CEAB's Graduate Attributes and Ontario's UUDLEs

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Abstract

In 2009, the Province of Ontario mandated University Undergraduate Degree Level Expectations (UUDLEs). The Canadian Engineering Accreditation Board (CEAB) began reviewing and assessing progress towards twelve graduate attributes in 2010. UUDLEs and Graduate Attributes are both a learning outcomes perspective on education. Unfortunately, the vocabulary of these two learning outcome requirements is not identical. This presentation will take a look at the intersection and the differences between the two requirements. Recognizing and understanding the differences is essential for Ontario engineering schools to maximize the educational benefits associated with these two new requirements.

1 Introduction

Learning Outcomes or Graduate Attributes are increasingly becoming the norm in higher education. They are changing the educational paradigm. Kuh identifies two primary reasons for learning outcomes: one is driven by accountability (and accreditation) like concerns and two is to advance teaching and learning [1]. The Washington Accord [2] for engineering and the Province of Ontario's University Undergraduate Degree Level Expectations [3] also identify international standards and international mobility has important drivers for learning outcomes approach.

ABET, Inc. introduced Engineering Criteria 2000 (EC2000) in 1997 [4]. The Washington Accord added learning outcomes in 2005 [2]. The Canadian Engineering Accreditation Board began reviewing graduate attributes in 2010 [5].

In 2009, the Ontario Universities Council on Quality Assurance introduced the University

Undergraduate Degree Level Expectations (UUDLEs). These expectations are for all bachelor degrees in the province including engineering. The goal is to provide accountability and to encourage continual improvement.

The objective of this paper is to provide a first pass comparison of the UUDLEs expectations and the CEAB requirements. It is recognized that the paper presents a single author's perspective and interpretation and as a result it has limitations. It is expected that the results will be valuable to all Ontario engineering schools as they develop approaches and systems to simultaneously satisfy both domains. It is hoped that non-Ontario schools also benefit as there are some valuable elements within the UUDLEs system and it is likely that many other provinces may be facing provincial expectations now or in the immediate future.

In terms of formatting the paper, it was assumed that all of the CEAB Graduate Attributes (CEAB GA's) are a given for all engineering schools in Canada and that each school has initiated work in this direction. Thus, the comparison with UUDLEs is to look at what is UUDLEs expected but not already required by CEAB. These are the elements that warrant additional attention and that engineering schools can learn from.

2 Province of Ontario UUDLEs not in CEAB's Graduate Attributes

In this section each of the Province of Ontario's University Undergraduate Degree Level Expectations (UUDLEs) is provided. The UUDLEs are provided in a separate font (indented, italics) to distinguish them from the main text and are all taken directly from the Ontario Universities Quality Assurance Framework [3]. Each UUDLE is followed by a discussion of that UUDLEs direct or implied inclusion in the Canadian Engineering Accreditation Board's Graduate

Attributes (CEAB GA's). A bold font is used whenever specific words from the CEAB GA's are referenced with the number for that GA provided in round brackets.

2.1 Depth and breadth of knowledge

Developed knowledge and critical understanding of the key concepts, methodologies, current advances, theoretical approaches and assumptions in a discipline overall, as well as in a specialized area of a discipline

This UUDLE is fairly comprehensive in terms of knowledge and understanding learning outcome level. A **knowledge base for engineering** (3.1.1) would match this UUDLE.

Words that aren't directly reflected are "current advances" and "assumptions". It is certainly expected or implied within the CEAB GA's that the **knowledge base for engineering** (3.1.1) would be inclusive of current advances.

"Assumptions" permeate the practice of engineering. However, CEAB GA's do not explicitly refer to assumptions and most engineering educators recognize that developing a student's comfort with assumptions is not as easy step. It is probably valuable for engineering schools to consider and understand where and how that skill is developed.

