Improving Student Communication of the Value Proposition for their Engineering Capstone Design Projects

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Starting in the 2018-2019 interdisciplinary engineering capstone sequence at the University of Idaho, several instructional strategies are implemented to improve students' ability to communicate and articulate the value proposition of their projects more effectively to a range of audiences. This effort in driven by one of the seven ABET learning outcomes and includes a multi-pronged approach incorporating: 1) opportunities to hear testimony and feedback from multiple outside voices, 2) a formal assignment to write a value proposition statement for the project, and c) multiple venues to practice their presentation skills to non-technical and younger demographics. With this increased emphasis, the instructors have observed more enriched discussion in the classroom about value proposition, and measured tangible improvement in student communication skills through formal judging by industry partners at the end-of-year Engineering Design EXPO.

Keywords: interdisciplinary, communication, value proposition, project value statement

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Introduction

One of the seven ABET learning outcomes required for engineering program accreditation is for students to demonstrate, "an ability to communicate effectively with a range of audiences[1]." This learning objective is highly relevant for students, as they will most likely move on to roles in which the ability to communicate is highly valued, as most engineering projects are done in collaboration with other engineers, disciplines, and within a larger organizational structure. At the same time, engineers are often required to communicate with non-technical people to increase the impact and market value of their projects and products. However, communication with non-technical audiences is often a challenge for students in fields with high technical focus, such as engineering. This may be due to any combination of factors including: a) communication is not their natural skill strength, or b) a diminished perceived value in the ability to communicate to non-technical audiences.

Engineering programs may approach this challenge through multiple strategies. Some programs require written project proposals which include a value proposition[2], and most programs provide multiple opportunities for students to practice their public speaking skills. This typically involves class projects with some form of oral presentation at the end. Additionally, most capstone design programs incorporate a culminating event at which student teams present their projects either through a poster presentation or an oral technical presentation, or both. In our experience, during these project presentations, students are quite eager to discuss the technical details of their projects in great detail, but often fail to provide context about how their projects fits into a larger societal challenge, or the over-arching "why?" that conveys the importance of their work. As a result, many non-technical audience members are unable to comprehend the larger impact and importance of the project, resulting in a deflated response to the student presentations.

The objective of this paper is to outline specific instructional methods targeted at improving student communication with non-technical audiences in an engineering capstone design program. The techniques are introduced in the 2018-2019 capstone design cycle, with notable improvement in student communication realized at the conclusion of their projects.

Methodology

The interdisciplinary engineering capstone design program at the University of Idaho (U of I) is a collaboration between six separate disciplines: a) electrical engineering, b) computer engineering, c) biological engineering, d) computer science, e) mechanical engineering, and f) materials science and engineering. A breakdown of the number of students from each discipline is illustrated in Fig. 1 for the past four capstone design cycles. With a combined course integrating six fields of engineering, the range of prior experience and relative skillsets in communicating with broad audiences is expected to vary dramatically.

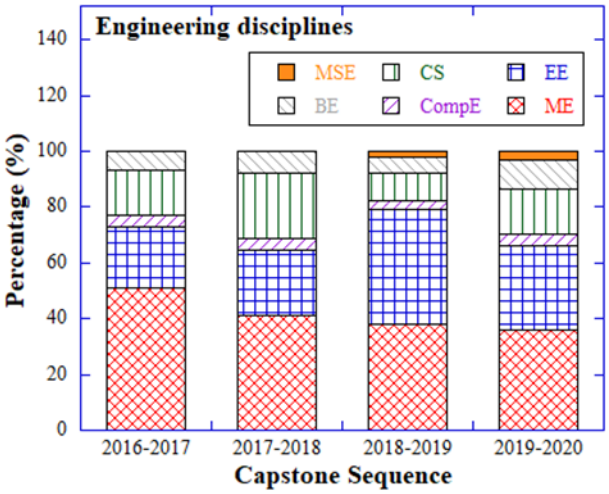

Figure 1. Relative split of students from each discipline in the U of I capstone design sequences from 2016-2020.

The following items (with the exception of industry judging) were introduced starting in the 2018-2019 interdisciplinary capstone design cycle.

Classroom Emphasis on Value Proposition

Within the classroom, it is important to invest time and resources to emphasize the concept of project value proposition. One way to do this is with testimony from witnesses outside of the engineering departments. First, we review feedback from past capstone design presentations given to non-technical audiences. Frequently, these audience members provide feedback to these presentations which commonly includes the following comments: "the students are doing really neat things with their design, but I don't understand the 'big picture' for *why* they are doing the project". This results in a lost opportunity for students to connect with their audience and increase the impact of their work.

Second, we invite an instructor from the College of Business and Economics to testify to the importance of the value proposition from a business and industry perspective. Students are given opportunities to "pitch" their projects in class, and in on-campus competitions. These in-class activities only need to occupy ~20-30 minutes of lecture time, but they also serve as a springboard for more frequent reinforcement and one-on-one coaching with students in and out of the classroom.

