Development of the Graduate Attribute Quality Assurance Process at the University of Toronto

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Abstract

This paper will describe the process that the University of Toronto is following in response to the Graduate Attributes recently introduced by CEAB. The Faculty of Applied Science and Engineering at the University of Toronto is using small teams to develop concise lists of global objectives and indicators for each attribute. This paper discusses the work done to date, including the indicators we have developed for the attributes. We will discuss the challenges we have encountered, and how we are meeting those challenges; and the positive collaborations and discussions that have resulted.

1 Background

The Faculty of Applied Science and Engineering at the University of Toronto is one of the largest faculties of engineering in Canada. It has approximately 4500 undergraduate students and 9 engineering programs. All of the programs are currently accredited and the next accreditation visit to our Faculty will be in 2012. The programs have independent curricula from year 1. The curriculum in each program is controlled by a curriculum committee which monitors the curriculum and proposes changes. The changes are considered, and generally approved, by a Faculty level curriculum committee. In most of the programs the curriculum is monitored according to content rather than outcomes.

We are now in the process of responding to the requirement from the CEAB (Canadian Engineering Accreditation Board) for the development of a continuous curriculum improvement process (CCIP) [1]. This requires us to consider the learning outcomes achieved by our graduating students, and in general to monitor our curricula at all levels based on learning outcomes. While some of our programs have been actively involved in curriculum mapping for some time (notably Engineering Science), for most of our programs this is a new way of understanding their program. At the University of Toronto we do not use

CDIO [2] explicitly or other frameworks that have “built in” outcomes. So we are effectively starting from scratch in this process. This was taken into account in our decisions about how to approach the development of a CCIP.

2 Format

We decided to use a Faculty level committee to begin the process of developing a CCIP. This group is called the Graduate Attributes Committee (GAC) and has representation from all of the programs. Some schools have started with a full curriculum mapping process; what could be termed a “bottom up” process. We decided instead to use a “top down” process for several reasons. First, to build capacity in outcomes development and assessment. Our faculty are not required to have stated outcomes for their courses so most of them are not familiar with development of learning objectives. By coaching a group of people through the process at the Faculty level, they can then serve as coaches within their departments. In a large diverse Faculty it was important to create this type of network. We do not expect every one of our faculty to become experts in developing learning objectives, but we do need to build some capacity within each department. Second, this allows us to develop a set of common indicators that pertain to every program. We felt that it was important to have commonality to a large degree across the Faculty. Shaping the indicators, and having them common, allows us to define what it means to be a “UofT engineering graduate”. Also, the GAC is made up largely of people who are on the Faculty Undergraduate Curriculum Committee or who have been involved with curriculum development before. They are generally well informed about the curricula across the Faculty and can provide a broad systems perspective on the development of the CCIP for our programs. We also found that using a Faculty level committee not only helped us develop commonality in our indicators, but also helped us develop a common process. This development process can now be

implemented at the departmental level. And the discussions we have had at the Faculty level will inform the work done at the departmental level.

Our Graduate Attributes Committee makes use of expert subcommittees to develop indicators for each of the attributes. For example, we asked our Engineering Communication Program (ECP) faculty to develop the indicators for attribute 3.1.7 Communication. And we had a group of our design instructors develop the indicators for attribute 3.1.4 Design. These expert groups brought their suggested indicators back to the GAC for review. Typically it required at least two passes through the GAC in order to converge on a clear, essential set of indicators for each attribute. To date we have developed a preliminary set of indicators for 7 out of the 12 attributes (see tables in Appendix A). We expect to have a complete set of indicators finished by December 2011.

In working through this process we found that it was difficult to move directly from the attributes as given by CEAB which are very general (or global) to indicators, which are clear, demonstrable outcomes. So to help us organize and structure the activity we developed a small set of global objectives for each attribute (see Tables 1 through 7). These global objectives assist us in creating a shared definition of the attribute. They provide our working group, and departments, with a more clear understanding of how we are interpreting or defining each attribute. Then our indicators for each attribute are organized within this structure. The set of indicators provides us with a set of specific abilities that comprise a component of the attribute.

This structure produces more indicators than we would typically want to measure for any one attribute. We would not expect any one program to collect data on all of these indicators. Instead, each program would select a subset of the indicators that they will use to measure competency in the attribute. Presumably the indicators chosen by a program would span the global objectives so that the data collected would give a broad picture of the student cohort outcomes.

To date we have developed indicators for 7 of the indicators and we have 3 more in progress. The work to date has been very informative. By discussing the attributes, our Faculty committee has been able to identify what we expect from our graduates across all programs. This has led to some very intense discussion, and reflection about what we are teaching, and what we need to be teaching. We have also found that there are substantial overlaps between our indicators (many indicators could be placed in two or more attribute categories). We are now in the process of mapping these connections to evaluate whether we

can harmonize our indicators; i.e. remove overlap (indicators with similar intent but different wording) and create instead indicators that pertain to two or more attributes.

