On the place of the humanities and social sciences in the engineering curriculum: a Canadian perspective

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ABSTRACT: The importance of training well-rounded engineers has been discussed by engineering educators since the 1940s. In Canada, required and elective courses in the humanities and social sciences are featured in the engineering curriculum to encourage students to develop *soft* skills, such as social competency, ethical awareness and the ability to express themselves with ease, both orally and in writing. This study explores the place of humanities and social sciences courses in the engineering curriculum from the perspective of students. The authors provide an overview of the historical and present debates on humanities and social sciences in the engineering curriculum. They then, using data obtained from written surveys and focus group studies, report on student feedback regarding their experience. The authors conclude that the recent Canadian Engineering Accreditation Board graduate attribute framework provides an excellent opportunity to assess the role of the humanities and social sciences in the Canadian engineering curriculum and suggest possible ways to measurably enhance student experience and learning of non-technical or *soft* skills in these courses.

Keywords: Humanities, social sciences, graduate attributes, complementary studies, soft skills, engineering, job readiness, non-technical subjects, general education

INTRODUCTION

In recent years, a number of scholars and journalists have called for a greater collaboration between the liberal arts and the disciplines of science, technology, engineering and mathematics (STEM) and, more precisely, for a greater partnership between engineering and the humanities as a way to foster greater cultural and social understanding, and develop flexibility and adaptability in students [1-5]. This call for the inclusion of the humanities in the engineering curriculum, is neither recent nor is it limited to a particular region. In fact, discussions of the importance of exposing future engineers to the humanities and social sciences, as well as providing them with soft skills expertise date back at least seventy years; and humanities and social sciences content has become mandated by the various accrediting bodies responsible for engineering curricula. For example, in the United States, the Accreditation Board for Engineering and Technology (ABET) requires a *general education component that complements the technical content of the curriculum and is consistent with the programme and institution objectives*, while also requiring documented student outcomes that demonstrate a *broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context* [6].

The UK Standard for Professional Engineering Competence (UK-SPEC), Engineers Australia Stage 1 Competency Standards, and the China Engineering Education Accreditation Association also require engineers to demonstrate proficiency in broad non-technical areas that complement their technical skills [7-9].

In Canada, the Canadian Engineering Accreditation Board (CEAB) requires courses and/or content dealing with the *central issues, methodologies, and thought processes of the humanities and social sciences*. Courses that fulfil this requirement are labelled *complementary studies*. These courses are often understood to provide students with an opportunity to hone some of their non-technical skills (soft skills).

But, what is the right level and approach to integrating the humanities and social sciences into the engineering curriculum? How do students understand their experience with these fields during their degree? Do they see the usefulness of the skills and content learned in their complementary courses for the job market? Are some of them interested in opportunities for greater exposure to the humanities and social sciences? What are the ways in which the value of complementary studies could be enhanced for engineering students? Moreover, how successful are these courses in developing communication and other soft skills? This study proposes to explore these questions within

the framework of the recently introduced assessment of graduating student performance based on twelve programme outcomes or graduate attributes, as defined by the CEAB [10]. These twelve graduate attributes cover a wide range of the knowledge, skills and attitudes expected of an accredited Canadian engineering programme graduate including discipline-specific knowledge and skills (engineering knowledge base and design), as well as non-technical skills and attitudes (individual and team work, communication, professionalism, impact of engineering on the society and the environment, ethics and equity, economics and project management, and lifelong learning).

Here, the authors begin by presenting an overview of the historical debates on the place of the humanities and social sciences in engineering education. They then, discuss complementary studies in today's Canadian engineering curriculum. Finally, they report on the feedback obtained from written surveys of first and fourth-year engineering students and focus groups of graduating students asked about their experience and attitudes relative to complementary studies and soft skills graduate attributes. They conclude that the new CEAB graduate attribute framework provides an excellent opportunity to assess the role of the humanities and social sciences in the engineering curriculum and suggest possible ways to measurably enhance student experience and learning of non-technical or soft skills.