The UUDLEs make explicit reference to discipline and specialized area of a discipline. Discipline overall is interpreted by this author to mean ENGINEERING and specialized area to mean ADJECTIVE ENGINEERING (e.g. Chemical, Mechanical etc.). CEAB GA's have a parallel structure a **knowledge base for engineering** (3.1.1) equally refers to **engineering fundamentals** (within 3.1.1) and to **specialized engineering knowledge appropriate to the program** (within 3.1.1). Both learning outcomes reinforce that there is a knowledge base that is common to ALL engineers that distinguishes engineering from other disciplines.

Developed understanding of many of the major fields in a discipline, including, where appropriate, from an interdisciplinary perspective, and how the fields may intersect with fields in related disciplines

The understanding of disciplines is not an explicit item within CEAB GA's. However, **individual and team work** (3.1.6) is a requirement and **preferably in a multi-disciplinary setting**. To work in teams with

individuals from varying fields in the discipline does require some understanding of each field. Equally, to work in a team involving individuals from multiple disciplines requires an understanding of how engineering, business, science, social science and other disciplines interface to advance society.

Developed ability to: i) gather, review, evaluate and interpret information; and ii) compare the merits of alternate hypotheses or creative options, relevant to one or more of the major fields in a discipline

Investigation (3.1.3) and **design** (3.1.4) would both be CEAB GA's that address this UUDLE. **Investigation** would address *the merits of alternate hypotheses* and **design** would address *the merits of creative options*.

The CEAB GA's would not directly address the "or more" part of the *one or more of the major fields in a discipline*.

Developed, detailed knowledge of and experience in research in an area of the discipline

Research defined within the limits of the advancement of knowledge and/or understanding within the field is not within the CEAB GA's. **Investigation** (3.1.3) within engineering attributes leads to learning for the student but it is not expected at the undergraduate level to lead to advancements within the discipline.

Life-long learning (3.1.12) does include **to allow them to contribute to the advancement of knowledge**. This is future looking as compared to the UUDLE that requires experience within the undergraduate degree.

Research interpreted more broadly as Research & Development is covered by **Design** (3.1.4). This design would need to be creative or innovative for many to believe that it fits within the R&D envelope.

Developed critical thinking and analytical skills inside and outside the discipline

Critical thinking is a widely used descriptor within university education. It is a broad descriptor that for many captures what a university education should be all about. The words critical thinking are not in the CEAB GA's. Where does critical thinking develop in an engineering program? Where does an engineer develop non-engineering critical thinking skills?

Ability to apply learning from one or more areas outside the discipline

Engineering is inherently an integrating discipline. Applying learning from *areas outside the discipline* is required in a **knowledge base for engineering** (3.1.1) which brings mathematics and science to **problem analysis** (3.1.2), **investigation** (3.1.3) and **design** (3.1.4). Social science learning is required in **impact of engineering on society and the environment** (3.1.9). Business and economics disciplines are required in **economics and project management** (3.1.11).

2.2 Knowledge of Methodologies

An understanding of methods of enquiry or creative activity, or both, in their primary area of study that enables the student to:

- *evaluate the appropriateness of different approaches to solving problems using well established ideas and techniques;*
- *devise and sustain arguments or solve problems using these methods*
- *describe and comment upon particular aspects of current research or equivalent advanced scholarship*

Methods of enquiry are embedded in the investigation process that is part of the CEAB GA on **investigation** (3.1.3). Methods associated with *creativity activity* are embedded in the design process within the **design** (3.1.4) attribute.

The CEAB GA's do not directly require a graduate to *describe and comment upon particular aspects of current research or equivalent advanced scholarship*. Engineering students are not explicitly required to have the ability to effectively critique the latest designs. Potentially the **impact of engineering on society and the environment** (3.1.9) attributes requires this skill but even this is narrower than the spirit of this UUDLE.

2.3 Application of knowledge

The ability to review, present and critically evaluate qualitative and quantitative information to:

- *develop lines of argument*
- *make sound judgments in accordance with the major theories, concepts and methods of the subject(s) of study;*

- *apply underlying concepts, principles, and techniques of analysis, both within and outside the discipline*
- *where appropriate use this knowledge in the creative process*

The application of knowledge is embedded through **problem analysis** (3.1.2), **investigation** (3.1.3) and **design** (3.1.4) within the CEAB GA's.

