

Enhancing Student Perceptions of Engineering Disciplines through Showcasing of Career Paths

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Changes in Student Perceptions of Engineering Disciplines through Showcasing of Career Paths

Abstract

This complete evidence-based practice paper describes an instructional technique used in a general first-year engineering course to enhance students' perceptions of engineering disciplines by highlighting current jobs and careers of people who studied across a variety of engineering-related fields throughout the semester. As part of this introductory course at Virginia Tech, a large land-grant university in the southeast United States, students are expected to investigate multiple engineering disciplines offered at the institution, which will help them choose a major of study as they move into their second year. At the study institution, there are over a dozen engineering majors students can choose from, and within those, many more sub-disciplines. This presents a challenge for instructors because, while important, selection of a discipline is only one of six learning outcomes for the course. Furthermore, many first-year students are not aware of the many different paths they can take as an engineer, and often are only familiar with the more popular disciplines.

One way instructors have sought to expose students to the wide variety of careers that people with engineering degrees go on to pursue is through presentation of an "Engineering Job of the Day" during most class sessions throughout the semester. The jobs presented are "real world" examples, mostly sought out through personal connections by several instructors in the course. Basic information is presented including the degrees each person has, where they work, job title, a typical day at work, and what they deem as important skills for their current position. Additionally, some featured jobs also include advice for first-year students; the people discussed in class are all alumni from the same institution where the information is being presented. In some cases, alumni were no longer in traditional engineering careers, but were able to describe how their engineering background helped them in their current jobs. The authors leveraged personal connections and networking through engineering advisors to obtain profiles.

In Spring 2018, the "Engineering Job of the Day" was delivered in twelve sections of approximately 30 students each. Classes met twice a week, with job profiles used starting in week 2 of classes so that by the end of the semester 24 profiles were introduced to students. At least one profile was presented per major offered at this institution. An online survey was administered at the end of the semester in Spring 2018 to 200+ enrolled students to assess students' perceptions of the engineering jobs presented and what impact they felt it had on them. It is notable that students taking the course in this semester are considered "off-semester," in that most of these students were enrolled in non-engineering majors at the study institution and seeking to transfer into engineering majors. The survey collected students' responses with respect to their perception of engineering as a whole, whether the class activity had an impact on

their decision pursue a discipline, if it was an effective use of class time to meet course learning outcomes, and suggestions for future implementations of the activity, among other questions. The survey involved a series of Likert scale and free response questions. Self-reported demographic information was also collected as part of the survey.

The authors present both quantitative and qualitative data from the survey. The paper discusses frequency and percent distributions of quantitative data. Qualitative data was coded using an open-coding framework. Preliminary results from this study will be discussed. The results of this analysis show that students found that practice of including engineering jobs in the way described was useful with respect to the different paths they can pursue with a degree in engineering based on this activity. International students provided more positive responses than non-international students. From the faculty perspective, some perceived benefits of this classroom activity include providing students with helpful real-world information without adding to the student's workload.

Introduction

Background and Purpose

This evidence-based practice paper discusses an instructional technique used in a first-year general engineering class to broaden students' perceptions of potential careers they can pursue with an engineering degree. Generally, the technique included highlighting an "Engineering Job of the Day" during most class periods over the semester in an attempt to show the wide variety of careers of alumni who received engineering degrees across a variety of disciplines and majors. This was introduced for several reasons: to assist students with selecting a major, to help them understand the potential roles of engineering disciplines, and on a more personal level, showcase the wide variety of careers so that they might be able to envision themselves in a similar role in the future.

The study was conducted at Virginia Tech, a large land-grant university in the southeast United States, in which students are admitted to a general engineering program prior to matriculating into major-specific departments. The two-credit course in which this study focuses (Foundations I) is the first of a two-course general engineering sequence that focuses on several outcomes such as understanding the contribution of different engineering disciplines, teamwork, and problem-solving strategies. At the same time, most students also take introductory courses such as calculus, chemistry, and general education requirements. The majority of students will select a major at the end of the second course in the two-course sequence. It is notable that the second course (Foundations II) focuses on the engineering design process, and not exploration of disciplines; therefore, the course in this study is the primary source of information for them to make that important decision.

