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Integrating Professional Skills and Leadership into an Undergraduate Engineering Program

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Background

Professional skills have gained traction as an essential component of engineering education. The case for such skills among graduates has come from engineering education research and program development [1, 2, 3, 4], as well as from industry [5, 6]. Rick Stephens, a retired Senior Vice President of Human Resources and Administration at the Boeing Company, states that the success or failure of many engineering graduates in the workplace is not determined by differences in technical competency, but by inadequate professional skills [6]. Engineers who struggle in their careers often do so because they are unable to effectively communicate with others, work well in teams, and manage conflict. This problem has been observed by many professionals, including one of the authors while working in industry.

Many universities have developed programs in professional skills and engineering leadership, offering for example: certificates, [7, 8], minors [7, 9], or a B.S. in engineering and a M.S. in engineering leadership in five years [10]. One of the more established programs is the Engineering Leadership Development program (ELD) at Penn State, which originated in the 1990s [9]. An optional program for undergraduate students, the ELD is an 18-credit minor consisting primarily of courses in leadership. What is common among these programs is they require students to take additional coursework outside their engineering major, something not all engineering students will pursue as such courses displace other electives. One survey of engineering leadership education (ELE) around the world referred to such programs as “explicit,” which means the overt and singular goal of such programs is to teach leadership skills, rather than embed leadership development within a larger sphere of engineering activity [11].

Perhaps less reported are the efforts to integrate professional skills into existing engineering curricula so that it reaches all engineering students, without requiring additional credit hours [12]. Such an approach is referred to as “non-explicit” by the previously mentioned study, as professional skills and leadership are embedded in another educational program and are not its explicit goal [11]. The authors are aware of only one such “non-explicit” engineering leadership education effort other than our own: a pilot program that integrates leadership skills into capstone senior design courses. This is the Emerging Engineering Leaders Development Program conducted by the J.W. Fanning Institute for Leadership Development, in collaboration with the College of Engineering, at the University of Georgia [12].

This path for supporting students can be challenging, however, as engineering professors may not have the training or knowledge to effectively integrate material on leadership and other professional skills, nor be interested in dropping disciplinary content in favor of nontechnical subjects. Training in such skills is a skill in itself, as simply reading about or lecturing on those subjects with no opportunity to practice has little impact on students [5].

This Work in Progress (WIP) paper summarizes current development of an integrated, or non-explicit, program of professional skills and leadership education into a two-semester engineering

senior capstone sequence. Based on limited available information, the present work seems somewhat similar to that underway at the University of Georgia [12].

The current approach was motivated by two primary goals:

1. Provide this education and training to all engineering students in the major without requiring additional courses.
2. Provide this education and training within the context of their team engineering capstone projects to improve their ability to apply what they have learned.

These goals highlight perhaps the two main differences between explicit and non-explicit ELE programs. The former programs are a separate course of study with the benefit of being much more rigorous, thorough and resulting in a certificate or minor, but at the cost of more select participation and loss of elective courses as well as greater institutional expense. The latter programs can provide a basic ELE education to all students within their capstone experience where they immediately practice these skills, at less institutional expense, but at the cost of less depth and rigor.

Current Approach

A faculty member in a Material Science and Engineering department initiated a partnership with the Director of a Leadership Certificate program at the same university with the intention of developing a series of sequential modules on leadership and teamwork for the senior capstone program. For development assistance, they relied on two leadership training and development professionals who had prior experience in managing, developing, and delivering leadership development programs in industry (i.e., HP and Boeing). These three parties—engineering faculty, leadership faculty, and industry practitioners—brought their respective experience together to determine the learning outcomes. The practitioners then developed teaching materials using their experience designing curriculum to help new college hires and interns succeed in the workplace.

This content was delivered by the practitioners, who were paid as adjunct instructors, in Fall 2018 and Spring 2019. There were seven modules, described below, each of which consisted of a two-hour lesson scheduled during the regular senior capstone lab period. Each module consisted of mini-lectures, applied learning activities, discussion and written reflection. During this year-long course, the 16 students were assigned to applied project teams and thus had opportunities to apply their learning in a team context.