The ability to use a range of established techniques to:

- *initiate and undertake critical evaluation of arguments, assumptions, abstract concepts and information*
- *propose solutions*
- *frame appropriate questions for the purpose of solving a problem*
- *solve a problem or create a new work*
- *to make critical use of scholarly reviews and primary sources*

Again this is embedded in **problem analysis** (3.1.2), **investigation** (3.1.3) and **design** (3.1.4). The established techniques would include general investigation process and the engineering design process.

The use of *scholarly reviews and primary sources* is not explicitly identified with the CEAB GA's.

2.4 Communication

The ability to communicate information, arguments, and analyses accurately and reliably, orally and in writing to a range of audiences

CEAB GA's captures the UUDLEs communication outcome and more.

2.5 Awareness of Limits of Knowledge

An understanding of the limits to their own knowledge and ability, and an appreciation of the uncertainty, ambiguity and limits to knowledge and how this might influence analyses and interpretations

Engineering tools (3.1.5) expects **an understanding of the associated limitations**. The **impact of engineering on society and the environment** (3.1.9) directly requires an understanding of **the uncertainties in the prediction of such interactions**.

Economics and project management (3.1.11) explicitly requires the graduate **to understand their limitations**.

The UUDLE is broader in intent than these specific CEAB GA's. The UUDLE is not limited to specific areas of knowledge, skills and values. The UUDLE also brings the limitations to the personal capable of the individual. An engineering tool may be widely accepted as appropriate for a particular design but that is not sufficient to ensure that any student can use the tool well. Due diligence is an analogous dimension that is widely recognized as an expectation of an engineer but due diligence is not overtly identified as a CEAB GA. Some might take this as a given and some might assume that **Professionalism** (3.1.8) covers this expectation. An important element of a learning outcomes approach is an attempt to be explicit in the desired attributes. Greater attention to limitations and to due diligence would likely be of value.

2.6 Autonomy and professional capacity

Qualities and transferable skills necessary for further study, employment, community involvement and other activities requiring:

- *the exercise of initiative, personal responsibility and accountability in both personal and group contexts*

Individual and team work (3.1.6), **Professionalism** (3.1.8) and **Ethics and Equity** (3.1.10) each speak in different ways to the *personal responsibility and accountability in both personal and group contexts*.

The *exercise of initiative* is not directly evident in any of the CEAB GA's.

- *working effectively with others*

Individual and team work (3.1.6) cover this UUDLE.

- *decision-making in complex contexts*

Problem solving (3.1.2), **investigation** (3.1.3), **design** (3.1.4) and **engineering tools** (3.1.5) all require the ability to deal with complex contexts.

- *the ability to manage their own learning in changing circumstances, both within and outside the discipline and to select an appropriate program of further study*

Life-long learning (3.1.12) matches this UUDLE quite effectively.

- *behaviour consistent with academic integrity and social responsibility*

Professionalism (3.1.8) and **impact of engineering on society and the environment** (3.1.9) require the ability or skill in this regard. *Behaviour* takes the UUDLEs level up a notch from that identified within the CEAB GA's.

3 Discussion

The majority of the Province of Ontario's UUDLEs are covered through the requirements of the CEAB GA's. This is particularly true with a modest amount of flexibility in the interpretation of the terminology used. The interpretation is that of the author and the author recognizes that other interpretations could be equally credible. A more liberal interpretation could increase the match and a more rigid interpretation would lead to greater gaps.

This section will discuss the gaps and issues that may exist and will offer suggestions for schools to consider in moving forward with their CEAB GA efforts.

3.1 Gaps and Issues

There are a few areas in which the vend diagram of the two systems do not match.

UUDLEs expect engineers to be critical thinkers within the engineering and outside of the engineering. Engineering educators would agree with this expectation. Where does this develop within the CEAB GA's? Critical thinking should be an explicit attribute for all engineering graduates.

