U of A's Sub-Committee (Dew et al., 2013) on Graduate Attributes identified and developed indicators for the following seven competencies/profiles as graduating attributes of its students: ethical responsibility, scholarship, critical thinking, communication, collaboration, creativity, and confidence. The development of the UGAs and subsequent work of the Sub-Committee on Graduate Attributes was an initiative led by students from the students' union representing various faculties, with advice and supervision by faculty members under the direct coordination of the Center for Teaching and Learning (CTL). The ultimate goal of these groups is a specific interest in identifying the attributes that students acquire during their university education that go beyond the classroom and the scholarship of the subject. The work was linked directly to employability attributes (i.e., these students wanted to identify what soft skills they acquire during their university overall experience that prepare them for the workplace). After two years of work, the Sub-Committee on Graduate Attributes published its seven university attributes and their sub-indicators as guidelines for all university programs (Dew et al., 2013).

Being notoriously difficult to implement and assess (Barrie, 2006; Drummond et al., 1998), typically because of their abstract and non-homogenous nature (Bennett et al., 1999; Green et al., 2009; Taylor et al., 2012), the integration of the UGAs has yet to gain traction campus-wide among instructors[7]. Previously, we devised a criteria-based model for assessing UGAs (Ipperciel & ElAtia, 2014). This model is founded on the understanding of UGAs as knowledge, skills, and attitudes, which allows us to integrate UGAs of a different nature. The model is also built around the notion that UGAs need to be "interpreted" as praxis-oriented, with can-do statements. These two measures allow for a subsequent and crucial step prior to the operationalization of the UGAs: the development of rubric scales for assessment. Following this first step, a readily implementable and practical UGAs assessment platform was developed (ElAtia et al., 2016; ElAtia & Ipperciel, 2017). The main objective is to have an implementation of the conceptualized model to establish an assessment procedure that accounts for the needs, interests, and concerns of the main GA stakeholders (i.e., students and instructors). This similar and parallel development of the university graduate attribute KSAs and praxis orientation and the CEAB-GA aspect and indicator development allowed for the possibility of mapping. This project proposes to implement an integrated assessment platform for both UGAs and CEAB-GAs for the Faculty of Engineering to determine to what extent both are addressed and acquired in the program.

Mixed Method Mapping Process for the UGAs to the CEAB-GAs

The mapping exercise was performed by two teams. The first group was composed of three members of the Faculty of Engineering, all of whom are subject-matter experts familiar with the CEAB-GAs and their assessment within the context of an engineering program. The second group was composed of two external members who were extensively researching the assessment and implementation of the UGAs. In this way, the teams are complementary and can have an objective, arms-length evaluation of the process. Both teams worked on mapping the two sets of attributes presented in Table 1 using the sub-attributes of both sets. A sequential mixed methods study design was utilized. A qualitative exploratory mapping study was followed by a quantitative aggregation of the mapping results. Integration of the qualitative and quantitative study results was completed as part of the interpretation of the results and presented in the results and analysis section.

For each of the 12 CEAB-GAs, the Faculty of Engineering had previously defined a list of sub-attributes, which constitute the key aspects of each graduate attribute. For each one of these sub-attributes, indicators had also been defined, which describe what a student must do to show competency in the attribute. Where possible, indicators were common across all nine engineering programs in the faculty; but where necessary, program-specific indicators were used. When assessing students, performance was rated on a 4-level scale based on a descriptive rubric consistent with accreditation standards.

Similarly, each of the seven UGAs have four sub-attributes associated with them. During the work to develop a criteria-based model for assessing UGAs, specific interpretations in the form of can-do statements were developed for each sub-attribute, along with descriptive rubrics for a 5-level rating scale to describe relative levels of attribute acquisition (ElAtia & Ipperciel, 2015a). The structure of these statements bears a close resemblance to the indicators and assessment rubrics written for the engineering sub-attributes and CEAB-GAs.

To map the UGAs to the CEAB-GAs, each Faculty of Engineering indicator was compared to the list of can-do statements and associated rubrics used to describe the University sub-attributes. Each team worked independently and then collaboratively in a group to compare analyses. Related sub-attributes and can-do statements were linked to the indicator in question as shown for example in Table 2. If appropriate, a single university sub-attribute could be assigned to multiple different Faculty of Engineering indicators, and multiple university sub-attributes could be linked to a single Faculty of Engineering indicator. If none of the can-do statements were appropriate, the indicator mapping was left blank.

