

# WHY DOES IT MATTER? EXPLAINING THE IMPORTANCE OF COMPLEMENTARY STUDIES TO FIRST-YEAR ENGINEERING STUDENTS

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**Abstract** – While complementary studies are an accreditation requirement and feature prominently in the Canadian engineering curriculum, focus-group conversations with upper-year engineering students have indicated that a lack of awareness of, and appreciation for, soft skills development often prevents students from benefiting from complementary studies to the fullest. Given this reported difficulty to grasp the importance of complementary studies, a study was undertaken at the University of Guelph using a quasi-experimental design to explore the possibility that triggering self-assessment and awareness about career development early in the engineering curriculum promotes greater engagement with complementary studies and soft-skill development. First-year engineering students took part in a learner-centered activity focused on the importance of complementary studies for the development of soft skills. Through active learning exercises and case studies of successful engineering graduates, who described the skills and knowledge required to perform their daily work, the session was designed to encourage students to develop greater self-awareness and intentionality about complementary studies and their associated graduate attributes. The outcomes of this activity and issues on how to embed it in the Engineering first-year curriculum will be discussed.

**Keywords:** Complementary Studies, Soft Skills, Graduate Attributes, Student-Centred Learning, Job Readiness, Goal Orientation.

## 1. INTRODUCTION

The successes and challenges of universities at teaching soft skills have become a frequent topic of discussion in the media (e.g., [1],[2],[3]). Soft skills, those skills that complement the technical skills associated with each specific field, are understood to be important for success in the work place but not always taught with

intentionality in the curriculum [9]. Within the Canadian engineering curriculum, soft skills are, at least in part, thought to be learned in complementary studies (CS) courses (defined to include humanities, social sciences, arts, management, engineering economics, and communications). But how do students understand their experience with CS during their degree? How do they choose their CS courses? Do they see the usefulness of the skills and content learned in these fields for the job market and actively choose courses with an eye toward job readiness? If not, how can we help students get the most out of their CS?

This project builds on focus-group conversations with upper-year engineering students at both the University of Guelph and the University of Waterloo about their CS experience [4]. These focus groups revealed that while students understood the importance of all graduate attributes, including those associated with soft skills, they placed little importance on their CS courses in developing the graduate attributes. Students indicated that the purpose of the CS requirement had not been explained clearly during their degree, nor had the courses themselves been presented as particularly relevant or important to their development. Some 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, one of “hurdles” to get over. Reflecting back from their final semester on graduate attributes and soft skills, many could now see the potential usefulness of the CS courses and wished they had been provided with more information and greater guidance regarding their selection earlier in their degree [4].

Given this reported difficulty to grasp the importance of CS, the present project seeks to investigate the hypothesis that introducing a CS focused learner-centred activity (intervention) to first year engineering students can promote greater engagement with CS and soft skills development for engineering students. In winter 2016, this

intervention was created and delivered, in collaboration with Dr M. Gloria González-Morales from the Department of Psychology, as part of a pilot study designed to evaluate its impact. The intervention consisted of active learning exercises and case studies of successful engineering graduates, who described the skills and knowledge required to perform their daily work. The session was designed to encourage students to develop greater self-awareness and intentionality around complementary studies and their associated soft skills and graduate attributes.

## 2. METHODOLOGY

### 2.1. Approach

The current study examines whether implementing a student-centred learning exercise, or “intervention”, early in an engineering program can improve student understanding of and attitude toward complementary studies as they relate to soft skill development in engineering programs. Given that goal orientation (“the goal pursued by individuals in achievement situations”) has been shown to impact attitudes toward skill development and learning more broadly, the study uses goal orientation as a moderating variable [6].

There are two types of goal-orientated approaches, *performance goal orientation* and *learning goal orientation*. Individuals with a performance goal orientation are more likely to not challenge themselves and search for easy tasks that they can perform well and for which they can get complimented. Conversely those with a learning goal orientation focus more on challenging themselves in learning situations and seek to acquire and understand knowledge [7]. For example, a learning goal-oriented student would more likely take courses that are challenging or outside their field of competence in order to develop new skills and knowledge while a more performance goal-oriented student would be more tempted to take courses dealing with familiar skills and knowledge in the hope of receiving a higher grade.