HISTORICAL CONTEXT: A BRIEF LITERATURE REVIEW

Since the 1940s, the humanities (and later the social sciences) have been seen as a means to prevent over-specialisation, enhance creativity and promote more socially-conscious engineers [11][12]. Good engineers should be engaged citizens, it was argued; and understanding human history, ideas and practices would help engineers serve the public in a more complete way [13][14]. In Canada, discussions of the role of the humanities were present from the beginning. At the fourth meeting of the Dominion Council of Professional Engineers in 1940, for example, a report on the training of young engineers affirmed that *[a]s engineers we have not reached the social status that we feel to be our due, largely because we have confined ourselves strictly to the technical aspects of our work. … [A]t any rate, we have not been interested enough to co-operate with our fellow citizen in adjusting our national life and economy to the far-reaching changes which we have helped to bring about*. The report went on to suggest that engineers be trained in public speaking and *the use of precise English by the writing of technical papers and reports* and encouraged to read literature, art and philosophy. Finally, engineers should *take their place in community life through service clubs and community organisations of various kinds* [15].

Echoes of this need for non-technical training were heard at following annual meetings, and, in 1944, the Dean of the Faculty of Applied Science and Engineering of the University of Toronto reported that the faculty was *liberalising all of its undergraduate courses*, having realised *…that the engineering graduate of the future must not only be a well skilled technologist, but at the same time must be a well informed and understanding citizen. Thoughtful engineers everywhere were in agreement that the highest usefulness of a professional man cannot be achieved unless relatively early in life he develops a lively interest in the workings of society and assumes some measure of responsibility for the economic, social, political, and cultural welfare of the community in which he lives*. Subjects to be added to the curriculum starting in fall 1945 included *English, engineering and society, general economics, political science, modern world history, modern political and economic trends, philosophy of science, and the profession of engineering* [16].

Yet the problem was perceived to continue, and calls for the inclusion of the human and social context in the engineering curriculum either as a way to promote open-mindedness, social responsibility and social standing or for the sake of developing a life-long interest and respect for the arts continued to be heard throughout the 1950s and 1960s [17]. At Syracuse University, Norman Balabanian argued that the curriculum should prepare engineers *…to participate intelligently in the affairs of his community. A person who is trained in a narrow engineering specialty, without emphasis on the scientific method and the broad social and philosophical implications of science and technology, will not develop the perceptions required to understand our world* [18].

In Canada, a report from the Committee on Future Development of the Engineering Profession (1963) stated that engineering graduates *…are generally very poorly informed as to the social, ethical and legal implications of engineering practice. Current engineering curricula usually omit these topics in favour of increased technical course content… It is considered vital to the wellbeing of the profession that its future members be formally acquainted, during their undergraduate days, with the responsibilities which they must accept in their future practice - responsibilities to society, to employers or clients, to other professionals, and to themselves, and to all ethical and legal requirements of such practice* [19].

As the Canadian Council of Professional Engineers prepared for a new accreditation framework in the mid-1960s, it continued to stress the importance of a liberal education for the profession: *It is not claimed that a Liberal Education will do a complete job of preparing a young man for life, but it initiates the sort of personal growth that leads to maturity. It helps to liberate him from provincialism, whether geographical, historical or occupational. It develops his capacity to make sound qualitative judgements so that he may distinguish that which is good, from that which is mediocre. It encourages wisdom, judgement and perspectives; qualities needed in facing the daily decisions of life* [20]. With accreditation, the recommendation to include humanities and social science content became a requirement. In its first annual report in 1975, the Canadian Accreditation Board stated that programme now required a *minimum of one-half year of appropriate humanities and social sciences, which should include at least a course in economics* [21].

A year later, administrative studies joined the humanities and social sciences, with the added stipulation …*[s]uch courses should be structured so as to prevent the student from merely examining the introductory aspects of a large number of subjects instead of studying fewer subjects in depth* [22]. Note that direct quotations of an historical nature, such as those in this paragraph often adopt a non-gender inclusive language that is typical of the period and not reflective of the views and opinions of the authors of this work.

Concerns with non-technical components of the engineering curriculum or the development of soft skills became apparent in the 1970s both in the US and in Canada. At the Worcester Polytechnic Institute, Massachusetts, Grogan fought the belief that *good engineering students are not interested in the humanities*, which he considered a dangerous myth. So too was the assumption that engineering students were *inherently poor in verbal skills.* To address this misconception, he proposed that engineering students completed a minor in the humanities and a community engagement project. Grogan's counterpart at the University of Toronto, Smith, recommended teaching humanities and social science values through engineering-centric courses by instructors who were trained in both fields [23].