The study was conducted in the Spring 2018 semester and included 204 students over several class sections of approximately 30 students each. These sections were taught by multiple

instructors, ranging from graduate students to full-time faculty members. It is notable that students taking this course during the spring semester are considered “off-semester” students. Traditionally, students enter the program in the fall and take the courses in a Fall-Spring sequence. In contrast, off-semester students take the courses in a Spring-Fall sequence. During the traditional sequence, each major-granting engineering department offers information sessions in the Fall for students taking the course. However, because of the reduced number of students taking the off-semester sequence, this resource is not available to them in the Spring semester.

The Foundations I course offered during Spring 2018 contained eight explicit learning outcomes:

1. Compare and contrast the contributions of different types of engineers in the development of a product, process, or system
2. Develop a plan of study for your undergraduate career
3. Articulate holistic issues that impact engineering solutions
4. Solve problems using systematic engineering approaches and tools
5. Model an engineering system
6. Synthesize information from several sources
7. Communicate information effectively
8. Contribute effectively to an engineering team

As might be expected, balancing coverage of these learning outcomes with the expectations of a two-credit introductory level course can be challenging for instructors. Many students enter the program with expectations that the course’s primary purpose is to help them select a major to pursue. However, as can be inferred from the learning outcomes, that outcome is only a small piece of a much larger set of goals. Because of this, an objective of many instructors is to develop course material that provides useful information without placing a large workload burden on students or occupying a significant amount of class time.

The featured engineering job of the day (EJOD) profile was initially developed as material to help fulfill this role. The typical presentation consisted of a single presentation slide in each class period about an engineering alum of the institution where the study course was taught, and included information about their current job, background, skills they find useful, and advice for first-year engineering students. While the primary intent and purpose of this information was initially to demonstrate to students that there are a variety of jobs they can pursue with an engineering degree, other outcomes included the possibility that students could identify with one or more of the profiles, potentially increasing their motivation and retention within engineering. To assess students’ perceptions of the EJOD profiles, a survey was assigned as part of class work at the end of the semester in an effort to determine the impact and whether they found presentation of profiles to be a worthwhile use of class time. The purpose of this paper is to explore the students’ responses to the profiles, which may be beneficial to other teachers involved in similar courses.

Relevant Literature and Prior Work

A broad range of research has been conducted on students' identities as engineers and how that affects their retention in engineering programs. Studies from several fields, ranging from social sciences to developmental psychology, have suggested that a strong sense of engineering identity is an important factor for students who choose to continue within an engineering program [1]. Students' perceptions of their experiences as they go through an engineering program have also been shown to be important, especially with how those experiences relate to their sense of identity as an engineer [2].

The future time perspective has also been shown to be useful in determining student motivation. Hilpert et. al looked at knowledge building in coursework and found that students' abilities to connect this to imagined futures was an important factor in their motivation to succeed [3]. More generally, the specific information that instructors emphasize with respect to the future in the classroom has been shown to be important to students [4].

The role of first-year engineering programs also may play a role in students' continuation and completion of an engineering degree and may contribute to a higher graduation rate than programs with a direct matriculation [5]. However, these programs are not without challenges. Notable concerns include a potential for a higher student workload, in a time when administrations are seeking to reduce this [6]. It has also been suggested that the content of first-year programs is important for students to select a major and, ultimately, a career in engineering. Jones et. al suggested that "by showing and teaching students why engineering is useful and important, they would be more likely to choose a career in engineering" as part of a study that examined some of the factors that affect whether first-year students choose an engineering career [7].

Several resources exist that could be of interest to students who want to expand their knowledge of specific jobs, but many of these are not tailored to the background of first-year general engineering students. Specifically, many of these profiles are targeted at a particular demographic group such as women [8][9] or a specific discipline/industry [10][11]. While these are all potentially valuable resources for students, the targeted nature of these sites makes integrating a broad view of potential engineering careers difficult in a general first-year course setting.

Methods

Over the course of a 15-week semester, approximately 27 engineering job of the day profiles were presented. Typically, this was accomplished with a single presentation slide containing summary information about the person, their job, background, and other pertinent information. The slides were supplemented with a brief lecture from the course instructor going into more detail with regard to the skills that each featured profile found important and advice for students from each engineer. It is important to note that there was some individual variation between

instructors; however, it is study team's understanding that the general process and information shared was consistent among class sections.

