TEACHING AND ASSESSING "LIFELONG LEARNING" IN ENGINEERING COMMUNICATION COURSES

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Abstract – *Recent changes to CEAB's accreditation process have resulted in the need for engineering programs in Canada to find ways to assess critical graduate attributes. While many of the attributes can be measured through traditional methods, others are more subtle and challenging to assess. One that can be particularly challenging both to teach and assess is lifelong learning. As its name suggests, lifelong learning is a process that begins before and continues after a person's formal education; it is a learner-initiated activity or habit of mind. As such, educators must develop ways to ensure that students understand the importance of learning itself, both during and after their formal engineering studies.*

Technical Communication courses are excellent vehicles for delivering and reinforcing the skills and competencies associated with lifelong learning. This paper will explore how "Lifelong Learning" as a CEAB graduate attribute can be taught and assessed in communication courses (APSC 176 and APSC 201) housed in an engineering program at UBC's School of Engineering. This paper will also explore the next steps in developing appropriate metrics for determining the success of these courses in meeting this element of accreditation.

Keywords: lifelong learning, communication, accreditation

1. INTRODUCTION

Engineering accreditation bodies have prioritized many professional skills that need to be both taught and assessed in post-secondary engineering programs. Lifelong learning is one of the most challenging of these professional skills for a multitude of reasons, not least of which is the hope that its assessment in post-secondary institutions will act as a predictor of students' future behaviour when they become practicing professionals. Lifelong learning has also been a major consideration of the CEAB and other accreditation bodies such as ABET. While engineering education researchers have focused on how to teach lifelong learning skills, assessment remains a large gap in the research [1]. Lifelong learning has been defined in previous CEEA papers as "[t]he process by which professionals continuously invest in the maintenance and improvement of their knowledge skills and competence necessary for the enhancement of the execution of professional and technical duties throughout the practitioner's working life that adds value to the resolution of clients' needs" [2]. The challenges associated with assessing the professional skills, including lifelong learning, according to a paper in the *Journal of Engineering Education*, are "the lack of consensus about definitions, the broad scope by which the outcome is assessed, and the nature of the outcome itself" [1].

In particular, the scope of educational experience required to master lifelong learning is more often developed both in and outside the classroom, which makes effective assessment of such skills especially challenging. That in combination with the fact that "lifelong" could extend 30 or more years after the students' completion of their formal education makes assessment guarantees of acquiring the skill impossible in the near future. In addition, though students may have acquired the skills necessary for lifelong learning, there is no guarantee that educators will be able to provide sufficient motivation to apply the knowledge and professional skills as practicing engineers. The prolonged behavioural change of becoming a lifelong learner, as a professional, seems to depend more on instructors instilling attitudes toward lifelong learning rather than providing feedback on particular exercises and assignments.

Communication courses in an engineering program are excellent vehicles for responding to these challenges: for delivering and reinforcing lifelong learning skills and competencies. This paper will explore how "Lifelong Learning" as a CEAB graduate attribute can be taught in communication courses housed in an engineering program, outline a developing curricular and co-curricular initiative for improved delivery, and describe a metric for assessing students' attitudes toward lifelong learning.

2. LIFELONG LEARNING IN THE CONTEXT OF PROFESSIONAL DEVELOPMENT

Accrediting bodies focus on lifelong learning at least in part because industry demands the skill as a part of the continued professional development of practicing engineers. Professional development is a significant part of the regulatory work done by Engineers Canada. On their website, they define the policy direction that guides professional development by making clear connections between an engineer's ethical obligations to protect the public: "Mandatory continuing professional development requirements protect the public by ensuring that licence holders meet ethical obligations to maintain the currency of their professional competencies and undertake continuous learning throughout their careers" [3]. Engineers Canada defines professional development as "the planned acquisition of knowledge, experience and skills and the development of personal qualities necessary for the execution of professional and technical duties throughout an engineer's professional life" [3]. This definition is similar to that identified in previous CEEA publications, but with a greater emphasis on the motivation of protecting the public.