Many agreed that the humanities and social sciences needed to be brought into the engineering curriculum in more engaging ways. Syracuse University's Glasford; for example, lamented the lack of familiarity across both sides of the liberal arts and the science divide and suggested designing a joint minor in liberal arts and scientific education for both engineers and non-engineers alike [24][25]. By 1979, the CEAB had changed its justification for the complementary studies to …*care must be taken to ensure the student participates in courses which deal with some of the central issues, methodologies and thought processes of the humanities and social sciences at a level which challenges the students* [26]. Meanwhile in Europe, a study conducted on engineering programmes found that in order for humanities or social sciences courses to influence engineering students, they had to be *fully integrated* into engineering curricula [27].

In 1981, chemist and editor of the *Journal of Chemical Education*, Lagowski, argued that …*perceptive scientists are troubled by the realisation that they are potential agents of unprecedented power but are not trained as arbiters of value. Many scientists suspect, and rightly so, that if their social predilections are allowed to influence their scientific judgment, they stand a real chance of doing poor, as well as potentially dangerous, science. Not only should we be aware of the common ground between the sciences and the humanities, we should also study it for the insights it can provide. We would probably be better scientists and better humans for the effort* [28]. A few years later, director of the Science, Technology and Society Studies at Lehigh University, Goldman, reiterated that the value of the humanities lay in their ability to teach interpretation and critical thinking while asserting that engineers must consider how their own work will be used [29].

More recently, calls for holistic engineering education have included discussions of multidisciplinary courses and the need for increased contact with students from other disciplines as a way to mirror typical professional group settings and better train engineering students to face the ethical, economic and social issues that often arise in the workplace [30-32]. By the mid-1990s, some engineering educators pushed for more English literature and creative writing courses [33]. Others looked toward the history of science and technology as a way to instil important ethical and social lessons, while fostering a better sense of how engineering work contributes to society [34][35].

Since 2000, and largely in response to the criticism of many engineering educators who believed that the ethics content in most engineering curricula was inadequate [36], problem-based learning, historical case studies and interdisciplinary courses have all been promoted as means to provide students with opportunities to creatively solve problems and develop as ethical and socially responsible engineers and leaders [37-40]. Historical studies, as well as cross-disciplinary and discussion-based courses within the humanities and social sciences have been described as excellent in teaching ethics and leadership skills to students while encouraging creativity.

The lack of effective communication skills among recent graduates and the role non-technical courses could play in alleviating the problem has also been a topic of interest [41-44]. Many engineering educators continued to stress the importance of fostering engineers who are self-motivated, emotionally aware and socially literate. These engineering graduates should be able to respond to a wide variety of social issues by developing self-awareness, cultural sensitivity, global understanding and the ability to function in a multitude of social situations [1][45-47]. Many researchers and educators emphasise the benefits of problem-based learning, team-based learning environments and multidisciplinary classes in teaching such skills [2][48-52].

COMPLEMENTARY STUDIES IN CANADA: AN OVERVIEW

In Canada, the CEAB presently requires students to take a minimum of 225 accreditation units (AU) in complementary studies defined to include humanities, social sciences, arts, management, engineering economics and communication. These courses must incorporate elements dealing with: the impact of technology on society, central issues, methodologies, and thought processes of the humanities and social sciences, oral and written communication, health and safety, professional ethics, equity and law, as well as sustainable development and environmental stewardship [10]. While programme hours and objectives are the same, each institution can decide on its own approach on how to implement these AUs. To understand the nature and variability of complementary studies implementation, the authors

reviewed the Web sites of the 43 Canadian institutions with accredited engineering programmes [10]. For each accredited institution they considered curricula, programme descriptions, programme guides, and academic calendars available on their Web sites.

Complementary Courses Requirements and Offerings

The number of compulsory and elective complementary studies courses varies across institutions, as does the range of courses engineering students can take to fulfil their complementary course requirements. Among compulsory complementary courses, business and economics are the most common and found in most schools. In addition, 33 institutions require an engineering and society course. Usually offered as an historical or philosophical survey, the course tends to be taught by external departments at larger institutions and engineering faculty at smaller ones. Communication courses are also widespread, with 27 institutions requiring at least one course in this field (either university writing, professional communication or English literature). Eighteen institutions require ethics and law courses; and four schools require a course in environmental stewardship. Complementary studies electives also vary. Institutions, such as the University of Toronto, York University, the University of Alberta and the University of Guelph allot four or more complementary studies electives, while some have no free complementary studies electives. When offered, the range of electives depends on institutions, and most engineering programmes take advantage of resources at their institutions to offer courses in anthropology, geography, history, philosophy, women's studies, English and classics. As a general trend, smaller and more specialised institutions offer a limited number of complementary study electives, while larger and more educationally diverse institutions offer greater choice.