The three steps in the mapping process were as follows. First, the preparatory phase: This phase consisted of various meetings. The first meeting was informative. In contrast, the purpose of the second meeting was a team calibration retreat of two days where various groups representing Faculty of Engineering met to discuss their program, their involvement with their program-specific requirements and the UGAs, and the challenges they face to the implementation of these. The third meeting was to draft a working document and identify the working group and subgroup, as well as tasks for individual members. Second, the qualitative analysis phase: Individual and group analyses were conducted. Initially, two groups were established: one group carried the mapping from CEAB to UGAs, and the other group was tasked to do the mapping of UGAs to CEAB. Each individual in each group conducted independent mapping exercises; then, all the individuals met to discuss a standard setting for each of the mapping of the attributes. Once the work of each group was finalized (Matrix), the two groups met to compare results of the mapping exercise. Third, the quantitative analysis phase: each subgroup within the groups analyzed their results and provided the analysis to the other members; aggregate tables were created and discrepancies amongst evaluators were discussed. A standard setting process was carried out to ensure the final reports of each group met all members' evaluations. Both convergences and divergences were documented. Finally, the debriefing and integration phase: Final mapping tables and aggregate analysis were shared and comparisons amongst groups were carried out. Final adjustments to the mapping were done.

Results and Analysis

When performing the mapping, all Faculty-wide indicators were mapped first, followed by any program-specific indicators. In total, 187 engineering indicators were mapped to the 28 University sub-attributes. Of the engineering indicators, 72 were common to all programs, and 115 were program-specific across the nine programs. Mapping the CEAB-GAs to the UGAs produced a table for each CEAB-GA linking CEAB-GA Faculty of Engineering indicators to corresponding UGA sub attributes. As a representative example, CEAB-GA Ethics and Equity was selected. Ethics and Equity intersected with two UGAs, Ethical Responsibility and Collaboration, as demonstrated in Table 3. The Faculty of Engineering indicators for Ethics and Equity were matched to the UGA sub-attributes. For example, consider the U of A indicator for the CEAB-GA Ethics and Equity: *Feels confident in ability to address ethical dilemmas*, which is measured by a survey question at program entrance and exit. The U of A engineering programs provide a variety of learning activities and courses intended to develop student ability to address ethical dilemmas including design, ethics, safety, and risk management. This indicator and measurement for Ethics and Equity encompassed the Ethical Responsibility sub-attributes of global citizenship, community engagement, social and environmental awareness, and professionalism.

Mapping results between CEAB-GAs and UGAs are summarized as an intensity map in Figure 5. The scale of the mapping ranges from white, meaning no overlap, to black, meaning that the four indicators of the UGAs are fully mapped within one CEAB-GA. It is important to note that this does not indicate that the reverse is always true; not all of the indicators of a CEAB-GA are mapped to one or more UGA. This is especially true when considering the Design CEAB-GA (4), which three UGA indicators map into completely. There are a number of aspects in the Design CEAB-GA (4) that extend well beyond that of the Ethical Responsibility, Critical Thinking, and Creativity UGA sub-attributes.

The following were the key findings resulting from the GA mapping exercise:

First, there is little in the UGAs that relates to the CEAB-GA for "Knowledge Base," as evidenced by the single match indicated in Figure 5. The only link found was related to the UGAs for "Scholarship," of which only a single sub-attribute was able to be mapped. This finding was not surprising, as the UGAs framework was designed to be broad in order to encompass all university programs, whereas the indicators defined for the "Knowledge Base" CEAB-GA tend to be targeted toward highly discipline-specific knowledge.

It was found that no UGAs explicitly dealt with the use of tools to accomplish a task, which led to limited mapping opportunities with the "Use of Engineering Tools" CEAB-GA. One UGAs sub-attribute from each of CM and CR were mapped, but neither UGA could be fully aligned. This is an important omission from the UGAs that should be addressed. The ability to use modern tools—such as word processing, which could apply to all, or in some disciplines a focus on specific tools, for example, musical instruments, artistic tools, and intravenous injections—is a key part of their university experience. This aspect is shared by students of all faculties and should be valued by the University.