Module 1: Emotional intelligence (fall, week 2)

The goal of this module was to provide students with a foundational understanding of emotional intelligence, including the four primary EQ skills [13], the ways EQ impacts performance [13], and related neuroscience. Application of EQ skills were practiced through use of the DISC behavioral model [14]. After individually completing the DISC assessment prior to class, results were debriefed during class as a means to increase awareness of self and others.

Module 2: Effective communication (fall, week 3)

The goal this module was to build on concepts learned in module one, including EQ and the DISC assessment, and focused on effective communication. Through a blend of lecture, discussion, role play, and self-reflection, students explored the goals and characteristics of effective communication; insights about their own communication strengths, opportunities, and preferences; and strategies for communicating effectively with others.

Module 3: Teambuilding (fall, week 4)

The goal of this module was to assist students to apply insights from the first two modules to the team context by examining how behavioral styles, EQ dimensions, and communication patterns impact teamwork. Students explored what team culture is and how it's formed, and how to maximize collaboration and team effectiveness through intentionally shaping the culture and norms. Within their project teams, they had an opportunity to discuss and define their desired team norms.

Module 4: Resolving conflict and giving feedback (fall, week 10)

The goal of this module was to develop the ability to skillfully engage in difficult conversations, including how to resolve conflict and give sensitive feedback. Students practiced using the Constructive Conversations™ model [15], a comprehensive roadmap for effectively preparing for and engaging in these difficult conversations.

Module 5: Individual and team goal setting (spring, week 2)

The goal of this module was to have students establish individual and team goals, which were evaluated and updated throughout the remainder of the semester. Learning to intentionally develop one's self through goal setting prepares students for ongoing, self-managed growth. Key concepts included a discussion of the growth mindset [16] and the Four Stages of Competence [17].

Module 6: Leadership versus management (spring, week 5)

The goal of this module was to identify when to apply leadership skills and when to apply management skills. Through a change management simulation exercise, students experienced the difference between the two, and the importance of both.

Module 7: Organizational culture and fit (spring, week 8)

The goal of this module was to help students to identify elements of organizational culture as guided by organizational values, behavioral norms, policies, procedures, and processes. Students were invited to identify their own individual values, purpose, strengths and interests and how these align (or conflict) with an organization's culture or a specific position.

Initial Assessment

Post-graduation, students were invited to complete a survey about their experiences in these modules and 12 out of the 16 students responded (75%). While this was a small, initial test of the impact of the material, the feedback indicated which topic areas had the highest and lowest impact on students. The survey consisted of some general questions regarding the value of the program, and some specific questions about particular modules. Both quantitative and qualitative measures were utilized. A copy of the full survey is available in Appendix A.

Sample questions included “Now that the semester has concluded, how would you score your team’s performance on that specific goal? *Not effective 1 2 3 4 5 Very effective*”, and “To what degree did the team effectiveness goal impact your project outcome?” *Negative or no impact 1 2 3 4 5 Very positive impact*. From the twelve responses, three people rated their team performance on reaching their team effectiveness goal from 1 to 3 (not effective to somewhat effective), with an average goal impact on project outcome of 1-4, or mixed impact. However, nine people reported team effectiveness of 4 or 5 (effective or very effective), with an average goal impact of 4.2+/-0.4, or positive impact. Overall, their experience was that improving team performance improved the success of their project.