An example of this connection between professional development and the safety of the public can be seen in a tragic engineering failure, and the subsequent enquiry into the failure. In June, 2012, the roof of the Algo Centre Mall, in Elliot Lake, Ontario, collapsed, resulting in two deaths and injury to 19 other people. The enquiry (chaired by the Honourable Paul R. Bélanger) that followed this tragedy identified human error as the primary cause: "the real story behind the collapse is one of human, not material, failure" [4; p. 4]. The enquiry produced numerous recommendations, including one (Recommendation 1.24) that pertains to the importance of ongoing professional development in the engineering profession, specifically that "[t]he Professional Engineers of Ontario should establish a system of mandatory continuing professional education for its members as soon as possible, and in any event no later than 18 months from the release of this Report" [4; p. 35]. This recommendation is highlighted on the Professional Engineers Ontario (PEO) website [5], as is the subsequent work of the Continuing Professional Development, Competence and Quality Assurance Task Force.

This tragic event reminds us of the importance of lifelong learning and why it is tasked upon educators to instil it in students before they become practicing engineers. Its importance is further emphasized by the prominence given to the topic on the websites of each of the twelve provincial and territorial regulatory agencies for professional engineers. Each of these agencies addresses professional development on its website. The ease with which a reader can locate the information, and the amount of detail, and depth, provided for members, varies from province to province.

The Association of Professional Engineers and Geoscientists of Saskatchewan (APEGS), for example, makes clear connections between their association's mandate and its role in fostering professional development. The website describes a four-step process for members to determine how to plan and report their professional development. The first two steps are of particular interest: "Identify where you are," and "Plan where you want to be" [6]. To complete these steps, members must reflect on their current state of knowledge, and think ahead to the "knowledge, skills, and abilities" that would be required for their present or future career.

On most association websites, the six categories in which professional development can be claimed are clearly identified, reporting mechanisms are carefully detailed, and members are given extensive instructions on how to count and record their hours of professional development. The following list of types of professional development is based on the

Association of Professional Engineers of Yukon (APEY)'s website, but it could have been drawn from almost any of the provincial or territorial associations:

- Professional practice,
- Formal activities (including courses),
- Informal activities (including self-directed study, conferences),
- Participation (mentoring, service on technical societies),
- Presentations (at a technical conference),
- Contributions to knowledge (developing codes or standards, publishing an article). [7]

Efforts have been made to encourage engagement in lifelong learning, and it appears that these efforts can yield results, as suggested by Engineers of Nova Scotia (ENS). ENS has conducted several studies over a 4-year period to determine their members' awareness of and engagement in professional development activities. Based on its most recent survey, ENS reports that 95% of respondents were aware of the professional development program, and that the most popular method of continuing education for members is informal learning [8]. However, is awareness of professional development programs sufficient? What is the nature of professionals' preferred learning strategies, and are those strategies sufficient for the continued education of professionals who are responsible for public safety in all of their projects?

These questions, in conjunction with the Hon. Bélanger's recommendation for a system of mandatory continuing professional education, suggest the need to more thoroughly instruct and assess lifelong learning skills. Moreover, if the majority of practicing professionals prefer self-directed study and informal learning in their ongoing professionalization (as suggested by APEY and ENS), it becomes particularly important to emphasize the meaning and value of lifelong learning for all students enrolled in an engineering program, rather than to insist that all students adhere to a singular, formal model of how to practice lifelong learning. The central question, then, becomes how can we, as educators, work to ensure that, in addition to acquiring a concrete skill set, our students sincerely embrace an attitude to learning that extends beyond requirements and curricular demands, and that lasts a lifetime?

3. TEACHING AND ASSESSING LIFELONG LEARNING

Core skills for effective lifelong learning include self-directed and informal learning, both of which are challenging to instruct and assess but which can be delivered effectively through combined curricular and co-curricular initiatives. To prepare students to be effective at informal learning when they are practicing professionals, educators need to focus on methods to develop this holistic skill that are not confined to specific courses or topics of study. In addition, special attention must also be paid to motivating students to become self-directed learners. Initiatives at the School of Engineering (SOE) at UBC's Okanagan campus are an example of how integrating lifelong learning into communication courses and complementary co-curricular activities can address some of these challenges.

3.1 Curricular Initiatives

Lifelong learning in an engineering program can and should be integrated into a variety of courses that students encounter throughout their engineering program. However, integrating assessments of lifelong learning often happens at the end of students' programs in capstone design courses. These assessments tend to be summative rather than formative, leaving little opportunity for faculty to help students continue developing these skills once weaknesses are identified. As a result, beginning to assess these skills in first and second year, as well as providing feedback to students, is appropriate to allow for formative assessment of the skills [9], and should be implemented in more structured and thorough ways. Communication courses that are integrated in students' early years of study can allow for a more formative assessment of students' lifelong learning abilities that can then be re-addressed and re-emphasized later in their studies. These courses can address some of the challenges inherent to lifelong learning more directly while complementing the efforts of engineering science and design courses.