The featured profiles were initially developed through personal connections with the course instructors. Generally, demographic information about each person was not shared with the students, other than information that could be surmised by names and a small number of participants who shared a photo of themselves. Over the course of the semester, each of the institution's fourteen engineering departments was featured at least one time. However, the jobs featured were varied in nature, ranging from highly technical more stereotypical engineering jobs to jobs that would not traditionally be considered engineering. The instructors who developed these profiles felt that it was important to showcase this range of jobs to students to help them understand that the skills learned while studying engineering can be useful even in what would be considered a non-engineering career and that career shifts are not unusual.

To compile each profile, each person whose job was featured was asked to provide as much of the following information as they were willing to share:

1. Name and Job Title
2. Description of employer
3. Type of engineering degree(s)
4. Description of a typical day at work
5. What type of skills are important for the job?
6. If not working in an engineering field, how did having an engineering help you get where you are now?
7. Any additional comments that would be useful to a first-year engineering student

An in-class survey was administered for a completion grade at the end of the semester to solicit feedback and reflection about the engineering job of the day profiles that were presented.

Notable questions to be explored in this paper include the following:

- *Q1*: How did the engineer of the day profiles affect your perception of engineering? (Likert Scale and free response)
- *Q2*: Did the Engineer of the Day profiles help you decide to pursue (or not to pursue) a specific discipline? (Yes/No)
- *Q3*: A question asking whether the profiles helped students pursue other opportunities such as membership in technical organizations, graduate school, etc. (Full list of potential responses included in Appendix A)
- *Q4*: How well did the Engineer of the Day profiles relate important career skills to course objectives? (Likert Scale)
- *Q5*: Did you follow up with additional exploration as a result of the Engineer of the Day profiles? If so, what? (Full list of potential responses included in Appendix A)
- *Q9*: Do you feel that this was a meaningful use of class time in this course? (Likert Scale)

Optional self-reported demographic information was also collected. Please refer to Appendix A for a full list of questions and the response format for each. The survey was administered electronically as a Google Form; student responses were de-identified prior to the responses being released to the study team for analysis. Only responses from students who had consented for their work to be used in department-level research were used in this analysis (N=204).

To analyze the qualitative data generated from the free response part of Q1 “How did the engineer of the day profiles affect your perception of engineering?”, two of the authors served as primary coders. They randomly selected a subset of responses to identify common themes that could be initially used for rating. Then, each coder independently rated all students’ responses, identifying one or more themes that emerged from a participant’s response. In some instances, a coder could not classify a response into one of the initial themes and generated a new theme for review. Each student response was allowed multiple connections in coding. Following independent ratings, the two coders discussed their ratings; most differences in the original ratings were resolved through discussion. For cases where coders could not resolve differences, a third coder was brought in. Through this process, about 10% of responses required resolution through a third coder. Please refer to Appendix B for a full table of qualitative themes that emerged.

Results and Discussion

Responses to Q1 “How did the Engineer of the Day profiles affect your perception of engineering?” were generally positive. On a Likert scale of 1 to 5, with 1 representing “negatively affected my perception” and 5 representing “positively affected my perception”, the average response was 4.13 with a standard deviation of 0.77. The data was also analyzed to determine if there was significant difference in responses between males and females as well as international and domestic students. The results of a two-tailed T-test found that international students had a higher perception than non-international students (P=0.049), while there was no statistically significant difference between male and female students (P=0.406).

Table 1: “How did the Engineer of the Day profiles affect your perception of engineering?” (Q1) Quantitative Summary by Group

<i>Group</i>	<i>Average</i>	<i>Std Dev.</i>	<i>N</i>
Male	4.16	0.74	155
Female	4.04	0.88	47
Intl	4.29	0.73	62
Domestic	4.06	0.78	142
Overall	4.13	0.77	204