Opportunities for Joint Programmes or Additional Specialisations

Specialisations, areas of concentration, minors, and joint degrees are offered at several institutions. The actual structure and credit requirement vary, but some general trends can be seen. The nine institutions that offer joint degrees with the arts typically require students to apply to both programmes independently and specify that a limited number of courses can be counted towards both degrees. For instance, Queens University and the University of Saskatchewan both specify that joint degree students must have 30 extra credits in their second degree field in order to successfully complete a dual programme. Bishop's University and Université de Sherbrooke offer a dual engineering and liberal arts programme in which students fulfil the engineering degree requirements from Sherbrooke, but also take several general sciences and liberal arts courses at Bishop's. Eighteen engineering programmes allow their students to take minors; of these, 10 specify that arts minors may be completed. A number of engineering programmes offer options to develop business skills. For example, École de Technologie Supérieure in Quebec offers both an e-business option and an international engineering option, the University of Ottawa and Ryerson University both offer a management and entrepreneurship option, the University of Saskatchewan provides entrepreneurship or professional communications options, the University of Waterloo offers an engineering entrepreneurship option, and the University of Western Ontario allows its students to obtain a Global and Intercultural Engagement honour.

Global Experience

Study abroad programmes and exchanges are possible at most institutions, but a few programmes also advertise formal exchange programmes with partner universities designed specifically for engineering students. For example, the University of Calgary allows small groups of mechanical engineers to study in Greece or China, while its electrical engineers can visit Switzerland. The University of New Brunswick offers a German for engineering students programme, exposing students to German language, culture and history for four weeks. In addition, several institutions offer international development courses, specialisations or options to prepare their students for international work opportunities. The École de Technologie Supérieure, the Université du Québec à Trois-Rivières, and Queen's University offer international development courses, some of which can be counted towards their complementary studies requirements. The University of Western Ontario and the University of Waterloo offer international development as an area of concentration, while York University offers an entire programme in engineering and international development, resulting in a dual Bachelor of Applied Science and Bachelor of Arts degree over five years.

Several institutions offer language instruction for their students. Due to CEAB requirements, there is often a credit limitation in place for language courses resulting in students only being able to take one or two language courses during their degree. French, German, Spanish and Italian are the most common languages offered, but Ojibwe, Yiddish, Sanskrit, Hebrew, Arabic and Japanese are also included at some institutions. Of note, French-speaking programmes often have an English language requirement in their engineering programmes for professional development.

STUDY OBJECTIVES AND RESEARCH QUESTIONS

Given the demanding engineering curriculum, finding time and options for complementary studies remains challenging for students. That said, engineering schools in Canada are making targeted efforts to provide a variety of opportunities for exposing students to the social sciences and humanities either directly (through mandatory and elective complementary studies courses) or through other experiences, such as problem-based learning, international opportunities and the introduction of non-engineering minors. While these efforts should be more broadly evaluated to

assess their degree of success in integrating the humanities and social sciences into the engineering curriculum, the present article aims to describe students' experiences and opinions of complementary studies, so as to understand the impact these efforts have on engineering students' learning. Here, the authors explore this question in two Canadian engineering programmes, the University of Waterloo and the University of Guelph, using the framework of the assessment of graduating student performance based on twelve programme outcomes or graduate attributes, as defined by the CEAB [10]. The University of Waterloo and the University of Guelph are both Canadian institutions with engineering programmes, and are located in the province of Ontario. The University of Waterloo programmes have mandatory Cooperative Education (co-op), which involves alternating academic and full-time work experience semesters, and the University of Guelph programmes offer co-op as an option.

Complementary studies at the University of Waterloo are generally implemented in six complementary studies courses, comprised of one or two mandatory courses and four to five elective courses from three specified lists, categorised as either *impact courses* (e.g. ethics, environmental and sustainability assessment), *engineering economics courses or humanities and social sciences courses (e.g. anthropology, classical studies)* [53].

At the University of Guelph, complementary studies are implemented in the engineering programmes through a series of two required courses (*Engineering Economics* and *Science and Technology in a Global Context*) and four elective courses selected from a broad list of options in humanities and social sciences, at least one from each of three categories: central issues (e.g. world politics), methodologies (e.g. leadership development in small organisations) and social sciences (e.g. sociology). Some complementary studies content is also delivered in a series of four core design courses [54].