UUDLEs expect that all engineers will graduate with an understanding of major fields within engineering. CEAB GA's do not require this understanding. Chemical Engineers are certainly expected to have engineering mechanics as part of their engineering fundamentals but this course does not lend itself to ensuring that Chemical Engineers understand the field that is Civil Engineering. UUDLEs expect that all engineers will graduate with an understanding of non-engineering disciplines (science, mathematics, humanities, social science, business, law, medicine) and broadly the methods in these disciplines. Engineering's role in society, our frequent participation in teams across engineering

fields and teams beyond engineering means that this UUDLE would be appropriate for explicit attention in our curriculum.

UUDLEs have **Awareness of Limits of Knowledge** as one of its six expectation areas. It is quite prominent as a result. Limitations, assumptions, due diligence are inherent factors in an engineer's professional obligations. However, within CEAB GA's these factors do not have the profile that one might expect. The profile that is present does not imply that these factors transcend all of what engineers do. The CEAB GA's also do not explicitly require the graduate to understand their personal limits. All Canadian engineering schools should overtly identify this factor as a graduate outcome.

UUDLEs expect research knowledge and experience. For some, research is limited to the advancement of knowledge for the field. If this interpretation holds then there is a significant gap between UUDLEs and CEAB GA's in this regard. However, if research is more broadly interpreted as Research and Development or Research, Design & Development then the gap can disappear. The gap disappears provided our students engage in innovative design work to develop new products, processes or systems. Routine cookbook design would not be sufficient in this context. It will be important for the Ontario schools that are the first to interact with the Province's Council on Quality Assurance to establish that research needs to be broadly interpreted.

Finally, the vocabulary within the Ontario UUDLEs is heavily knowledge and understanding which are both at the lower levels of learning taxonomies. Under some knowledge expectations there are higher learning levels identified but this combination is awkward. It is likely that the UUDLEs and CEAB GA's will evolve and definitions will become normalized. In this evolution additional gaps are likely to surface. One example of this is the use of "behaviour" within the *Autonomy and Professional Capacity* UUDLE. *Behaviour* would be aligned with a values learning level and a higher level than required under the CEAB GA's (**Professionalism**).

3.2 Moving Forward

The intersection between Ontario's UUDLEs and CEAB GA's is considerable. However, the translation from one system to the other is not a single valued relationship. Many UUDLEs connect to several GA's. Thus, if each Ontario engineering school sets up a system for the CEAB GA's this system may not easily generate evidence associated for the UUDLEs.

This aspect may be illustrated through the *Application of Knowledge* UUDLE. It is addressed within **problem solving, investigation and design** but not all student design work would require *sound judgement based on major theories*. The use of student's design work to address this UUDLE would be insufficient. A gap would be evident from an UUDLEs' perspective.

Simultaneous consideration of UUDLEs and CEAB GA's is encouraged. It will ensure that as definition is developed for the graduate attributes that this definition will be overtly inclusive of the UUDLE requirements. It is necessary to ensure what has been implied, assumed or interpreted becomes explicit. It will also ensure that the systems developed are capable of responding to and demonstrating both CEAB graduate attributes and Ontario UUDLEs. Ontario and non-Ontario schools should develop systems that are flexible, can easily evolve as the quality of our education progresses and can handle learning outcomes driven by more than one internal or external entity.

This comparison is a first pass and has been largely limited to consistency in learning outcome areas between UUDLEs and CEAB GA's. Once greater definition has been developed around the performance level expected or required under each outcome there will likely be further gaps between the two systems.

The transformation to a learning outcomes paradigm will require ongoing effort to ensure that the intended outcomes are the correct. Ongoing dialogue associated with how we define and interpret these outcomes is essential.

References

- [1] Khu G.D., Ewell P.T. "The State of Learning Outcomes Assessment in the United States", *Higher Education Management and Policy*, 22(1):9-28, 2010
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