For example, undergraduate students in the School of Engineering (SoE) at the University of British Columbia complete two communication courses, Applied Science (APSC) 176 and 201, in their first and second years of study, respectively. Both courses have approximate enrollments of 30-35 students per section. APSC 176 (Engineering Communication) provides fundamental skills in writing, analysis, research, and presentation, and APSC 201 (Technical Communication) builds on these skills to introduce specific elements of technical communication in academic and professional contexts. Together these courses are two separate interventions where students receive more individualized formative feedback on aspects relevant to lifelong learning.

Communication courses like APSC 176 and APSC 201 often focus on teaching students writing processes that require students to practice skillsets core to lifelong learning. The writing process not only mirrors the problem-solving process of design that engineers need, but also the general critical thinking process required to reflect on a problem. In all of these problem-solving processes, students learn and practice how to assess where gaps in information lie, and use their retrieval skills to fill those gaps in order to have a fuller picture and then be able to come up with a solution, whether it be a design or a written document. The lifelong learning skills that are effectively taught through practicing the writing process in communication courses are information retrieval through research-oriented writing projects and self-assessment through written reflections [10, 11].

In the SOE's first year communication course, APSC 176: Engineering Communication, for example, all students are explicitly taught and assessed on their information retrieval skills and reflection skills in separate written assignments. These assignments are not unusual in many communication courses, but if the courses are offered specifically within engineering programs, they can be the initial teaching and assessing of students' lifelong learning abilities that can be metrics for accreditation and serve as formative assessment for students as they continue in their engineering degree program.

As identified by professional development requirements of the regulatory bodies, the first two steps of lifelong learning are to reflect on the professional's current state of knowledge and then plan where they need to be. Lifelong learning necessarily requires self-reflection in order for students to know what information they still need to acquire in order to fill gaps in their knowledge to solve problems. Students' informal assessment of their own work and that of their colleagues, completed through exercises often built into traditional engineering courses, builds core competencies in lifelong learning, but pedagogical researchers acknowledge that the best assessment methods require the most faculty time and student effort [12].

Design courses in engineering programs teach many lifelong learning skills, but generally on a team basis to accommodate the large numbers in the program. On the other hand, first- and second-year communication courses in engineering programs often offer such courses with dedicated faculty members to address the particular needs of engineering students. As a result, an effective use of resources would be to use these engineering-specific communication courses to teach and assess the skills associated with lifelong learning in first and second year of engineering education. These courses are already smaller in number (often 20-40 students) and can easily incorporate research-based writing and reflections, if they do not already. As a result, communication courses not only already teach and assess core skills that are necessary for lifelong learning, but they are already often at a student to teacher ratio that can allow for meaningful formative assessment of those skills.

The amorphous nature of lifelong learning that makes it challenging to assess also means that it can be developed synchronously with the development of the other professional skills required by accreditation. Shuman, Besterfield-Sacre, & McGorty assert in their article published in the *Journal of Engineering Education*: "We propose that as students acquire the other [ABET] professional skills, especially the other two awareness skills, as well as the process skills, that they will, in fact, acquire the ability to do lifelong learning. Hence, one will become a proficient lifelong learner as one becomes proficient in the broad spectrum of professional skills." [1, p. 49]. Engineering-focused communication courses also can teach and assess other professional skills that

CEAB requires and that will in turn further enhance students' ability to be lifelong learners. Throughout both courses, students engage in individual and team-based exercises to reach defined learning outcomes. In order to reach these outcomes, instructors in APSC 176 and 201 have incorporated specific tools and course requirements to better develop and assess professional skills that enhance lifelong learning skills. These include peer-review through tools like Community Service Learning (CSL) and iPeer. CSL projects allow students to experience the uncertainty and complexity of solving real world problems that require more than classroom skills. Peer assessments of student team participation, completed through structured activities like iPeer, allow for more complex assessments of student skills in multiple settings.