This study has three main hypotheses:

- H1: Students who underwent the intervention will show a pre to posttest increase in the value of complementary studies for skill development.
- H2: Students who underwent the intervention will show a pre to posttest increase in the importance of complementary studies for their studies and future careers.
- H3: Students with a low learning goal orientation who participated in the intervention will show a greater increase in the value of complementary studies for skill development compared to those with a high learning orientation.

- H4: Students with a high performance goal orientation who participated in the intervention will show a greater increase in value of complementary studies for skill development compared to those with a low performance goal orientation.

### 2.2. Procedure

The School of Engineering at the University of Guelph has approximately 400 first-year students. In winter 2016, all first-year students 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 learning management system. As incentive, those who volunteered to participate in the study were entered in a draw to win one of 20 hospitality \$10 gift cards.

During winter semesters, first-year engineering students at the University of Guelph enroll in either HIST\*1250 (Science and Society in a Global Context) or ENG\*1210 (Engineering Mechanics) with roughly half of the cohort enrolled in each course. In this quasi-experimental design, students in HIST\*1250 were chosen as the experimental group to receive a 90-minute intervention on the importance of CS and their associated soft skills. Students in ENGG\*1210 did not receive the intervention and acted as the control group.

To measure the impact of the intervention, voluntary online pretest and posttest surveys were administered to participants in both HIST\*1250 and ENG\*1210. The pretest occurred in early January and was administered to participants enrolled in either class. The posttest was administered in early March to all students, including those participants who completed the pretest in either class. The pretest and posttest surveys consisted of the same questions.

Participants were asked to provide identification and demographic information, such as their university identification number, gender, and age. They were asked about their future career aspirations and answered questions meant to measure their goal orientation and attitudes towards course selection, skill development, and complementary studies. Finally, participants were asked to identify which graduate attributes as set by the Canadian Engineering Accreditation Board [5], contribute to complementary studies. The list of survey questions is presented in Appendix A.

### 2.3. Intervention Activity

At the end of January 2016, students enrolled in HIST\*1250 (participants in the experimental group) underwent a 90-minute intervention targeting attitudes towards complementary studies and soft skills. Of the approximately 175 students present, 90 students completed a voluntary feedback survey. The intervention

consisted of a presentation on the accreditation requirements for CS, the importance of soft skills from an employer perspective, and the identification of explicit opportunities for CS courses in the Guelph engineering curriculum, all organized around three main student-centred activities:

- (1) Case studies: First-person accounts from current and past engineering students from the University of Guelph identifying their use of soft skills in their coop terms and their profession were discussed so as to present participants with comparable others (a peer and a recent peer now on the job market) and allow them to build personal connections to the material;
- (2) Soft skill self-assessment: Participants were asked to self-assess competency in the soft skills associated with CS and identify gaps and personal areas for improvement. Soft skills were then linked to job interview skills and job readiness;
- (3) Goal setting: Participants were asked to create a plan to enhance the soft skills they had individually identified as important to them and prepare a list of specific, measurable, actionable, realistic, and timely goals linked to soft skills and CS courses.

Together these activities were designed to encourage participants to develop awareness and intentionality around complementary studies in their association with soft skills development.

Students enrolled in ENG\*1210 did not receive an intervention and served as the control group.

## 2.4. Measures

Participants in both the experimental group and the control group, and in both pretest and posttest, were asked questions that were measured on four different scales.

- (1) Value of Complementary Studies for Skill Development. Participants were measured on the value they placed on complementary studies for skill development based on two questions created by the study team and rated on 7-point Likert scale. (Sample question: "Thinking about education and achieving an engineering degree, how valuable do you believe complementary study courses are for your skill development?") The scale had a reliability of .898 at the pretest and .933 at the posttest for the study.
- (2) Importance of Complementary Studies. Participants were measured on the importance they placed on complementary studies for their studies and future careers based their level of agreement with four questions created by the study team and rated based on a 7-point Likert scale. (Sample question: "Thinking about education and achieving an engineering degree, how important do you believe complementary study courses are?") The scale has a

reliability of .820 at the pretest and .904 at the posttest.