Value Proposition Statement Assignment

During the first half of the two-semester capstone sequence, students are assigned to articulate a value proposition statement in writing for their project. This assignment occurs after students have defined their problem statement, identified the requirements, and are developing concepts for their designs. Guidelines for the assignment include a 150 word limit, and the expectation to address the following items[3]:

1. What is the greater goal to be accomplished?
2. What is the missing solution or knowledge gap?
3. What is the objective of the project?
4. How will the new design meet the objective?

These statements provide a foundation for students in creating their strategies for future written and oral communication. The same format of the assignment also works well for both executive summaries and research abstracts, making the assignment highly relevant for future careers in both industry and academia.

Practice Presentations to Diverse Audiences

As with most capstone programs, students are given frequently opportunities to practice presenting their projects in a variety of formats to a broad range of audiences. Common formats include periodic poster sessions enabling students to show visual representations coupled with brief verbal summaries of their projects[4]. These events offer ideal opportunities for students to practice their "elevator speeches", which should be based on the value proposition statements developed above.

During the second semester of the capstone sequence at the U of I, the instructors have integrated one of these poster presentations (i.e. Snapshot #3) to coincide with an on-campus Women in Engineering Exploration (WIEE) event. This event invites 9th-10th grade women to visit campus and learn about opportunities in STEM fields, including hearing about the current interdisciplinary engineering capstone design projects at the U of I (Fig. 2). The coincidence of these events requires capstone students to ensure they present and emphasize the value proposition of their project to a younger audience.

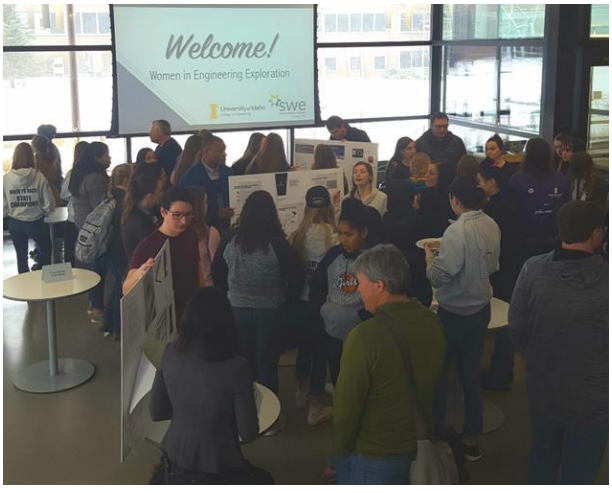

Figure 2. Interaction between students and visitors at the U of I Women in Engineering Explore event, Feb. 2019.

Industry Judging at Engineering Design EXPO

As the culminating event for the engineering capstone design sequence, students are required to present their projects at the annual Engineering Design EXPO in two different formats: 1) booth presentations including posters and prototype demonstrations (if applicable), and 2) 20-minute oral presentations summarizing their methodology and outcomes. The Engineering Design EXPO is open to the public, while dozens of industry partners and project sponsors are invited to attend and provide impartial judging of the students and their capstone projects. The booth and oral presentations are each judged separately.

Booth presentations are judged on a 1-to-5 scale on the basis of four separate criteria: 1) Communication, 2) Concept Development, 3) Solution Realization, and 4) Solution Impact. Within the Communication criterion, judges are asked to determine if the presentation "clearly articulates project objective and requirements, and conveys value proposition", while the Solution Impact criterion is described as, "explores and conveys the broader impacts potential of the solution."

Oral presentations are also judged on the same 1-to-5 scale on the basis of five different criteria: 1) Context, 2) Organization, 3) Evidence, 4) Visual Aids, and 5) Delivery. For the Context criterion, judges are asked to determine how well the presentation "clearly articulates the big picture and conveys value proposition".

The scores of each interdisciplinary capstone design team are compiled and averaged for each criterion to provide an overall comparison. Student teams which score highly on either presentation formats (or both) are awarded recognition of their efforts at a later date.

Results

Increasing classroom time by ~30 minutes to discuss value proposition enables multiple opportunities for formative assessment of the students. Continuous reinforcement of these principles throughout the capstone experience helps ensure that students retain and practice these skills. The following is a summary of the more summative assessments associated with communicating the value proposition of senior design projects.

Value Proposition Assignment

Each interdisciplinary capstone design team develops a value proposition statement for their respective projects in the middle of the first semester. These statements provided a foundation for the students to create verbal "elevator speeches" for future presentations, and written abstracts for their projects, which are published in the Engineering Design EXPO program. Two examples of student value proposition statements are provided below.

Example A:

Universal Electric Airplane Tug

Currently, there are no airplane tugs on the market that can tow multiple aircraft with little input from the user or without significant modification with changes in wheel type. As the average age of the general aviation pilot increases, the need for an easy to use powered airplane tug increases. The goal is to create a solution for this problem by designing an airplane tug that can be used with a wide variety of tire sizes and types including those with wheel pants. Our solution will be easy to use and require very little input from the user.