Figure 1 illustrates the degree to which the students believed they will need the information and skills they gained during the modules during their careers. Skills that were considered most important were emotional intelligence (EQ) and communication. Open-ended responses that supported this trend included: “The communication stuff. It really got my group talking to each other,” “I found that emotional intelligence teachings were particularly important. It helped me think about my feelings and how they influence my decisions in a more objective and positive way,” “The use of the DISC assessment helped to really open up my mind to what I do and how

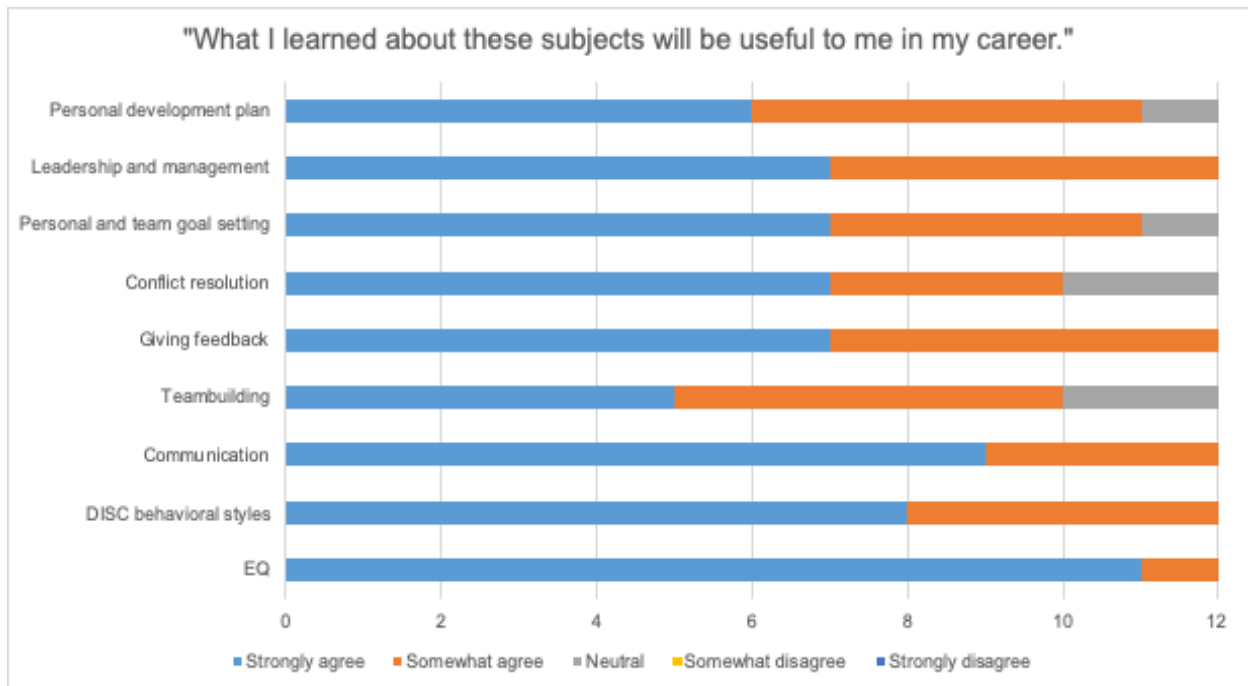


Figure 1. Student survey responses for how useful they believe professional skills will be in their career.

people function differently in various settings. I didn't realize how different people are and how certain situations need to be handled differently." Teambuilding was rated well, though lower than all other skills.

Continued Development

As a result of the successes and opportunities for improvement derived from 2018-2019, the intervention is occurring again in 2019-2020, with some changes. Modules 1-5 and 7 were highly valued by students in the prior year, and thus were maintained in Fall, 2019. The module on leadership versus management was moved from sixth to fifth in the sequence to directly follow Module 4, the last module based on communication and interpersonal relationships. It was also broadened to include different leadership styles because early feedback in spring 2019 indicated students needed greater support identifying the different styles, their relative merits, and knowing which was most appropriate for a given situation.

The second adjustment currently under consideration is the use of a peer feedback tool. A simple survey tool has been used in the engineering capstone program, however it offers limited opportunity for students to learn from the results. One of the authors has been testing Peerassessment.com in a separate class, and has found it to be both a cost-effective and user-friendly way to gather and share peer-to-peer feedback on teamwork skills. This tool will be adopted for following capstone cohorts.