- (3) Learning Goal Orientation. Participants were measured on learning goal orientation based on a 5-point Likert scale, rating their level of agreement with 8 statements created by Button et al., (1996) [8]. (Sample question: "The opportunity to do challenging work is important to me.") The scale had a reliability in Button et al., (1996) [8] of .79, in the current study the reliability at the pretest was .851 and was .687 at the posttest.
- (4) Performance Goal Orientation. Participants were measured on performance goal orientation based on a 5-point Likert scale, rating their level of agreement with 8 statements created by Button et al., (1996) [8]. (Sample question: "I feel smart when I do something without making any mistakes.") The scale had a reliability in Button et al., (1996) [8] of .76, in the current study the reliability at the pretest was .672 and was .673 at the posttest.

## 3. RESULTS

### 3.1. Impact of Intervention

The online survey study involved a control group of 42 at pretest and 32 at posttest. Of these, 10 participants answered the online surveys both at pre and posttest. The experimental group had 35 participants at pretest and 40 participants at posttest. Of these, 4 participants answered the online survey both at the pre and posttest.

To examine the hypothesis that the intervention had a positive impact on student attitudes toward complementary studies and soft skills, the survey results were examined for differences between the control and experimental group on: the value of complementary studies for skill development, the importance of complementary studies, learning goal orientation, and performance goal orientation, at pretest and posttest. Four different one-way analysis of variance were considered and no significant differences between the control and the experimental group in the pretest or posttest for any of the four variables were found. Based on the results of this analysis it was concluded that there were no differences between the two groups.

Given that no significant differences were found between the control and the experimental groups at pretest and posttest and that only a few participants completed both tests, further analyses were performed on combined samples of the control and experimental groups. Two samples were created, one sample (Sample 1) at pretest (in January) and another (Sample 2) at posttest (in March), with the intent to study whether the value of complementary studies for skill development, learning

goal orientation and/or performance goal orientation might correlate strongly with the importance of complementary studies directly.

Correlations were performed on learning goal orientation, performance goal orientation, importance of complementary studies, and value of complementary studies for skill development with the results summarized in Table 1 below.

Table 1 – Correlations to CS Importance ( $p < 0.01$ )

Relation	Sample 1	Sample 2
Value of CS for Skill Development to Importance of CS	$r = .557$	$r = .800$
Learning Goal Orientation to Importance of CS	$r = .360$	not significant
Performance Goal Orientation to Importance of CS	not significant	not significant

To further examine the positive correlation seen between Value of CS for Skill Development and Importance of CS shown in both samples, it was hypothesized that this relationship might be moderated by individual goal orientation. A regression analysis was conducted to examine this possibility. The analysis showed for both Sample 1 and Sample 2 that neither performance goal nor learning goal orientation moderated the relationship between value of CS for skill development and importance of CS.

### 3.2. Additional Survey Results

In addition to the pre and posttest Likert Scale questions, a number of open-ended questions on the importance of complementary studies and their relation to course selection and graduate attributes were asked. The results of these additional survey questions are not presented in this paper and await further analysis.

## 4. INTERVENTION FEEDBACK

To gain student insight into the intervention itself, participants were asked to complete an in-class feedback survey at the end of the session. In general, the 90 participants who answered the survey found the intervention useful but too long and not practical enough. Many noted that they would have liked to see more case studies included. Participants also reported that the intervention made them think about their future careers and the need to develop skills beyond the technical. Many also noted that they had not previously thought about complementary studies as a means to develop soft skills.

In addition, participants rated the session on several specific questions, with the following results:

- **47%** of attendees noted their enjoyment of the session
- **55%** of attendees found the session worthwhile
- **63%** of attendees indicated an intention to think more carefully about course selection
- **90%** of attendees indicated that they understood the importance of soft skills
- **84%** of attendees recommended that **all first-year engineering students should receive this session**

## 5. DISCUSSION

The current study was designed to examine whether implementing a student-centred learning exercise, or “intervention”, early in an engineering program could improve student understanding of and attitude toward complementary studies as they relate to skill development in engineering programs. Although the study did not have large enough samples in the control and experimental conditions, nor enough participants who completed both the pretest and posttest, to strongly examine the hypotheses, it nonetheless provides valuable insights into the importance of having students critically consider their complementary studies training as it relates to non-technical skills training for their profession. As such, the study can serve as a pilot to inform subsequent research and development of interventions for training first-year engineering students to contemplate the significance of CS courses for their career planning and job readiness.