3.2 Co-curricular initiatives

Solely relying on curricular efforts to reinforce the skills of lifelong learning is not only not sufficient to support students' development of those skills, but also not reflective of the reality of shifting student attitudes towards lifelong learning. To this end, SOE is developing Introduction to Engineering (I2E), a co-curricular introduction for all first-year engineering students to the graduate attributes that support personal and professional development, including lifelong learning.

I2E will be embedded in the first year of study (specifically in a first-year, first-term drawing course and a first-year, second-term design course) and developed further in three pillar courses (second-year design, third-year project management, and fourth-year capstone). I2E is intended to introduce students to core concepts that will support their academic and professional success: individual and teamwork skills, professionalism, ethics and equity, and lifelong learning. I2E supports engineering students in developing healthy and sustainable practices, positive and robust engineering identities, and the metacognitive skills (self-analysis, self-knowledge) that are necessary for mature professional behaviour, including a commitment to lifelong learning. Assessment mechanisms (including reflection) and formative feedback will help students incorporate their learning in both their formal education and professional careers.

In Phase 1 of I2E, faculty and specially trained TAs will lead tutorials on topics that support engineering student development, thereby helping students develop the knowledge and competencies that will support their academic and professional success. The concepts will be introduced in micro-lectures (10-15 minute guest lectures) and further supported through activities conducted in tutorials and led by a faculty member along with a graduate student teaching assistant who has received training specific to I2E and to each tutorial topic. The voices and viewpoints of upper-level students and early-in-career engineers will be incorporated into the tutorials via a video series. Students' developing mastery of these attributes will be assessed and supported through a variety of mechanisms, most significantly a series of reflections. By making this instruction explicit and by embedding it in core courses, and by incorporating student, professional, faculty, and graduate student viewpoints into the tutorials, we will help students understand the centrality and importance of these topics, as well as support their development in each of these areas.

4. METRICS FOR ASSESSMENT

In addition to curricular improvements and embedded co-curricular professionalism programs, measuring students' ability to be self-directed learners outside of their formal education is necessary to support efforts of lifelong learning. The propensity for graduates of engineering programs to be lifelong learners is related to their ability to be self-directed learners first, largely because they will likely no longer be enrolled in formal education once they begin their professional careers. Measuring students' motivation to be self-directed learners is crucial, therefore, in assessing their ability to be lifelong learners.

Though the adjustments in the CEAB accreditation guidelines around lifelong learning provide a new emphasis in engineering education, tools for measuring students' attitudes toward this skillset have been around for decades. Guglielmino's *Self-directed Learning Readiness Scale* is a metric was developed almost 40 years ago and has been tested and used in a variety of circumstances to determine propensity for self-directed learning[13]. This survey uses a 5-point Likert scale of agreement designed to elicit attitudes about lifelong learning, and it could be adapted and used to determine the success of engineering communication courses in meeting the lifelong learning element of accreditation. For example, while communication courses can teach information retrieval skills, this instruction needs to be coupled with understanding the level to which students subscribe to beliefs of themselves such as “If I discover a need for information that I don't have, I know where to go to get it” or “No one but me is truly responsible for what I learn” [13]. Using appropriate metrics to determine the attitudes of student learning could also be useful in longitudinal studies that assess whether students’ self-directed learning readiness increases over the course of a student’s education.

5. Conclusions

Lifelong learning, particularly through professional development requirements, is and will be an important part of many engineers’ careers. However, not all graduates of engineering programs become professional engineers; many will work within the profession (or outside it) without formal supervision and measurement of their ongoing commitment to and engagement in lifelong learning. The expectation of educators, though, remains: that we prepare all students to have the skills and attitudes necessary to be lifelong learners.

Teaching undergraduate engineering students how to practice lifelong learning and instilling the value of that practice means implementing sustained and robust mechanisms for delivery and assessment. Communication courses like SOE’s APSC 176 and 201, in conjunction with co-curricular initiatives like I2E, provide opportunities for significant impact among undergraduate engineering students, given those courses’ comparatively small enrollment. Moreover, communication instruction and practice themselves model a basis for lifelong learning: that it be continuous and self-directed. Developing and applying a modified readiness scale as a metric will provide instructors a means of evaluating skills and attitudes among students in both the short and longer term. The authors look forward to the initial results of these delivery and assessment initiatives, and anticipate using those results to revise both I2E and the modified readiness scale.

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