The research questions that guided this process can be summarised as the following:

1. How do students understand their experience with complementary studies fields during their degree?
2. Do they see the usefulness of the skills and content learned in their complementary courses for the job market?
3. Would they be interested in opportunities for greater exposure to the humanities and social sciences?
4. How successful are these courses in developing communication and other soft skills?
5. What are the ways in which the value of complementary studies could be enhanced for engineering students?

To explore these questions, two studies were implemented. First, two of the authors conducted focus groups with engineering students in the final year of their graduating programmes at both the University of Waterloo and the University of Guelph. Second, the following academic year, a voluntary survey on complementary studies courses was completed by first and fourth-year students at the University of Guelph.

COMPLEMENTARY STUDIES: THE STUDENT EXPERIENCE

Study 1: Student Focus Groups

In winter 2015, four focus groups, each two hours in length, were conducted; two at the University of Guelph and two at the University of Waterloo. The focus groups were led by Donald and Lachapelle. A total of 14 students in their final year participated, 10 male and 4 female. The students were interviewed in groups of three to four and, given the depth and breadth of the discussions, the small individual focus group numbers proved to be appropriate and provided an excellent variety of responses and opinions. The engineering programmes represented at each institution were biomedical and environmental from the University of Guelph, and civil, environmental and chemical from the University of Waterloo.

The objective of the focus groups was to explore the student perspective on complementary studies courses in the context of the CEAB graduate attribute framework. Therefore, the main questions were structured specifically around CEAB graduate attributes and the complementary study course experience. Students were also asked to discuss the place of cultural competency and versatility in the context of complementary studies.

Focus Group Observations

Focus group sessions were organised around three topics and set of questions dealing with non-technical or soft skills graduate attributes, complementary studies, and cultural competency and versatility.

CEAB Soft Skill *Graduate Attributes*

A set of focus group questions was designed to gain student feedback on experience and self-perceived competency in the social sciences and humanities as it relates to the seven *soft skill* graduate attributes (GA); namely:

GA 6. Individual and team work
GA 7. Communication skills
GA 8. Professionalism

GA 9. Impact of engineering on the society and the environment
GA 10. Ethics and equity
GA 11. Economics and project management
GA 12. Lifelong learning

Questions included: *How important are these attributes to you?, What kind of exposure did you have to them?* and *Do you feel you need more or less exposure to these attributes?*

In all focus groups, it became apparent that using the graduate attribute framework creates an awareness of the importance of the soft skills and allows students to reflect in a structured and fruitful way on the relative contributions made by difference aspects of their programme, including the engineering courses, complementary studies courses and their experiences outside the classroom setting.

All students viewed proficiency in these seven graduate attributes as essential to becoming an effective engineering professional. One group even saw soft skills as more important than technical ones (in particular, communication and individual and teamwork). In terms of their own experience of the curriculum, students felt that most of their exposure to the soft skill graduate attributes had come from their engineering courses and, in particular, from their participation in design project courses, but recognised the role of complementary studies particularly in enhancing their communication skills, as well as their ability to write and speak to both technical and non-technical audiences.

Most participants believed that there could be more opportunities in the curriculum for improving their oral and writing skills. They spoke of the lack of feedback on their writing and of rubrics that put little emphasis on quality of writing in their engineering courses:

> *…there is always a section about grammar and spelling but it is always very low-weighted compared to the rest of the report, so like even if you got an absolute zero [on it], you could still pass the report assuming you have met all of the others criteria.*

But, while all participants indicated a strong belief in the importance of writing and oral skills for the professional world and in the lack of opportunities to develop such skills in the present curriculum, most participants showed little enthusiasm at the idea of complementary studies courses meant to target written and oral communication skills.

Students also noted the importance of activities set outside the classroom in learning the soft skills graduate attributes. Among them, co-op was identified as key to developing and reinforcing each of the seven soft skill attributes and providing a tangible link between what is learned in the classroom and what is useful in the workplace. This became clear in comments, such as: *Co-op is where we start to see problems in writing* (despite the significant amount of report writing required in courses) or *80% of my experience with presenting has come from co-op terms*. On risk and safety one student commented: *I did not know how important it was until I went into the workplace*. With respect to professionalism and communication, another student said: *You learn a lot from interviews, how to talk to people about yourself and your profession*. Students also mentioned the importance of their co-op supervisors in learning professionalism: *…in terms of professionalism, I learned a lot in co-op terms especially due to my supervisor.*

Students also identified the classroom as providing a safe environment to work out some skills before going into co-op. On team work, for example, one student said that: *I think it is important that you learn that [team work] because when you go in the real world you are going to be working with different types of people*. Students also identified the positive role that participation in clubs, societies, newspapers and other campus activities can have in the development of soft skills. This is not surprising, but it does indicate the value of co-op and campus opportunities to the development of soft skills.