Another important oversight observed was that none of the UGAs considered time management, economics,

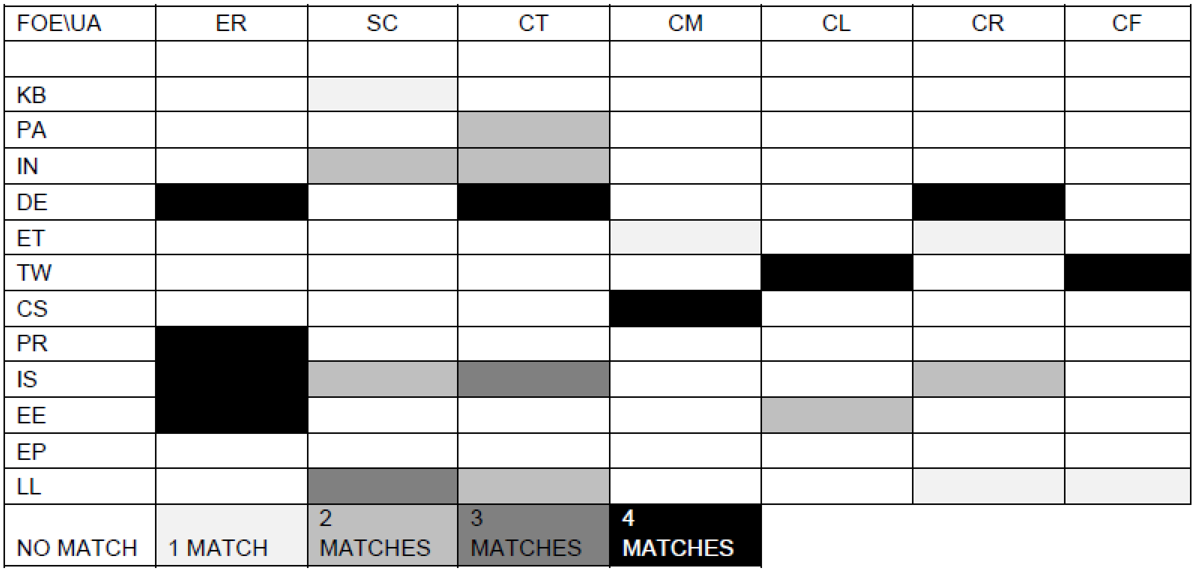
Table 2

University and CEAB Graduate Attributes Mapping Example

CEAB-GA #10: Ethics and Equity		
Faculty of Engineering		University
Sub-attribute	Indicator	Sub-attribute *(Can-do Statement)*
Awareness of Ethical Issues	Feels confident in ability to address ethical dilemmas	1a. Global citizenship *(Can consider issues from a global perspective)* 1b. Community engagement *(Can consider issues from the perspective of their impact on the community)* 1c. Social and environmental awareness *(Can adopt the perspective of the public good and take into consideration our embeddedness within society and nature)* 1d. Professionalism *(Is willing to meet the level of expertise and deontological expectations of her intended profession)*
Code of Ethics	Identifies provisions of the APEGA Code of Ethics	1d. Professionalism *(Is willing to meet the level of expertise and deontological expectations of her intended profession)*
Makes Ethical Choices	Makes ethical choices in complex situations	1a. Global citizenship *(Can consider issues from a global perspective)* 1b. Community engagement *(Can consider issues from the perspective of their impact on the community)* 1c. Social and environmental awareness *(Can adopt the perspective of the public good and take into consideration our embeddedness within society and nature)* 1d. Professionalism *(Is willing to meet the level of expertise and deontological expectations of her intended profession)*
Awareness of Equity Issues	Identifies situations containing equity issues	5a. Openness to diversity *(Can engage with a diversity of people (in terms of race, religion, cultures, classes, sex orientation and appearance)*
Awareness of Equity Issues	Is aware of provisions within the *Alberta Human Rights, Citizenship and Multiculturalism Act*	5a. Openness to diversity *(Can engage with a diversity of people (in terms of race, religion, cultures, classes, sex orientation and appearance)*
Awareness of Equity Issues	Feels confident in ability to address equity	5a. Openness to diversity *(Can engage with a diversity of people (in terms of race, religion, cultures, classes, sex orientation and appearance)*