3 Next steps

In order to collect data on the indicators we are now mapping our indicators to our assessment tools. This mapping involves looking at assessment rubrics we are already using in several of our capstone courses and identifying connections between the criteria on the rubrics and the indicators we have developed. One example is our fourth year thesis course in Engineering Science, ESC499. The rubric used for the final project in this course was mapped to the indicators for Investigation and Communication. We are currently collecting data using this rubric. We will be looking at the data we collect this semester from this rubric to see if we can reasonably draw conclusions from this assessment tool about our students' abilities in these two attributes. We are collecting similar data in several other capstone courses as well. By June 2011 we should have some results that will indicate how we might want to evolve our indicators, assessment tools and data collection to create a strong quality assurance process.

We have already identified several issues with the assessment tools we currently use. First, some of the rubrics do not have enough information about the levels (e.g. below expectations, meets expectations, etc.) to allow for clear assessment of the indicators. Second, some of the indicators do not map well to the assessment tools we are currently using so we need to consider whether to change the indicator or the assessment tool. And third, the attributes we are currently piloting (Communication, and Investigation) are very clearly ones that we already explicitly assess. However, we have already identified that we do not currently assess teamwork explicitly in upper years in most programs (it is explicitly assessed in first year). To assess teamwork as a graduate attribute will require changes to our current assessment system and possibly our curriculum.

4 Future work and conclusions

We have now moved from the Faculty level phase of this project to the phase that will be driven more strongly at the departmental level. The two remaining attributes that need to be developed are Knowledge Base and Engineering Tools, which are more discipline specific. The GAC will be responsible for developing a few core indicators for the Knowledge

Base and Engineering Tools attributes. However, the departments will then take the lead in developing departmentally specific indicators for these two attributes. The departments are also tasked now with identifying courses, and other learning experiences, where attainment of graduate attributes are demonstrated. The departments must (working with the GAC members) adapt or create assessment tools that map sufficiently well to the indicators to collect meaningful data. We expect this whole system to be ready for piloting by December of 2011.

While the departments are busy getting their assessment plans together, the GAC will be working out guidelines for the continuous curriculum improvement process. This includes decisions about data collection methodology including sampling, and timing. The timing issue is of particular importance. We do not intend to collect data on every attribute every year. So deciding whether to follow a cohort or

cycle through the attributes is an important decision. Overall we are progressing toward a cohesive curriculum improvement process. However, we expect that significant evolution of our original plans will be necessary to achieve the goal.

References

- [1] Canadian Engineering Accreditation Board, (2010), *Accreditation Criteria and Procedures*. [Online] Accessed May 7, 2011. Available: http://www.engineerscanada.ca/e/files/Accreditation_Criteria_Procedures_2010.pdf
- [2] Worldwide CDIO Initiative, CDIO Home page. [Online] Accessed May 7, 2011, Available: <http://www.cdio.org/>

Table 1. Attribute 3.1.3 Investigation

Global Objectives	Indicators
Ability to define the problem	• State the problem, its scope and importance • Describe the previous work • State the objective of the work
Ability to devise and execute a plan to solve the problem	• Select a set of tests to be conducted • Select, plan and apply the methods for collecting the results • Identify limitations of the methods used and their impact on the results.
Ability to use critical analysis to reach valid conclusions supported by the results of the plan	• Analyze the results • Formulate the conclusions • Validate conclusions by induction or deduction • Compare conclusions with previous work • Characterize the limitations and implications of the conclusions

Table 2. Attribute 3.1.6 Individual and team work

Global Objectives	Indicators
Ability to participate effectively and manage a team.	• Identify or explain operational characteristics of effective teams and stages in team development • Identify or explain tools to manage team processes • Demonstrate personal qualities of an effective team member • Demonstrate the application of tools and processes to manage teams
Ability to interact with fellow group members effectively in a team	• Identify or explain relational characteristics of effective teams • Identify or explain characteristics of individuals that influence relational interactions • Demonstrate the application of tools and processes that foster effective interactions
Ability to communicate effectively in a team	• Identify or explain communication techniques to interact effectively within a team • Demonstrate the application of communication tools and processes to foster creativity and build ideas • Demonstrate the ability to construct feedback for fellow group members

Table 3. Attribute 3.1.7 Communication skills

Global Objectives	Indicators
Ability to identify and credibly communicate engineering knowledge	• Situate, in document or presentation, the solution or design in the world of existing engineering, taking into account social, environmental, economic and ethical consequences • Recognize a credible argument (reading) • Construct a credible argument in written or spoken form – to persuasively present evidence in support of a claim • Organize written or spoken material– to structure overall elements so that their relationship to a main point and to one another is clear • Create “flow” in document or presentation – flow is a logical progression of ideas, sentence to sentence and paragraph to paragraph
Ability to incorporate visual elements in communication	• Incorporate visual material that enhances communication without detracting from it • Incorporate various media appropriately • Incorporate principles of visual design appropriately
Ability to develop communication through an iterative process	• Use iteration to clarify and amplify understanding of issues being communicated • Use reflection to determine and guide self-development