Finally, students emphasised the importance of models and the faculty's own behaviour, stating several times that in order for them to truly internalise the soft skill graduate attribute, it is important for faculty members themselves to exemplify these skills. Examples provided included dress code and behaviour (professionalism), keeping course material current and up-to-date (lifelong learning), effective lectures and presentations (communication skills), and adequate referencing of material (ethics).

Overall, students rarely brought up complementary studies when discussing graduate attributes. While they agree that complementary studies could help them develop the graduate attributes, it was hard for them to describe how this had actually happened in their case. This initial conversation on graduate attributes; however, was instrumental in preparing participants for the following discussion on complementary studies courses and the ways in which such courses are and are not presently used in the curriculum.

Complementary Studies Courses

The authors began the focus group section on complementary studies (CS) by explaining the rationale for these courses in the context of the graduate attributes and the accreditation process. Questions then included: *Do you feel that the role*

of complementary studies has been explained sufficiently to you?, Did you enjoy these courses and how much time did you spend working on them?, Did you feel these courses were useful?, What about now?, What did you learn? and *Are there particular skills or topics that you feel could benefit you?*

In all focus groups, it rapidly became evident that students had generally placed little importance on their CS courses. They indicated that the purpose of the CS requirement had not been explained very clearly during their degree, nor had the courses themselves been presented as particularly relevant or important to their development. Some participants were even surprised to find out that the CS requirement was part of the accreditation process and not an institutional choice. Students generally felt that this lack of understanding had contributed to their attitude and approach to their CS requirement, that is, as one of the *hurdles* to get over. This attitude was expressed in statements such as: *…the focus is on engineering courses. Unless you are interested in it, you just get by*, and *I only took them because I had to*.

Many participants expressed that it would have been beneficial to have the opportunity for greater guidance when choosing their CS courses. At both the University of Guelph and the University of Waterloo, students are required to select their elective CS courses from an approved list. And, while students in our focus groups had all been very familiar with these lists and their content, many had still struggled with course selection. What course should they have taken and why? Now in their final semester and reflecting back on graduate attributes, they could see the potential usefulness of the CS courses and wish they had been provided with more information and greater guidance regarding their selection earlier in their degree. For some, there was the sense of a missed opportunity for valuable experience and skill development:

> *I think if I, if I had more knowledge about this in first year, like these are the things the accreditation board wants us to have, I might have picked my complementary studies courses a bit differently or if I knew maybe what skills I wanted to develop….*

Others felt that if a stronger link between the demands of the job market and the complementary studies courses had been made, they might have paid more attention to them:

> *…when you are starting your programme what are employers looking for? … people with … more focus on the business aspect or …people with good writing skills, or [are they] really looking for technical people, or computer savvy? [It] would probably be useful to help say oh well employers are interested in having this and this kind of focus, maybe I should take some electives that should associate with that.*

For those who did make the effort to maximise the opportunities provided by the CS courses, there had been practical barriers. Students reported that, by its nature, the engineering degree makes it difficult to fully benefit from CS courses. Workload, particularly in the early years, makes students feel like they are in *survival mode*. Students reported taking CS courses *…that were easy or will reduce workload*; for example, introductory courses with a reputation for multiple choice tests and examinations as oppose to essays. Students contemplating graduate studies also pointed to their worry about their engineering grade point average (GPA) as greater than their desire for interesting CS courses, giving them another incentive to choose *easy* courses.

Beyond the pressures of the engineering curriculum, there are other logistical issues that made it difficult for students trying to choose meaningful CS courses. Commonly identified issues were:

1. Scheduling: at both Guelph and Waterloo, the CS lists appear varied and long, but the engineering schedule makes it hard to find any space, and choice is in reality very limited. Students do have some options at night, but many reported being tired after a full day of lectures and laboratories.
2. Accessibility: popular courses fill quickly. Even if a course does fit in students' schedules, access can be limited.
3. Prerequisites: access to many interesting upper-year courses require prerequisites, barring access to engineering students who have difficulties fitting specific courses into their schedule. CS courses often end up being first-year introductory courses, which in the words of one student are *not that productive*.

For all these reasons, students reported feeling constrained to take at least some distance education (DE) courses. With respect to DE courses, the student feedback was mixed. While some did not like the experience, others stated *you get out what you put in*.

