GRADUATE ATTRIBUTE ASSESSMENT PRACTICE IN CANADIAN ENGINEERING PROGRAMS (2010-2017)

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Abstract — This paper explores graduate attribute assessment across Canadian engineering programs. Research papers from the 2010-2017 CEEA conferences were reviewed to gather a snapshot of how graduate attributes are assessed in the classroom. The purpose of the review is to begin the process of identifying gaps in GA assessment. The analysis is based on a framework by Wiggins and McTighe in Understanding by Design. A discrepancy in diagnostic, formative and summative assessment was found.

Keywords: Graduate attributes, assessment, evaluation.

1. INTRODUCTION

Graduate attributes (GAs) were identified by the Canadian Engineering Accreditation Board (CEAB) in 2009, and were included in the accreditation process beginning in 2014. Most, if not all, Canadian engineering programs have gone through an accreditation cycle that has included GAs.


These attributes are diverse, require a wide range of skills, and challenge faculty and instructors to develop new ways of teaching and assessing engineering students. Many of the graduate attributes depend on each other and rely on qualitative assessment which adds to the challenge [1]. While the graduate attributes are frequently discussed at the CEEA conference, there has not yet been a comprehensive review looking at how they are being assessed across Canada. Assessment plays a critical role in student motivation and learning [2], and the discussion is very important.

“The advancement of engineering education in many ways depends on assessment. High quality assessments can provide educators with information they can use to move the field forward. Inadequate or poorly constructed assessments can cause educators to pursue ineffective paths, resulting in the loss of time, money, and energy.” [3, p. 13]

This paper provides brief background information on assessment, followed by an introductory exploration of how the graduate attributes are being assessed in Canadian engineering schools.

2. ASSESSMENT

2.1. Framework

There are different ways to view assessment, however, good assessment should both improve student learning, and improve curriculum and programs [4].

The framework chosen for this analysis comes from Understanding by Design written by Grant Wiggins and Jay McTighe, which is a thorough investigation of how to design curriculum, assessment, and instruction to foster student understanding [5].

We are interested in how the graduate attribute requirement translates into classroom assessment practice, and Wiggins and McTighe provide a clear framework. First, it focuses on “what the student should be able to know, do, and understand upon leaving, expressed in performance and product terms [5, p.6]” which corresponds directly to the graduate attributes. Second, this framework presents curriculum development as a design process, and turns education pedagogy into something that engineering faculty can relate to. According to Wiggins and McTighe, there are three stages to designing curriculum, assessment, and instruction, which they call “backward design” [5]:

Step 1 Identify results: Identify what students should know, understand, and be able to do. Specify what content is worthy of understanding.

Step 2 Determine acceptable evidence: Identify how instructors will know if students have achieved the desired
result. Determine what evidence of student understanding and proficiency is required.

**Step 3 Plan learning experience:** Determine the most appropriate instructional activities. Identify knowledge (facts, concepts, principles) and skills (processes, procedures, strategies) students will need in order to perform effectively and achieve desired results. Select activities that will equip students with the needed knowledge and skills.

**2.2. Evidence, assessment, and evaluation**

This paper focuses on the second step of the above design process: determining acceptable evidence. This evidence is gathered through assessment.

Assessment is the deliberate use of multiple methods to analyze student accomplishment. It is process focused, provides feedback to enable improvement, focuses on learning, and not all aspects need to be graded [5]. “Assessments vary in scope (simple to complex), time frame (short-term to long-term), setting (decontextualized to authentic), and structure (directive to unstructured) [5, p.152].” Assessment should be thought of as collection of evidence gathered over time. Note, that evaluation is not synonymous to assessment. Evaluation is summative, credential related, and graded. Evaluation is only one part of student assessment.

Assessment can be broken down into three categories:

- **Diagnostic assessment:** Diagnostic assessment is extremely important, as it provides information on where students currently are.
- **Formative assessment:** Widely understood to be an essential part of learning, “Formative assessment […] is to be interpreted as encompassing all those activities undertaken by teachers, and/or by their students, which provide information to be used as feedback to modify the teaching and learning activities in which they are engaged [6, p. 7-8].” In formative assessment, students receive feedback on their progress, and their progress informs what is done in the classroom.
- **Summative assessment:** Summative assessment is used to provide grades and evaluate what students have learned.

**3. RESEARCH QUESTION**

Based on the framework above, how are Canadian engineering students assessed on the CEAB graduate attributes in the classroom?

**4. METHODOLOGY**

The Canadian Engineering Education Conference is a practice oriented conference, and is a great resource for what is currently happening in Canadian engineering classrooms. Therefore the data for this research comes from the CEEA conference proceedings (2010-2017) [7].

Using the online database, a search for “graduate attributes” returned 210 results. These papers were categorized manually in two stages. The first stage categorized the papers based on the orientation of the paper: program level assessment, learning opportunities and classroom assessment. These categories are further explained in Section V. The second stage categorized the assessment papers into diagnostic, formative and summative assessment, as described in Section II.

This categorization was done manually and did involve personal judgement. While this analysis does provide a snapshot at assessment methods most frequently discussed at the CEEA conference, it is not a comprehensive review.