Figure 5

Intensity Map of the Overall Overlap in CEAB-GAs and UGAs[8]



project management, or financial literacy (employability TSA). As a result, there was nothing that could be mapped to the "Economics and Project Management" CEAB-GA. It can easily be argued that these attributes are vital to all university graduates, who will require knowledge and skills in economics and project management in both their personal and professional lives, and that an additional UGA should be added to reflect this. In the case of the medical association requirements (CACMS, 2019), time management in handling patients is included for example, however, there was no such equivalent in Law (FLSC, 2018), but one should expect that lawyers have sound project and time management and budgeting skills. In many cases, medicine and law are secondary degrees, and these skills are acquired prior and expected to be demonstrated by the graduates. Engineering and most other undergraduate programs on campuses are direct entry from high school programs. The UGA "Communication: Multilingualism" has been interpreted during this mapping process to include computer languages and technical drawings. These are important languages used to accomplish tasks and communicate ideas within an engineering context. The CEAB does recognize language courses (such as French, Spanish, etc.) and they count as complementary studies courses, however being multi- or bilingual is not a requirement to complete an undergraduate engineering degree. As such, there could be no link to multilingualism in a more conventional sense. However, it should be noted that multilingualism will not be an engineering learning outcome or indicator in communication skills. Allowing students to make their own choice of complementary studies course is an important principle of the programs, while programming language skills are inherent to the professional skills.

An ancillary benefit of the mapping process was that it allowed the Engineering group the opportunity to further reflect upon and refine the current CEAB-GA Aspects and Indicators being used for assessment. As a result, a number of potential improvements to the list of aspects and indicators were identified and recorded for future consideration and implementation by the affected engineering programs.

Discussion

During this process, it became evident that, for the successful implementation of the UGAs, certain elements are important for consideration. Training is important for all individuals involved in the mapping process. Stakeholder perspectives must be taken into consideration during the process. The Matrix model (in group, between groups) process (Osserman, 1995) is useful to ensure that all perspectives are met. To ensure validity and objectivity, it is important to have two sets of evaluators to meet those goals: those heavily involved with the programs (validity), and those at arm's length that can be neutral to the process (objectivity).

The mapping process was primarily qualitative in nature, followed by a tabulation amongst the five reviewers in the research team, to better understand the degree of divergence and overlap of the two sets of attributes. As the CEAB-GAs are part of the Canadian accreditation process and developed via international agreement they are not subject to adaptation by a single university. The processes to change the CEAB-GA institution-specified sub-attributes, indicators, and assessments are subject to revision by the U of A Faculty of Engineering and could be revised as part of the GACIP process. The UGAs were specified by the U of A and as such could be revised by the University. In addition, the can-do statements may also be revised as part of a CIP. This does allow for some tailoring and integration of sub-attributes and can-do statements at the institution level to reduce the divergence of the two sets of graduate attributes as they are embedded in the courses of a program.

It was noted that the UGAs did not cover some of the items that the CEAB-GAs did, and that the process used to develop the CEAB-GAs and introduce them into the accreditation process was lengthy. While the UGAs present a wider, more flexible frame of transferable skills (demonstrated by the fact that the mapping team was able to often map one UGA with a few GEAB-GAs), program-specific GAs target professionally oriented knowledge and skills. Thus, while the UGAs contribute to the overall vision for a university graduate as a global citizen, program-specific GAs ensure their functionality in their future profession. Moreover, the UGAs present a set of transferable skills that are applicable across programs and disciplines, while program-specific GAs combine some transferable skills that are applicable to a wide variety of disciplines, in addition to technical program requirements. These requirements might not find their analogue in, or may even be resisted by, other programs. A good example to this would be the attribute of problem solving, which is a basic requirement to programs across the scientific disciplines, but may not be a necessity for all arts programs. According to Oliver and Jorre de St. Jorre (2018), the most specified Australian university-level graduate attributes were: global citizenship, written and oral communication, critical thinking, problem solving, information literacy, and the ability to work independently. Of these items, the CEAB-GAs would address all of them explicitly at the graduate attribute description level with the exception of global citizenship, which is implicit in ethics and equity. Engineering leadership and management programs have been developing across Canada over the last 10 years, suggesting this aspect is a part of engineering education and work (Jamieson & Donald, 2020). The mapping analysis also suggests the UGAs continual improvement processes may need to consider including time management, economics, project management, problem solving, independent work, and financial literacy as part of the can-do statements or perhaps adding another attribute. Oliver and Jorre de St. Jorre (2018) note many of these items are seen as necessary by employers and are categorized in their work as *Independence* or *Employability* skills (work under pressure, be flexible in the workplace, meet deadlines, understand business/organization, leadership, management skills, take responsibility for personal professional development, demonstrate initiative). Oliver and Jorre de St. Jorre's main points are that (a) UGAs should be thought of and incorporated during the course development process, and (b) they should be communicated to students early and regularly, which will provide a better understanding, implementation, and achievement of the UGAs. Students should understand what the goals are for higher education and they should see how the courses they are taking help them make progress to that end.