Example B:

Liquid NanoTint™ Performance Evaluation

An enormous amount of energy is spent heating and cooling our buildings and much of it is wasted through the building's windows. Most options to help insulate windows and reduce solar heat gain are expensive or block out most of the window's visible light. Liquid Nanotint™ offers a cheap and easy to apply coating that claims to block almost all UV and IR rays while reducing visible light transmission very little. We will be applying Liquid Nanotint to University of Idaho's Golf Pro Shop in order to quantify the coating's effectiveness and electricity use reduction in a real-world setting. We will also be building a demonstration unit that will show the product's benefits and effectiveness in real time to prospective clients.

EXPO Judging

Judging results for the last three Engineering Design EXPO events are shown in Table 1 and Fig. 3. With the above strategies implemented in the 2018-2019 design cycle, the judging results from the 2019 Engineering Design EXPO reflect incremental improvements in student performance for each of the criteria.

Table 1. Summary of EXPO judging results 2017-2019.

Year	Booth		Oral
	Communication	Impact	Context
2017	3.6 ± 0.7	3.4 ± 0.6	3.8 ± 0.6
2018	3.9 ± 0.8	3.6 ± 0.8	3.8 ± 1.1
2019	4.2 ± 0.2	3.7 ± 0.2	3.8 ± 0.3

Scores for the Booth-Communication criteria increase from 3.6 (2017) to 3.9 (2018) and 4.2 (2019), while Booth-Solution Impact scores increase from 3.4 to 3.6 and 3.7. The Oral Presentation-Context scores are generally flat at 3.8, but with a smaller standard deviation in 2019 suggesting fewer teams are scoring poorly. All these criteria exhibit positive improvement following implementation of the strategies outlined above.

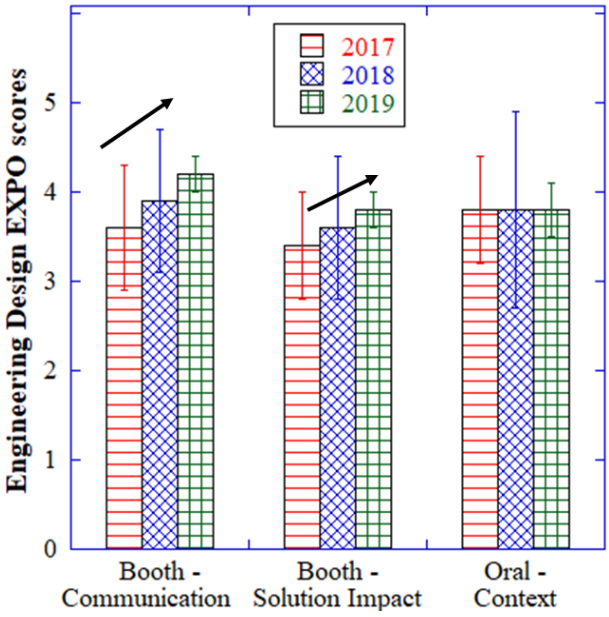

Figure 3. Summary of judging scores at the U of I Engineering Design EXPO from 2017 to 2019 for categories involving communication of the value proposition for projects.

Discussion

The instructors for U of I's interdisciplinary capstone design program are making a concerted effort to help students strengthen their communication skills when talking and presenting their projects to a range of audiences. This effort includes a multi-pronged approach incorporating: 1) opportunities to hear testimony from multiple outside voices, 2) a formal assignment to write a value proposition statement for the project, and c) multiple venues to practice their presentation skills to non-technical and younger demographics.

The use of dedicated time in the classroom helps to reinforce the importance of communication and clearly articulating the value proposition, particularly when multiple perspectives are brought to the classroom through outside testimony. Plus, this format provides opportunity for formative assessment of the students' current understanding of the "big picture" for their respective projects. In our experience, the topic generates tangible classroom discussion about the engineering perspective of value proposition, and how it differs from traditional marketing slogans which are frequently used to promote and market the products we design. It is important to emphasize that a project value proposition is not a marketing slogan, but instead is a concise statement about the "big picture" goals for the project, the knowledge or technology gap being addressed, and the expected or realized outcome of the project.

Next, the assignment to write a project value statement early in the capstone sequence enables continuous reinforcement of its importance. In addition, it gives a solid foundation for students to craft their message about the relevance and importance of their projects. Students are enabled to practice this messaging through multiple opportunities with a wide range of audiences. The formal presentations at U of I's WIEE event in the second semester provide a valuable dress rehearsal before their formal assessment at the Engineering Design EXPO.

Conclusions

Starting in the 2018-2019 interdisciplinary engineering capstone sequence at the U of I, several strategies are implemented to improve the students' ability to communicate and articulate the value proposition of their projects more effectively to a range of audiences. Through the addition of three new focus areas, the following observations and results have been achieved:

- Soliciting input and testimony from partners outside of engineering enriches the discussion around value propositions and their societal importance.
- An assignment to write a formal value statement for their projects enables continuous reinforcement and articulation for future presentations.
- Multiple opportunities to practice their "elevator speeches" reinforces importance and provides a valuable dress rehearsal before final assessment.
- Design EXPO judging of the student team's demonstrated improvement in communication, solution impact, and context for both the booth and oral presentation formats following implementation of new teaching strategies.

Overall, it has been shown that increased emphasis on a particular topic or skill set can produce tangible improvements, even for "soft skills" which are typically not central to engineering education programs.

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