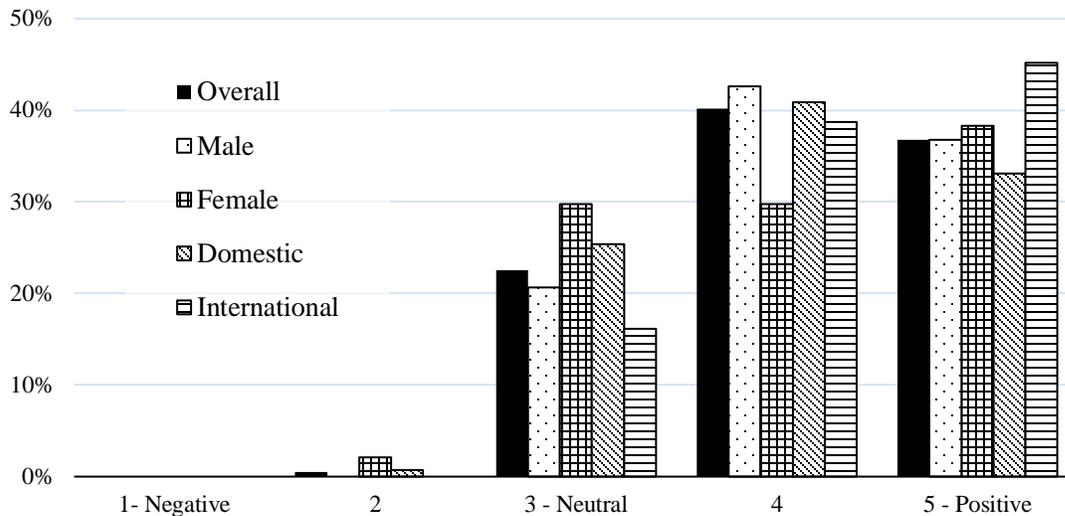


Figure 1: Q1 Quantitative Responses “How did the Engineer of the Day profiles affect your perception of engineering?”

There were twenty students who responded to the survey, but did not leave any free response comments, leaving 204 free responses for analysis. Once coding was complete, due some comments covering multiple coding categories, a total of 300 coding results were analyzed. In order to better process the coding information, each of the qualitative codes were grouped into one of four themes: Positive comments, negative comments, neutral comments and suggestions. Results of this themed grouping are shown below in Figure 2.

Eight of the twenty codes were determined to be positive feedback and grouped together. This included responses that noted a better understanding of engineering jobs and real work applications, as well as helping students make connections to alumni and choices they are making in their undergraduate education. See Appendix B for a full listing. The positive comments included 230 of the 300 coded results, representing 77% of the results. Two examples of positive student responses include “They offered insight into the day-to-day tasks and responsibilities of engineers and gave good advice on what students should be doing to prepare for a job in engineering. Overall, they were a great way to start each class and should be continued into future semesters.” and “I really liked it and it's very unique as we get to see the day to day life of different types of Engineer. I would want to keep it in the curriculum as it shows someone of the key components an engineer is required to have.” Over one third of the total comments about the EJOD were designated as “Demonstrated diverse opportunities and learned about the profession and/or engineering disciplines.”