In order to begin teaching professional skills earlier in the curriculum, short lessons will be provided to junior engineering students to introduce them to foundational concepts supporting leadership. Examples of these include learning about styles of thinking, effective listening, and understanding the different meanings in communication, such as relationship and content messages. This began in a junior lab course near the end of the fall 2019 semester with a simple assessment about thinking styles [18] and a discussion about how each brings value to a cognitively diverse team.

The final improvement is to provide a working collection of books, podcasts, and other reference materials in the fields of emotional intelligence, communication, teamwork, leadership, and management. The purpose of this resource is to support students' and graduates' professional development when they have questions and are ready to continue their self-education and personal development.

Conclusions

This preliminary integrated professional skills and leadership education program has demonstrated some small-scale initial success with regard to student valuation of what they learned. Continued evaluation by students will reveal if this work continues to be valued, and if adjustments made after the previous year were effective. All students agreed to participate in future surveys in one to five years after graduation so their views of the program may be collected after they have been working. A survey of employers of these graduates is also being developed for deployment in the summer of 2020. The analysis of the combined data sets is expected to guide this developing program toward a successful future.

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Appendix A: Survey Questions. *Provided answer selections are in italics.*

1. In class, your project team set a goal focused on improving team effectiveness. What was your team goal? _____
2. Now that the semester has concluded, how would you score your team’s performance on that specific goal?
Not effective 1 2 3 4 5 Very effective
3. What helped your team make progress on the team effectiveness goal? _____
4. To what degree did the team effectiveness goal impact your project outcome?
Negative or no impact 1 2 3 4 5 Very positive impact
5. In class, you also set an individual development goal. What was your goal?
6. To what degree did this goal impact the ways in which you engaged with your project team and in class?
Negative or no impact 1 2 3 4 5 Very positive impact
7. What I learned about these subjects will be useful to me in my career.
Strongly disagree; Somewhat disagree; Neutral; Somewhat agree; Strongly agree

Emotional Intelligence (EQ)	Giving feedback	Leadership and management
DISC behavioral styles (DISC)	Conflict resolution	Personal, team development and goal setting
Communication using EQ and DISC	Team building, Project Aristotle	My personal development plan

8. What was especially useful to you that was covered? _____
9. What worked well that should definitely be repeated with future classes? _____
10. How can we make this more effective? _____
11. How would you rate your level of engagement in these professional development activities?
Not engaged 1 2 3 4 5 Very engaged
12. Was there anything you wanted to learn, but it wasn’t included? _____
13. Over time your perspectives and opinions may evolve. Are you willing to share what you are thinking then on a somewhat similar survey in
1 year? 2 years? 5 years? Sorry, I would rather not.

Appendix B: Student responses to open ended questions.

What was especially useful to you that was covered?

- *“Understanding how various DISC styles communicate.”*
- *“Putting into works by strengths/weaknesses.”*
- *“The communication stuff. It really got my group talking to each other.”*

- *“The use of the DISC assessment helped to really open up my mind to what I do and how people function differently in various settings. I didn’t realize how different people are and how certain situations need to be handled differently.”*
- *“I found that emotional intelligence teachings were particularly important. It helped me think about my feelings and how they influence my decisions in a more objective and positive way.”*
- *“Communication with different personality types.”*
- *“Understanding how I like to be communicated to made it a lot easier to think of how I can adjust my communication to get the most out of my teammates.”*

What worked well that should definitely be repeated in future classes?

- *“Continue using DISC.”*
- *“Abbey and Steve were one of my favorite parts of the entire class! ...it gave me personally a tool set to deal with the differences between the teams involved. Second, it illuminated just how important exposure to this type of training/education is to professional development. We as MSE students are far and away more prepared for what may follow graduation.”*
- *“Emotional intelligence.”*
- *“Keep doing DISC. I learned a phenomenal amount about myself and my classmates. Doing the team building activities of how to deal with conflict and other things helped a lot to force open discussion within the group.”*
- *“Taking and giving feedback. I think this is something that is super beneficial in the workplace and am really glad it was covered.”*
- *“The EQ, DISC, and team building sessions with Abbey and Steve were a highlight of the course for me. I think future classes should implement similar sessions.”*
- *“Goal setting.”*