O'Connell et al. (2017) provide a list of transferable skills and attributes including: knowledge and understanding, ethical and professional understandings, computer-based skills, written and oral communications, adaptability and flexibility, time management and organizational skills, management and leadership, teamwork and interpersonal skills, information literacy skills, problem solving, research skills, and synthesis/creativity. While this list would find significant overlap with the CEAB-GA definitions, it would overlap less with the UGAs, again suggesting further study. This seems to indicate inclusion of these items in the UGAs and that creatively thinking about what the graduates will need in the future would better position them as an employability tool for graduates in a rapidly changing world. Further, it could support the role of the UGAs as providing a sense of who students could become after engaging in a university education, how they will benefit from this engagement, and what they will be able to contribute to society. UGAs should speak to and demonstrate the transformative nature of higher education. This model engages students with knowledge on the basis of who they are and the complex or wicked problems before us. It moves higher education beyond being student-centred or knowledge-centred to focus on the relations between students and knowledge (Ashwin, 2020) and the communities and world they live in.

As the employment of the dialectical method to map out the UGAs to program specific GAs offers a lucid critique to each set of graduate attributes, it also brings to light the importance of the coexistence of the two sets, as each one of them contributes to a different aspect of higher education outcomes; the UGAs and program-specific GAs each ensure the graduates' competence at different skills, both as employable global citizens as well as professionals. The overlap in the mapping process also brings to light the possibility of reducing program-specific requirements to the aspects that do not map out to the general UGAs to avoid redundancy.

Conclusion and Recommendations

The mapping process carried out for this project was a timely and illuminating task. The constructive debate during the dialectical mapping process and result interpretation led to a synthesis of new ideas regarding graduate attributes, their measurement, their use, their integration, and their implementation in professional and general university programs, as well as in the larger university context. During the exercise, it became evident that a continual improvement process for the graduate attributes is essential to embed the attributes at the program and course level. This process should include further constructive debate among stakeholders regarding the characteristics of higher education graduates, the measurement of such characteristics, and the use of such measures as metrics for institutional funding determinants and employability criteria. If the graduate attributes are to be used as a means to set institutional goals for student development and achievement, the attributes should be reflective of the discipline and institutional identity of the graduates, and not solely of the employability characteristics or funding metrics. For professional programs like engineering, this may be reflected in the requirements for the practice of the profession. For more generalized degree programs this may be more challenging to elucidate but necessary to determine the appropriate set of graduate attributes reflective of student development requirements. Consideration should be given to professional identity of graduates and their intellectual development including cognitive, affective, social, and psychomotor development. The purpose of higher education should be reflected in the graduate attributes and their measurement and not merely be a measure of the institution's ability to produce graduates with the current employability characteristics or funder metrics. The study also highlighted the need for more revisions and updates of UGAs by including various stakeholders who can substantially contribute to the implementation and assessment of UGAs.

There are two further and important items for consideration: it would be of utmost importance for the validity of the mapping process to include instructor and student feedback. The success of the graduate attributes lies in the adoption of the vision of what attributes a program graduate should have by both the instructors and the students. Without a shared vision of the goals of the program and courses within the program implementation of the graduate attributes, their measurement, and their contribution to shaping student development, will be hollow. Second, the university central administration must have an active role in the mapping process to inform and ensure a concrete implementation of the UGAs in programs consistent with goals of the institution, as well as lead implementation buy-in. Unless these stakeholder groups are actively involved, any attempts to truly demonstrate student and institutional achievement of the UGAs will remain elusive.

Thus far, the implication of this study is the generic UGAs, which will not be sufficient to encompass all programs within a university institution, especially those of a professional nature and that require federal and/or provincial accreditations. In such situations, program administrators must first abide by the accrediting body requirements. A concern arises regarding an excessive program administrative burden with the implementation and assessment of several sets of graduating attributes that is inconsistent with the drive to reduce costs. This project concludes that all graduating attributes must be implemented within discipline-specific frameworks to ensure there is sufficient disciplinary knowledge, consistency, and limited redundancy, which serves to ensure the implementation of a meaningful continual improvement process.