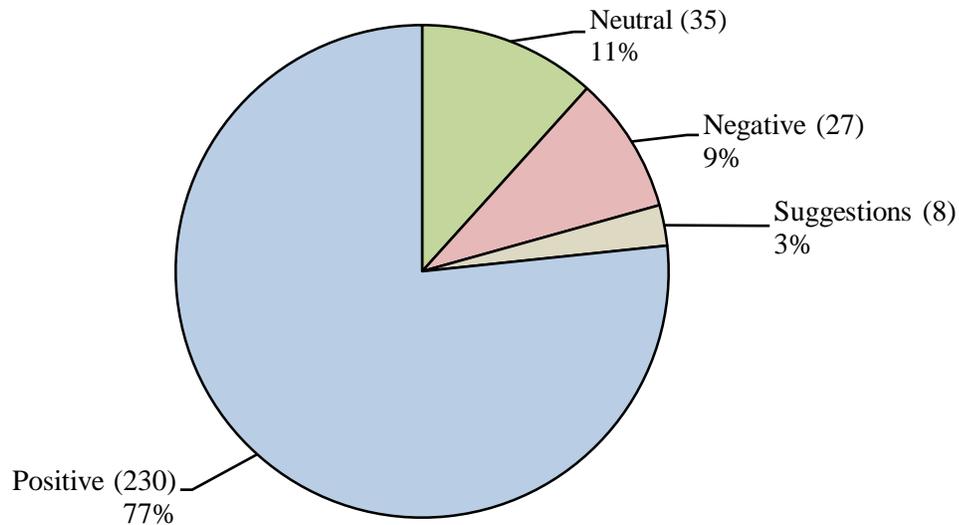


Figure 2. Results of Q1 coding groups

While the majority of the comments were positive, there were also comments that seemed to be negative about the experience with some students noting that the time devoted to the slides was insufficient or that the jobs did not seem interesting, etc. This group also represented eight of the twenty coding outcomes but represented only 9% of the given feedback. Examples of negative responses included “We did not get much time to cover the stories and they did not make much of an impact when they were introduced.” and “Hearing about the different roles engineers play in the business world is interesting, but I would like for it to be more than just a token slide at the beginning of class that gets passed over relatively quickly.” The researchers believe that an underlying cause for some of the comments was based on the delivery of the material to the students and not the content itself. Some of the instructors presenting the material had more teaching and industry experience to be able to make better connections with students. To try and reduce some of the negative comments in the future, additional training and emphasis on the importance of the profiles should be provided to the course instructors to work to prevent these perceptions.

The final two groups resulting from the Q1 free response coding -included neutral comments about the EJOD and suggestions for improvement. Each of these groups comprised two of the coding classifications. The neutral group was 11% of the coded results. Some of the responses indicated that students had already chosen a path of study, so the impact was limited, and others noted the profiles were as expected, so they did not learn much. Typical responses included comments such as “I already have my career destination and done all my research so I did not fully concentrate on the content.” and “It did not change how I thought about engineering for the better or worse.” It is to be expected in an introductory course that there will be some students who feel this way, but the percentage was not high.

While the results of Q2(“Did the Engineer of the Day profiles help you decide to pursue (or not to pursue) a specific discipline?”) indicate that learning about the engineering jobs of the day did not help them decide to pursue, or not to pursue, a specific discipline (Yes=37%, No=63%), 89% of respondents indicated that they were influenced to pursue something such as joining a club or organization, undergraduate research, or an internship in their responses to the question “Did the profiles influence you to consider pursuing any of the following?” (Q3). Specifically, the activities with the highest follow-up response were internship/co-op (16.3%), pursuing a minor or multiple majors (14.3%), undergraduate research (12.0%), and joining a technical student organization (11.6%). Students were allowed to choose multiple options from those presented in this question.

Building on this, the survey also asked students if they followed up with any additional exploration as a result of viewing the profiles in class (Q5). 51% of respondents indicated that they did not follow up. Of those who did follow up, 34% looked into a specific job discussed, 28% searched for similar positions or companies, 24% explored a major or minor they had not previously considered, and 15% looked up a specific company that was mentioned. Please refer to Appendix A for the full list of potential responses to Q3 and Q5.

Two questions (Q4, Q9) were presented to solicit feedback from students as to whether they perceived the EJOD profiles as being applicable to meeting course learning outcomes and a worthwhile use of class time. When asked how well they perceived the profiles as relating to important career skills and course objectives, the average response was 3.8 with a standard deviation of 1.02 on a scale of 1 (Not at all), to 5 (Greatly). For the subsets analyzed (men/women, domestic/international), the only statistically significant difference in the means was that international students perceived a greater applicability compared to non-international students ($P=0.002$).

Students were also asked their perception of whether this exercise was a beneficial use of class time, with generally positive responses (Q9). When presented with a Likert Scale ranging from “1 - Not Useful” to “5 - Useful”, the mean response was 3.8. Please refer to Figure 4 for the range of responses to this question. Similar to results previously discussed, the mean responses of international students were statistically significantly higher than non-international students ($P=0.04$). Please refer to figures 3 and 4 for a summary of responses to Q4 and Q9, respectively.