Students who participated in the intervention provided valuable feedback on the ways in which the session could be improved. A particularly interesting observation from the feedback is that although less than half (i.e., 47%) of the students rated the session as enjoyable, a strong majority (i.e., 84%) of the participants recommended that all first-year engineers receive a similar intervention. Like those fourth-year students who participated in the focus groups of the previous study [4], these first-year students recognize a need to learn about CS courses and their place in the engineering curriculum and its graduate attributes. This finding supports the notion that engineering programs should do more to convey information related to the importance of CS to their students.

Given that students with different goal orientations will likely see complementary studies in different ways, training programs should be developed in ways to appeal to students with different orientations. For example, training for students with learning goal orientation could emphasize that CS courses provide them with an opportunity for intellectual as well as personal growth, while training for students with a performance goal orientation could emphasize the importance of CS courses for improving job readiness and other tangible benefits.

In addition to a training session (or intervention), ideas to consider when trying to improve intentionality around complementary studies and soft skill development include: information sessions during orientation weeks, materials sent out with the acceptance packages, and the development of information resources for program counsellors to support students' purposeful use of CS within their engineering degree (e.g., online videos, reference guides).

Beyond this, two aspects of the study design could be modified to improve the impact of the research components of the work. (1) The timing of the intervention: the placement of the intervention in second semester of study was not ideal as the control and experimental group had different exposure to CS based on first-semester course selection. It is anticipated that future interventions will be targeted at students in their first semester of university. (2) The methodology for recruiting participants: selection bias may have been a contributing factor in the results here. Selection into the experimental group did not occur randomly and was based on a convenient split in the courses students were currently taking. Furthermore, survey recruitment was based on the potential of a small reward (\$10 hospitality gift card), perhaps biasing participation toward students who already valued complementary studies and soft skill development. Future studies will look for techniques to randomly assign participants to either the control or the experimental group and encourage greater participation in the voluntary surveys.

Finally, future research may find more benefit in greater mixed method approaches. Qualitative data gathered through interviews may provide contextual information that will illuminate some of the behavioral intentions and attitudes that our quantitative methods could not explore. However, more quantitative methods and larger samples remain useful to understand broader patterns and relationships both in individual student over time and between students.

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This study has been reviewed and received ethics clearance through the University of Guelph.

### References

- [1] Brown, Louise. 22 February 2016. "Young Grads Need to Brush up on 3 R's, Employers Say" Toronto Star.
- [2] Morris, Catherine, 16 November 2014. "Panel Discusses Job-Readiness for College Graduates," *Diverse Issues in Higher Education*.
- [3] Tattrie, John, 12 January 2016. "Bridging the Experience Gap: Young Graduates Making an Immediate Impact in the Workforce," *The Chronicle Herald*.
- [4] Donald, John, Sofie Lachapelle, J. McIsaac, T. Abraham, R. Clemmer, K. Gordon, S. McCook, R.G. Zytner, "Training Versatile Engineers: A Historical and Present Perspective on the Place of the Humanities and Social Sciences in the Canadian Engineering Context." in Proc. Canadian Engineering Education Conference (CEEAA15), (Hamilton, ON; May 31-June 3 2015), 8pp., 2015
- [5] Engineers Canada -- Canadian Engineering Accreditation Board, 2015, "2015 Accreditation Criteria and Procedures", retrieved from <http://www.engineerscanada.ca>
- [6] Chiaburu, D. S., & Marinova, S. V. (2005). What predicts skill transfer? An exploratory study of goal orientation, training self-efficacy and organizational supports. *International journal of training and development*, 9(2), 110-123.
- [7] Locke, E. A., & Latham, G. P. (2002). Building a practically useful theory of goal setting and task motivation: A 35-year odyssey. *American psychologist*, 57(9), 705-717.
- [8] Button, S. B., Mathieu, J. E., & Zajac, D. M. (1996). Goal orientation in organizational research: A conceptual and empirical foundation. *Organizational behavior and human decision processes*, 67(1), 26-48.
- [9] Schulz, B. (2008). The importance of soft skills: Education beyond academic knowledge. *Journal of Language and Communication*, June, 146-154.