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Notes

1 Parker et al. (2019) provide a comprehensive summary of the Canadian engineering graduate attribute literature from 2010 to 2017.

2 In this paper and to avoid confusion, we will refer to the general University Graduate Attributes as (UGAs), and we will refer to the Canadian Engineering Accreditation Board attributes as CEAB-GAs.

3 The International Engineering Alliance (IEA) is a non-profit organization that establishes and enforces international standards for engineering education to ensure quality and mobility.

4 Queen's University, the University of Calgary, UBC, the University of Toronto, Dalhousie, and the University of Guelph (Frank et al., 2011; Kaupp et al., 2012; Kaupp & Frank, 2016; Stiver et al., 2010; Stiver, 2011), Ryerson University (Easa, 2013; Salustri & Neumann, 2016; Shehata & Schwartz, 2015), Concordia University (Gopakumar et al., 2013; Hamou-Lhadj et al., 2015), the University of Manitoba (Seniuk-Cicek et al., 2014; Sepheri, 2013), the University of Alberta (Dew et al., 2013; ElAtia & Ipperciel, 2015a, 2015b; ElAtia et al., 2016; ElAtia et al., 2020; Ivey, 2017; Ivey et al., 2018; Parker et al., 2019; Watson et al., 2018), the University of Victoria (Gwyn, 2016, 2017; Gwyn & Gupta, 2015), and Memorial University (Spracklin-Reid & Fisher, 2012, 2014).

5 It is worth noting that other engineering schools manage more than one set of Graduate Attributes.

6 Engineering program and course design using the CEAB-GA competency-based performance criteria in a continual improvement feedback process utilizing a curriculum design process concept map (Hattie, 2009) and illustrating constructive alignment (Biggs, 1996). Diagram Jamieson (2016).

7 UGAs are widely supported by students and student unions within the university. The majority of the resistance to the integration of the UGAs comes from university professors.

8 UGA: Ethical Responsibility (ER); Scholarship (SC); Critical Thinking (CT); Communication (CM); Collaboration (CL); Creativity (CR); Confidence (CF); CEAB-GA: Knowledge base in engineering (KB); Problem analysis (PA); Investigation (IN); Design (DE); Use of Engineering tools (ET); Individual and team work (TW); Communication skills (CS); Professionalism (PR); Impact of engineering on society and environment (IS); Ethics and equity (EE); Economics and project management (EP); Lifelong learning (LL)

Appendix A

Table A

List of Canadian Engineering Accreditation Board graduate attribute definitions with acronyms – referred to in text at CEAB-GAs

Term	Definition
1. A knowledge base for engineering (KB)	Demonstrated competence in university level mathematics, natural sciences, engineering fundamentals, and specialized engineering knowledge appropriate to the program.
2. Problem analysis (PA)	An ability to use appropriate knowledge and skills to identify, formulate, analyze, and solve complex engineering problems in order to reach substantiated conclusions.
3. Investigation (IN)	An ability to conduct investigations of complex problems by methods that include appropriate experiments, analysis and interpretation of data, and synthesis of information in order to reach valid conclusions.
4. Design (DE)	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.
5. Use of engineering tools (ET)	An ability to create, select, apply, adapt, and extend appropriate techniques, resources, and modern engineering tools to a range of engineering activities, from simple to complex, with an understanding of the associated limitations.
6. Individual and team work (TW)	An ability to work effectively as a member and leader in teams, preferably in a multi-disciplinary setting.
7. Communication skills (CS)	An ability to communicate complex engineering concepts within the profession and with society at large. Such ability includes reading, writing, speaking and listening, and the ability to comprehend and write effective reports and design documentation, and to give and effectively respond to clear instructions.
8. Professionalism (PR)	An understanding of the roles and responsibilities of the professional engineer in society, especially the primary role of protection of the public interest.
9. Impact of engineering on society and the environment (IS)	An ability to analyze social and environmental aspects of engineering activities. Such ability includes an understanding of the interactions that engineering has with the economics, social, health, safety, legal, and cultural aspects of society, the uncertainties in the prediction of such interactions; and the concepts of sustainable design and development and environmental stewardship.
10. Ethics and equity (EE)	An ability to apply professional ethics, accountability, and equity.
11. Economics and project management (EP)	An ability to appropriately incorporate economics and business practices including project, risk, and change management into the practice of engineering and to understand their limitations.
12. Life-long learning (LL)	An ability to identify and to address their own educational needs in a changing world in ways sufficient to maintain their competence and to allow them to contribute to the advancement of knowledge.