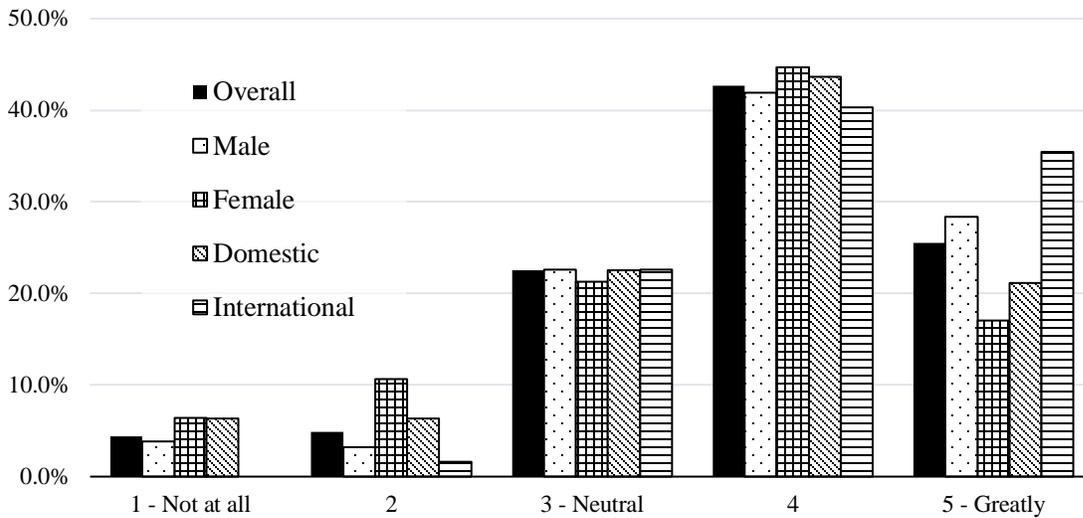


Figure 3: Q4 Responses “How well did the Engineer of the Day profiles relate important career skills to course objectives?”

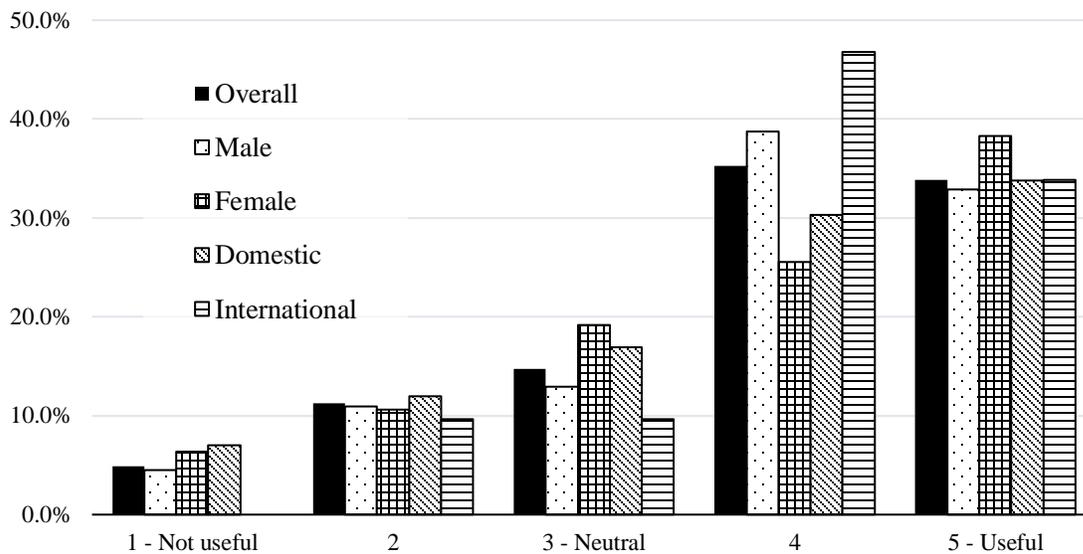


Figure 4: Q9 Responses “Do you feel that this was a meaningful use of class time in this course?”

Future Work

The authors of this paper plan to continue to use the EJOD profiles in upcoming offerings of the course. As such, this allows for further research on the impact of the profiles on a different population of students such as on-semester students who were admitted into the College of Engineering. A future study will include a possible comparison to on and off semester populations of students to see if the same themes emerge and with what frequency. In addition, since the on and off semester students have different access to resources regarding majors, one area authors would like to study more closely includes how students were impacted in terms of Q2 (impact on discipline choice) and Q5 (additional exploration as a result of EJOD).

While authors did ask students to provide suggestions for improving EJOD, coding of students' responses regarding Q8 collected in spring 2018 and subsequent semester(s) will be performed in the future.

With the unexpected difference between international and domestic students' responses with respect to Q4 and Q9, the authors are interested in seeing if this difference can be detected within the on-semester population. Authors are considering a future study that would ask more specific questions to help determine why these differences exist.

Conclusions

The results of the in-class survey suggest that including an engineering job of the day regularly throughout the semester was positively received by the students, and that it is worthwhile to continue as a method to help showcase the breadth of engineering disciplines available to students in alignment with course objectives for the study institution's first-year program. The majority of students indicated a positive reception in their responses to both quantitative and qualitative questions. This was specifically indicated by the high percentage of respondents who indicated the profiles influenced them to pursue activities such as clubs or extracurricular activities. Also, approximately half of the respondents conducted additional exploration on their own related to the profiles featured in class. These responses suggest that the activity provides a great deal of benefit for students in the class, especially given the relatively small amount of class time and instructional preparation necessary to implement it.