Overall, and in the context of this discussion of graduate attributes, students did look back on their CS courses as providing positive and different types of experiences:

- *a different kind of thinking;*
- *free form;*
- *emphasised having a thesis … making a statement and actually backing it up;*
- *definitely gave some exposure to different perspective;*
- *I feel that the biggest thing that complementary studies courses have done is, it takes you out of the engineering environment basically … [it puts you] somewhere where you're not necessarily familiar with the environment…*

how things are typically done and it, it shows you that different ways of doing things and highlights some of these ways …you kind of have to do something you are not comfortable with necessarily;

- *feeling like a minority* as an engineering student in a humanities course, something, which many participants agreed, was a valuable experience.

Cultural Competency and Versatility

A final group of questions dealt with cultural competency and versatility within the engineering degree in general and CS requirement in particular. Here, questions included: *How much international exposure have you had?, Is it important in today's job market?, Do you feel that your degree has provided you with the versatility required in the job market?, What role did complementary studies play in this?*

Students identified cultural competency as important but felt limited in their experience. One participant talked about their experiences with international exchange students in teams. In the same group, another student talked about the benefits of not deciding partners in teamwork, but being assigned to work in a particular group did …*get you ready for the real world.* Another participant reflected on the fact that in the Canadian work force …*you are going to have to face a very inter-cultural team.*

A few students explained that while they did feel culturally *competent*, this did not come from the classroom, but rather from experience outside the classroom, most notably co-op and the workplace. Interestingly, most groups also identified cultures with different disciplines outside engineering and discussed the CS courses as contributing to their cultural competency. They talked in particular of the humanities as a different world, often with greater percentage of female students. Commenting on a history course and depth and breadth of knowledge, one student said: *it was an eye-opener.* Another participant commented on the different atmosphere in the humanities part of the campus. One participant explained the potential of complementary studies for cultural competency in this way: *I think an important thing is having a course that helps you understand that culture is important but having a course that also includes how to respect the culture as well is important.*

In relation to versatility, although they planned to pursue a career in engineering, the students believed that their degree had provided them with a foundation that could allow them to pursue paths beyond engineering; this belief was exemplified by a comment from a student who stated …*many of my classmates took the MCAT or LSAT.* A few participants spoke of problem-solving as an exportable skill learned in the degree. The actual process of making it through such a challenging programme was also described as a useful skill developed during their undergraduate studies.

Summary about Focus Group Information

Students' opinions and experiences about CS were consistent among participants and suggest that CS courses are valuable and instrumental in the integral and comprehensive education of engineers, but that more explicit and clear explanations of the objectives and functioning of CS would make this process more intentional and consequently less frustrating and challenging for the students. To explore if the experiences reported and opinions obtained in the focus groups were widespread, a survey study was implemented. The design and results of this second study are described in the following sections.

Study 2: Voluntary Survey

In winter 2016, all first-year and fourth-year students at the University of Guelph were invited to participate in a study on the importance of CS and soft skill development. Participants were recruited in class through announcements and reminders on the University of Guelph's learning management system.

A total of 135 first-year and 73 fourth-year participants answered the survey for which they were entered in a draw to win one of 20 hospitality $10 gift cards. Participants were asked demographic information, including their gender and age, and open-ended questions on their attitudes toward CS and the factors that could influence their selection of CS courses including: *What rationale might someone give as to why complementary studies are important or valuable for the Bachelor of Engineering programme?* and *What rationale might someone give as to why complementary studies are not important or valuable for the Bachelor of Engineering programme?*

Voluntary Survey Results

When explaining the usefulness of CS, participants in first and fourth year did not differentiate themselves in notable ways. The majority of participants made reference to the importance of being a well-rounded individual: *You become a much more well-rounded student and it allows you to expand your horizons into new studies.*

Many participants related the importance of CS to the work place: *Working with others and understanding your client lives is critical to success in the workplace.* Some answered the question in terms of course content and described the

benefits of CS in providing the larger context: *Learn more about how the world works socially, economically, etc, rather than just technically.*

Other participants focused on skills, communication and social skills, creativity, and problem-solving most often.

- *Makes sure we are more than just logical robots.*
- *In the long run, these courses allow an individual to develop skills everyone should have, like communicating with others in a variety of forms.*
- *It helps engineers think from another perspective which can make solving a problem easier. It can help increase an engineer's creativity so that they could design things more out of the box.*

On the other side, when explaining why CS might not be useful, participants of both years explained that CS could be seen as taking time away from the engineering curriculum and contribute to the heavy course load, and that the course content may seem irrelevant to a future engineer or the connection is difficult to see.