APPENDIX B

Table B

List of Canadian Engineering Accreditation Board graduate attribute aspects and indicators as developed by the University of Alberta Faculty of Engineering implementation team in conjunction with each program. Mechanical Engineering is used as an example and discipline specific indicators are highlighted in grey.

1. A Knowledge Base for Engineering	
Aspect	Indicator
Mathematics	Completes a sequence of math courses involving calculus, differential equations and linear algebra
Mathematics	Self-assessment of knowledge base for mathematics
Chemistry	Completes a sequence of physical chemistry courses
Physics	Completes a sequence of foundational physics courses
Natural Sciences	Self-assessment of knowledge base for natural sciences
Engineering Fundamentals	Completes a sequence of foundational engineering courses
Engineering Fundamentals	Self-assessment of knowledge base for engineering fundamentals
Specialized Engineering Knowledge	Self-assessment of specialized engineering knowledge
Thermal Sciences	Applies the principles of thermodynamics to solve multicomponent power or refrigeration cycles
Solid Mechanics	Applies the concepts of strength of materials to analyze failure by: applied load; or by deflection; or due to instability
Fluid Mechanics	Apply the extended Bernoulli equation to a flow system that includes local and distributed losses or pumps/turbines
Mechanics	Apply the concepts of kinematics and dynamics to system of rigid bodies that form a mechanism
Dynamics and Control	Apply either root locus or Bode plots to design a lead/lag compensator
Bio Med	Apply the basic concepts of solid mechanics to soft or hard tissue

2. Problem Analysis	
Aspect	Indicator
Understand the Problem	Able to state the essential problem to address
Understand the Problem	Self-assessment of ability to understand the problem
Assemble Knowledge	Assembles the relevant models and formulae
Assemble Knowledge	Self-assessment of ability to assemble requisite knowledge to solve the problem

Apply Models	Applies the appropriate formulae or technique to generate a result
Apply Models	Self-assessment of ability to assemble requisite knowledge to solve the problem
Evaluate	Assesses the result for reasonableness and applicability to models used
Evaluate	Self-assessment of ability to solve the problem

3. Investigation	
Aspect	Indicator
Recognizes Unknowns	Identifies the unknown information or behavior to solve a problem
Measures Data	Employs appropriate techniques to collect data
Analyzes Data	Analyzes and interprets data
Analyzes Data	Assess data uncertainty and error
Reaches Conclusions	Reaches supported conclusions from the investigation and compares to model or theory
Self-Assessment	Self-assessment of ability to apply investigation

4. Design	
Aspect	Indicator
Requirements	Determines appropriate regulatory, legal, environmental, social, and ethical constraints and sensitivities
Requirements	Elicits and articulates project requirements from the client
Creativity	Synthesizes plausible solutions
Analysis	Analyzes performance of proposed solution
Iteration	Recognizes iterative process, refining solution until requirements met
Assessment	Assesses impact of solution against social and environmental factors as appropriate
Assessment	Assesses effectiveness of solution against customer's requirements, as well as impact on social and environmental factors
Self-Assessment	Self-assessment of ability to design

5. Use of Engineering Tools	
Aspect	Indicator
Computation	Uses computer programming to solve engineering problems

System Description	Uses Computer Aided Design (CAD) software to define complex structural systems
System Modeling	Uses finite numerical methods to numerically solve engineering problems
Analysis	Applies software to analyze thermos-fluids or lumped parameter dynamic models
Measurement	Understanding of base measurement tools including one of: pressure, temperature, length, strain, current and voltage
Self-Assessment	Self-assessment of ability to use engineering tools

6. Individual and Team Work	
Aspect	Indicator
Time Management	Completes essential tasks on time with an appropriate amount of effort
Team work - Roles	Understands and performs assigned role
Team work - Responsible	Meets expected responsibilities and tasks
Team work - Participates	Actively contributes to team discussion and planning
Team work - Respect	Respects contributions of other team members
Team work - Member	Self-assessment as team member
Team work - Leader	Self-assessment as leader