## APPENDIX A: Pre and Post Test Survey

### Value of Complementary Studies for Skill Development:

1. Thinking about education and achieving an engineering degree, how valuable do you believe complementary study courses are for your skill development?
2. Thinking about your future career, how valuable do you believe complementary study courses are for your skill development?

### Importance of Complementary Studies:

1. Thinking about education and achieving an engineering degree, how important do you believe complementary study courses are?
2. Thinking about your future career, how important do you believe complementary study courses are?
3. Thinking about education and achieving an engineering degree, how valuable do you believe the content knowledge is in complementary study courses?
4. Thinking about your future career, how valuable do you believe the content knowledge is in complementary study courses?
5. \*To what extent do you agree that complementary studies courses make an individual a more well-rounded, globally-oriented student?
6. \*To what extent do you agree that complementary studies courses make an individual a more well-rounded, globally-oriented citizen or employee?

*Note: \*Item removed from the scale. Did not show a good fit in an item analysis.*

### Learning Goal Orientation:

The eight questions related to Learning Goal Orientation were taken from Button et al. (1996) [8].

### Performance Goal Orientation

The eight questions related to Performance Goal Orientation were taken from Button et al. (1996) [8].

### Demographics

1. Please provide your University of Guelph student identification number: \_\_\_\_\_
2. Please indicate the gender(s) with which you identify
  - a. Female
  - b. Male
  - c. Other \_\_\_\_\_
3. What is your current age in years: \_\_\_\_\_
4. Did you take HIST\*1250 Science and Technology in a Global Context in the Fall 2015 semester?
  - a. Yes
  - b. No.
5. Please indicate which course you are currently enrolled in for the Winter 2016 semester at the University of Guelph:
  - a. ENG\*1210 Engineering Mechanics I
  - b. HIST\*1250 Science and Technology in a Global Context
  - c. I am currently enrolled in both courses for the Winter 2016 semester
6. Are you enrolled in an engineering degree?
  - a. Yes
  - b. No

7. Between the time you completed a secondary school diploma and prior to your current enrolment at the University of Guelph did you (please select all that apply):
  - a. Do a fifth year of high school (e.g., victory lap)
  - b. Take time off from school to work
  - c. Enroll at another university or college
  - d. Enroll in another program and then transfer to your current program
  - e. None of the above
8. Is English your first language?
  - a. Yes
  - b. No
  - c. Prefer not to answer
9. What current career goals do you foresee for yourself (please select all that apply)?
  - a. Engineering work
  - b. Research
  - c. Teaching
  - d. Consulting
  - e. Other \_\_\_\_\_

### Attitudes towards Course Selection and Complementary Studies

1. When you register for courses, what factors do you consider as you make your course selection (e.g., instructor, course calendar requirements, workload, timing and scheduling, interest in content, distance education, prerequisites, etc.)? \_\_\_\_\_
2. What rationale might someone give as to why Complementary Studies are important or valuable for the B.Eng program? \_\_\_\_\_
3. What rationale might someone give as to why Complementary Studies are not important or valuable for the B.Eng program? \_\_\_\_\_

### Graduate Attributes

The Canadian Engineering Accreditation Board (CEAB) has outlined attributes they expect graduates of engineering programs to possess. Based on your experiences with complementary studies courses, **to what extent do you feel that the following attributes are developed in those complementary studies courses?**

1. A knowledge base for engineering
2. Problem analysis
3. Investigation
4. Design
5. Use of engineering tools
6. Individual and team work
7. Communication skills
8. Professionalism
9. Impact of engineering on society and the environment
10. Ethics and equity
11. Economics and project management
12. Life-long learning