Table 4. Attribute 3.1.8 Professionalism

Global Objectives	Indicators
Ability to describe engineering roles in the broader context	• Identify and describe various engineering roles (product vs process design, manufacture vs construction vs maintenance vs disposal) • Demonstrate an understanding of RAGAGEP (Recognized as Generally Accepted Good Engineering Practice) appropriate to the discipline, including regulations, standards, guidelines, quality of written work
Ability to describe engineering roles as they pertain to Environmental, Health and Safety	• Understand the concepts of risk management (hazard vs risk; identification, assessment, mitigation, tolerance, etc) • Consider the entire life cycle within such an evaluation • Identify options, select and defend a preferred option as part of an integrated design experience
Ability to discuss the impacts of engineering within a global society (the broader public interest)	• Recognize the limitations of regulations, codes and standards, and the limits of a life cycle analysis, when engineering in a global context
Ability to behave in a professional manner	• Understands and behaves in a manner consistent with the Guideline on Professional Practice, particularly with regards to interpersonal relations • Demonstrates professional etiquette and conduct as illustrated in the Guideline on Professional Practice, particularly with regards to interpersonal relations

Table 5. Attribute 3.1.9 Impact of engineering on society and the environment

Global Objectives	Indicators
Understand the relationships among technology and the social, cultural, economic and environmental conditions of society, locally and globally.	● Explain the interconnectedness of social and technological development, including both the impacts of technology on society and impacts of society on technology ● Describe the role of technological development in globalization and as a local and global socio-economic force ● Describe the types of impacts, both positive and negative, of technological development on the natural environment ● Describe the types of impacts, both positive and negative, of technological development on the social and cultural aspects of society
Ability to identify the types of short-and long-term impacts of a specific technology on society, the environment, and human health and safety.	● Identify the possible social, cultural, environmental and human health-related impacts over the life-cycle of an engineering product or activity relevant to the student's discipline Identify and evaluate the potential risks (likelihood and consequences) to human health and the environment of an engineering product or activity relevant to the student's discipline ● Identify relevant viewpoints and stakeholders in an engineering activity ● Communicate information about the potential impacts of an engineering products and activities to a non-technical audience ● Recognize the challenge of prediction, given the complexity of social, environmental and technological systems, and demonstrate an appreciation of what isn't known.
Ability to identify and choose alternative ways to mitigate or prevent adverse social, environmental, human health and safety impacts.	● Compare technological alternatives and identify means to mitigate the social, environmental, human health and safety impacts ● Apply principles of preventive engineering and sustainable development to an engineering activity or product relevant to the student's discipline
Ability to identify legal issues relevant to an engineering activity.	● Identify legal requirements relevant to a specific engineering activity, such as standards, codes or regulations ● Recognize relevant codes and standards, and when to apply them ● Identify legal risks relevant to a specific engineering activity
Appreciate the role of the engineer, and other disciplines and professions, in social/technological development.	● Describe the unique role of the engineer in social/technology development ● Appreciate the social and natural sciences and diverse epistemological viewpoints in a technology-driven society

Table 6. Attribute 3.1.10 Ethics and equity

Global Objectives	Indicators
Ability to recognize ethical and equitable dilemmas	• Distinguishes the differences between ethics, tort law and common law • Articulate the issues involved in ethical case studies • Ability to work with a diverse group of people(s) in a mutually respectful manner
Ability to apply the Code of Ethics in Engineering circumstances	• Analyze a case, describe and defend an appropriate response in which the Code of Ethics is applied
Ability to understand new codes of practice/behaviour/ethics and apply in an organization appropriate manner.	• Assess a situation, describe and defend an appropriate response in which a different Code is applied (e.g., demonstrate ethical behaviour in an academic framework - Code of Student Conduct, Code of Behaviour on Academic Matters)

Table 7. Attribute 3.1.11 Economics and project management

Global Objectives	Indicators
Ability to estimate the life-cycle economic and financial costs and benefits for relevant engineering activities	• Identify the various types of economic and financial benefits and costs of an engineering activity • Identify credible estimates of the costs and benefits • Recognize the uncertainties in the estimates
Ability to evaluate the economic and financial performance of an engineering activity and compare alternative proposals on the basis of these measures	• Calculate appropriate economic and financial performance measures of an engineering activity • Choose the most appropriate alternative based on economic and financial considerations • Explain the implications of inflation, taxes and uncertainties on these values and comparisons
Ability to read and understand financial statements for engineering activities	• Explain the various types of financial statements and the terminology used in them, and calculate key financial measures
Ability to plan and manage engineering activities to be within time and budget constraints	• Identify the tasks required to complete an engineering activity, and the resources required to complete the tasks • Determine and adjust the schedule of tasks and their resources to complete an engineering activity on time and within budget