- *Some complementary studies may be nothing but waste of time, providing information that may be irrelevant or not interesting to the individual.*
- *Sometimes it is difficult to see the direct relation of a course to a skill I need to acquire to succeed in my field in the future.*

Overall, an analysis of the responses suggest that, when asked, participants were able to reflect and provide a reason for the place given to the humanities and social sciences within their curriculum, and that these answers were very similar whether students were in their first or their fourth year in the programme.

RECOMMENDATIONS

Both survey and focus groups suggest that the majority of engineering students in first and fourth year hold some understanding of the importance of the humanities and social sciences courses within their curriculum; and, conceptually, many see this importance in terms of developing non-technical or soft skills. In practice, however, students struggle to truly benefit from their contact with other disciplines, because of a heavy workload, as well as practical barriers, such as scheduling and prerequisites. Students also feel a general lack direction or understanding of what they are supposed to learn in specific courses and do not reflect on their personal goals in terms of soft skills.

Participants in focus groups did suggest ways to improve the effectiveness of CS courses, based on their ideas the authors propose the following suggestions:

1. Communicate the importance of CS courses for accreditation and employers early in the programme.
2. Develop tools to better guide students in their selection of CS courses and to help students plan and schedule their courses. This could include suggesting series of courses related to a particular theme or skill.
3. Link courses in the CS lists to specific graduate attributes.
4. Provide opportunities for upper-year undergraduate students to talk about their own experience of particular CS courses to lower-year cohorts. Students would like to hear from their peers about CS courses, not just their professors or programme counsellors. Informal sessions could be organised.
5. Many participants expressed an interest in packages of CS courses to guide them through their CS selection and allow them to market themselves in a certain way: *I do not think they want to look at what elective did you take… but having the certificate or something else you can say yeah like I focused my ideas on whatever topic right?* This is an interesting idea for engineering programmes to develop at a curricular level, in order to create CS certificates that provide this information to recruiters during selection processes.

Soft skills and non-technical areas are captured both in engineering and CS courses. The added value of the non-engineering CS courses experienced by the participants is that they provide a different perspective and culture, and can take the engineering students out of their comfort zone. Students do not always perceive that they can further extend the depth of their soft skills development from the CS courses, but the recommendations provided above may help them to do so. From the focus group discussions and the surveys, one can extract observations of note that can create the environment for a productive dialog with students related to their approach to intentionally developing soft skills as part of their undergraduate engineering educational experience. These are:

1. Graduate attributes provide a good framework for relevant discussion; and,
2. The goal of preparing students for job readiness provides a relevant context for students that capture their attention. This way one can inform both student understanding and discussion related to soft skill attitudes and soft skill development.

SUMMARY

This study has explored the place and value of the humanities and social sciences in the Canadian engineering curriculum. The four focus group sessions with graduating students at the two different universities, as well as the

written surveys of first and fourth-year students at the University of Guelph have provided valuable insight into the attitudes and behaviour of students related to the complementary studies requirement mandated of all Canadian accredited engineering programmes. The authors believe that the time is right for such a focus as the new CEAB soft skill graduate attributes provided an excellent framework to organise useful discussions. While the responses of first and fourth-year students in surveys did not differ much when it came to explaining the usefulness of complementary studies courses, students who participated in the focus groups discussions that were organised around graduate attributes ended up reflecting more deeply on the place complementary studies courses did and could have in their curriculum. Thinking back on their undergraduate experience, the students in the focus groups demonstrated a strong grasp of the soft skill graduate attributes, yet saw their humanities and social sciences courses as a *missed opportunity* brought on by their lack of understanding of the purpose of these courses, as well as practical challenges associated with the heavy workload and busy schedule of a demanding curriculum.

Given the effort that Canadian programmes put toward creating complementary studies lists that meet accreditation standards, students suggested that information and guidance beyond that presently available should be provided. Understanding the importance of the complementary studies courses for employers and the workplace, appreciating complementary studies courses as an integral part of the graduate attributes, and obtaining some guidance from upper-year students would be beneficial.

Equally important would be scheduled paths for complementary studies courses early in their programme, formal guidance in the form of online tools or guidebooks identifying particular complementary studies themes (e.g. law, business or ethics), and increased awareness of certificates or minors as a possibility. All of this would go a long way toward maximising the value of, and appreciation for, complementary studies courses and, thus, humanities and social sciences content and competencies.

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