**5. RESULTS AND DISCUSSION**

A total of 210 papers were returned from the initial search. Several papers that did not relate were removed and 197 papers were categorized. Figure 2 shows the frequency of each graduate attribute within these papers. About half (101/197) of all papers refer to the graduate attributes in a general way (e.g. no distinction between attributes).
It is interesting to look at the discrepancy in frequency of each GA in the proceedings. It is not surprising that knowledge base is lowest, as it is frequently discussed outside of the context of graduate attributes. However, for a profession that prides itself heavily on ethics and equity, it seems to be addressed very little. With rapidly changing advances in technology, the ethical landscape of engineering is changing, and should be at the forefront of discussion.

If we look at the attributes that are most frequently addressed, it raises some questions. Are these being addressed because of convenience (e.g. if students are already doing teamwork, it is relatively easy to add peer assessment) or because they are more highly valued? This leads into the more general discussion of which graduate attributes are most important, or if they are all equally important.

In order to narrow down the papers into those referring to assessment, papers were classified into “program” oriented, “learning” oriented, and “assessment” oriented. Results are shown in Figure 3. Note that one paper could fall into more than one category.

- **Program orientation**: These papers are looking at the graduate attributes from the program perspective, for example mapping graduate attributes to indicators and learning outcomes, or training faculty. While this process relates to assessment, it is not addressed in this paper.
- **Learning orientation**: These papers are describing both curricular and co-curricular opportunities for students to develop graduate attributes. For example, interdisciplinary capstone projects, entrepreneurship modules, and service learning opportunities. While these papers may discuss student engagement, they do not necessarily discuss the collection of evidence of student learning or understanding.
- **Classroom orientation**: These papers describe specific classroom assessment techniques, as discussed in Section II.

Overall, there seems to be a relatively even distribution of papers discussing graduate attributes from the three orientations. If you look at the annual progression (figure 4), the group with the most growth overall appears to be assessment.
Fig. 4. CEEA archive papers classified by orientation and year

All assessment oriented papers were further classified into the type of assessment, and results are shown in Figure 5.

Engineering programs clearly, and not surprisingly, lean towards summative assessment. With 33% of papers discussing formative assessment, there is some discussion in that area, however, at 13%, there is a severe lack of diagnostic assessment being discussed at the conference.

Figure 6 further categorizes which types of assessment are used for each attribute. The results are not significantly different than the overall breakdown.

GA7 to GA12 are often addressed together, however the most frequent combination is impact on society, professionalism, and ethics and equity. Between GA1 and GA6, the most common combination was problem analysis and design.
5.1. Assessment instruments:

We will use the term “assessment instruments” to distinguish the assessment process from assessment tools. Tests, reports, presentations, etc. are instruments that people use to make assessments. Furthermore, the validity of an assessment tool refers to the interpretations and use of it, rather than the tool itself [8].

Various instruments are used to collect evidence within each type of assessment. For example, a self-assessment can be used for diagnostic assessment at the beginning of a course. If it is used together with reflections and feedback it can also be used for formative assessment, and finally it can be used for summative assessment at the end of a course.

Below is a list of assessment instruments that were shared in the conference proceedings. The instruments are grouped by which type of assessment they were used for in the proceedings. Note that it is the way these instruments are used that determines the type of assessment, more than the tool itself, and therefore it is difficult to compare assessment instruments directly [4].

Diagnostic assessment instruments: Self-tests, self-assessments, team quizzes, pre-assessments, surveys, and team quizzes.

Formative assessment instruments: Peer feedback, TA Training to increase feedback to students, Expert/follower labs, CATME, IF-AT cards, reflections, personal guidance from industry, learn-act-reflect cycles, 360 degree reviews, ITP metrics, formative assessment of term papers, journaling, formative feedback for communication, increased dialogue training, guided group meetings, seminar time with instructor feedback, colour coded portfolios, portfolios with reflections, observations, interviews, and focus groups.

Summative assessment instruments: Assignments, quizzes, exams, reports, coded multiple choice exams, self-assessments, design deliverables, proposals, presentations, lifelong learning plans, reflections, surveys, colour coded portfolios, 360 degree reviews, journaling, portfolios, co-op surveys, and concept inventories.

It is very easy to assume that summative assessment is somehow better than other types of assessment because it is quantifiable and replicable. While quantitative results provide generalizations that are familiar and can be statistically analyzed, qualitative results provide more detailed descriptions that account for human perceptions and motivations. Perceptions that qualitative data is less rigorous often comes from a misunderstanding of the process [9].

If there is too much evidence on only one or two types of assessment evidence, there is a risk of developing a bias in your overall student assessment. For example, if the only evidence comes from exams, students who have stronger exams skills, lower test anxiety, or who practiced enough problems until the pattern emerged, have a continuous advantage. However, if students also respond to oral questions in a more casual classroom environment, this could counter that bias and help students who might know the material well, but are less skilled at exam writing. If students then also created exam questions as an exercise,
even more information about what that student understands would emerge. Not only do these assessment techniques better reflect the graduate attributes, if this extra information is collected periodically throughout the term, adjustments can be made to tailor the course direction to student abilities. This process is extremely valuable to student learning.

6. CONCLUSIONS

Classroom assessment of graduate attributes is a critical component of the graduate attribute discussion. Part of this discussion is expanding the understanding of what assessment really means. Engineering has a very strong culture of summative assessment, but these methods may not be appropriate for all graduate attributes. It is critical that assessment for student learning is continuously improved to ensure engineering students develop the skills they need for an increasingly changing world.

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References