The survey results also positively reflect that the students were able to create connections between the course learning outcomes and career skills, and also positively affects their perception of the engineering profession. These results contribute to previous research that evaluates the role of first-year engineering programs, and those programs' importance in helping students choose a discipline and understand engineering as a profession.

One interesting and unintended outcome that the study found is that international students appeared to find this activity more useful and informative than non-international students. While future work will be required to further explore this difference, the authors are encouraged that

this population had positive perceptions, as international students sometimes don't have access to the same resources as other students to know the many career paths that others who have graduated from the same institution have taken.

This information could be beneficial to other instructors who are seeking to meet similar objectives without sacrificing a lot of valuable class time or overload students with additional out of class work. While this work focused on implementation of profiles within a first-year introductory general engineering course, a similar approach could be used for introductory discipline-specific courses to highlight a range careers within that discipline. Based on analysis of student feedback, continuation and even potential expansion of the EJOD appears to be an effective instructional method to help students understand the breadth of the engineering discipline.

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Appendix A: In-Class Survey Questions

Administered electronically via Google Forms

Q1: How did the Engineer of the Day profiles affect your profile of engineering?

Likert Scale: 1 - Negatively affected my perception, 3 - Neutral, 5 - Positively affected my perception

Free Response: "Please Explain"

Q2: Did the Engineer of the Day profiles help you decide to pursue (or not to pursue) a specific discipline?

Yes/No Change

Q3: Did the profiles influence you to consider pursuing any of the following?

Check All that apply:

- Joining a non-technical student organization (i.e. club sports, social clubs, non-engineering service organizations, etc.)
- Joining a technical student organization (i.e. a design team, professional society, etc.)
- Pursuing a minor or multiple majors
- Study Abroad
- Undergraduate Research
- Internship or Co-op Opportunities
- Graduate School
- Professional Engineering (PE) License
- None
- Other

Q4: How well did the Engineer of the Day profiles relate important career skills to course objectives?

Likert Scale: 1 - not at all, 3 - neutral, 5 - greatly

Q5: Did you follow up with additional exploration as a result of the Engineer of the Day profiles? If so, what?

Check all that apply

- No follow up
- Looked up a specific company mentioned
- Looked into a specific job discussed
- Searched for similar positions or companies

- Explored a major/minor I had not previously considered

Q6: What were the most important things you learned from the Engineer of the Day profiles?

Free Response

Q7: If you found any of the profiles interesting, please describe which ones:

Free Response

Q8: What, if any, additional information or types of profiles would you find useful to be included?

Free Response

Q9: Do you feel that this was a meaningful use of class time in this course?

Likert Scale: 1 - not useful, 3 - neutral, 5 - useful

Q10: Choose as many options as you feel describe yourself:

- Male
- Female
- In-state Student
- Out-of-state Student
- International Student
- American Indian or Alaskan Native
- Asian
- Black or African American
- Hispanic
- Native Hawaiian or Pacific Islander
- White
- 2 or more races
- First-generation college student

Appendix B: Coding Themes

<i>Count</i>	<i>Code Description</i>	<i>Classification</i>
114	Demonstrated diverse opportunities, learn about the profession and/or disciplines	Positive
36	General positive word such as good, great, interesting, etc.	
24	Real life/real world	
22	Useful to students, for planning and/or major/career decisions	
16	Better idea of daily work for an engineer	
6	Alumni reference	
5	Motivation	
4	Links to specific class material/activities/objectives/etc.	
3	Acts as a reference material	
27	Neutral/No impact	Neutral
8	Some of all of the jobs did not match my interests (or has already chosen major)	
8	One slide or time spent was not sufficient	Negative
6	Not a good use of time	
4	Jobs seemed easy/boring	
3	Didn't seem to be presented as expected	
3	Feels repetitive	
1	Not a good representation of an engineering job	
1	Not necessary	
1	Discouraging from engineering	
2	Desire to link profiles to how they made their choices	Suggestions
6	Recommendation or implied recommendation for improvement	
Total = 300		