7. Communication Skills	
Aspect	Indicator
Organized Message	Presents information in an organized fashion
Writing	Uses proper grammar and punctuation
Writing	Uses language effectively
Reading	Comprehends written document
Speaking	Prepares and delivers an effective oral presentation
Use of Graphics	Makes effective use of graphical elements to support message
Self-Assessment	Self-assessment of ability to communicate complex engineering concepts

8. Professionalism	
Aspect	**Indicator**
Legal Responsibilities	Understands responsibilities and consequences set out under EGGP Act and OHS legislation
Licensure Requirements	Understands requirements for licensure in province, across Canada and in USA
Safety	Understands concepts of safety and risk management
Self-Assessment	Self-assessment of professionalism

9. Impact of Engineering on Society and Environment	
Aspect	**Indicator**
Awareness of the Impacts of Technology on Society	Completes ITS Elective
Impact Assessment	Analyzes environmental impact of proposed engineering project
Impact Assessment	Understands concepts of environmental impact in an engineering context
Sustainable Design	Understands concept of sustainability in engineering context
Sustainable Design	Designs to meet sustainability criteria
Self-Assessment	Self-assessment of awareness of impact of engineering on society and the environment

10. Ethics and Equity	
Aspect	**Indicator**
Awareness of Ethical Issues	Feels confident in ability to address ethical dilemmas
Code of Ethics	Identifies provisions of the APEGA Code of Ethics
Makes Ethical Choices	Makes ethical choices in complex situations
Awareness of Equity Issues	Identifies situations containing equity issues
Awareness of Equity Issues	Is aware of provisions within the Alberta Human Rights, Citizenship and Multiculturalism Act
Awareness of Equity Issues	Feels confident in ability to address equity

11. Economics and Project Management	
Aspect	**Indicator**
Engineering Economics	Completes Engineering Economics required course

Engineering Economics	Self-assessment of ability to incorporate engineering economics into engineering practice
Economic Assessment	Includes economic analysis within design project
Project Management	Prepares and follows a project management process
Project Management	Feels competent to manage a project

12. Life-Long Learning	
Aspect	Indicator
Curious	Demonstrates an interest in sustaining learning
Able to Assess Needs	Develops a research plan identifying information needed
Resourceful	Identifies and accesses appropriate sources of knowledge/ training
Discriminating	Evaluates information sources critically for accuracy and relevancy
Self-Assessment	Self-assessment of ability to address learning needs

Table C

Example of engineering graduate attribute mapping table

CEAB-GA #10: Ethics and Equity		
Faculty of Engineering		**University**
Sub-attribute	**Indicator**	**Sub-attribute *(Can-do statement)***
Awareness of Ethical Issues	Feels confident in ability to address ethical dilemmas	1a. Global citizenship *(Can consider issues from a global perspective)* 1b. Community engagement (*Can consider issues from the perspective of their impact on the community)* 1c. Social and environmental awareness (*Can adopt the perspective of the public good and take into consideration our embeddedness within society and nature)* 1d. Professionalism *(Is willing to meet the level of expertise and deontological expectations of her intended profession)*
Code of Ethics	Identifies provisions of the APEGA Code of Ethics	1d. Professionalism *(Is willing to meet the level of expertise and deontological expectations of her intended profession)*
Makes Ethical Choices	Makes ethical choices in complex situations	1a. Global citizenship *(Can consider issues from a global perspective)* 1b. Community engagement *(Can consider issues from the perspective of their impact on the community)* 1c. Social and environmental awareness *(Can adopt the perspective of the public good and take into consideration our embeddedness within society and nature)* 1d. Professionalism *(Is willing to meet the level of expertise and deontological expectations of her intended profession)*

CEAB-GA #10: Ethics and Equity		
Faculty of Engineering		**University**
Sub-attribute	**Indicator**	**Sub-attribute *(Can-do statement)***
Awareness of Equity Issues	Identifies situations containing equity issues	5a. Openness to diversity *(Can engage with a diversity of people [in terms of race, religion, cultures, classes, sex orientation and appearance])*
Awareness of Equity Issues	Is aware of provisions within the Alberta Human Rights, Citizenship and Multiculturalism Act	5a. Openness to diversity *(Can engage with a diversity of people [in terms of race, religion, cultures, classes, sex orientation and appearance])*
Awareness of Equity Issues	Feels confident in ability to address equity	5a. Openness to diversity *(Can engage with a diversity of people [in terms of race, religion, cultures, classes, sex orientation and appearance])*