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Early Design Sprint Impact on Engineering Identity and Entrepreneurial Mindset in the First Year

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Abstract

This Complete Research paper describes the impact of a design sprint early in a first-year engineering course on engineering identity and the entrepreneurial mindset (EM). In an introduction to engineering class, many first-year students do not see the connection of small, one-off lab activities, to their engineering identity and the EM. The first year is a critical time for students to develop their sense of self and identity. The purpose of this paper was to determine if introducing a design sprint on the second day of class would increase first-year students' ability to strengthen their engineering identity and EM compared to students who did not complete the design sprint early in the semester. Faculty identified the gap in EM skills and believed an early introduction to EM could improve their engineering identity. In fall 2023, five sections (126 students) of an introduction to engineering class were taught at a predominantly undergraduate, private institution. Three sections (73 students) completed a design sprint activity (experimental) on the second day of class while two sections (53 students) completed an environmental engineering activity (control). Students were surveyed on engineering identity and EM before the initial activity, in week five and in the class's last week. Engineering identity significantly increased during the semester for the experimental group. The control group's engineering identity did increase during the semester, but not significantly. Results suggest the intervention of the design sprint early in the semester did not increase EM in students compared to those who did not complete the design sprint. Although not designed to, the environmental engineering activity appears to have contributed to student's EM. While the design sprint did not change student's EM, those in the experimental group did have a higher engineering identity. Findings support other work that shows an increase in engineering identity in first-year engineering experiences. Future work will examine how engineering identity and EM differ across demographics and students' selected majors.

Introduction

This Complete Research paper describes the impact of a design sprint early in a first-year engineering course on engineering identity and the entrepreneurial mindset (EM). Engineering identity is a person's belief they are an engineer, and engineering-related experiences can strengthen a student's engineering identity [1]. Prior research has shown the first year is critical in forming an identity, and a strong engineering identity has been linked to retention [2]-[4]. Problem-based learning [5], service-learning projects [6], summer bridge programs [7] and case studies [8] are just a few examples of interventions used in engineering classes to improve engineering identity. Specifically examining the first year, one study determined that different formats for the first-year engineering course affected engineering identity but could not state what caused the changes [9]. In the current paper, specifically, Godwin's theory of engineering identity is used where students self-assess their interest, performance, and recognition by others as an engineer [10]. Godwin's theory of engineering identity has been used to quantify students' engineering identity in many other studies [11], [12]. After completing a first-year engineering computing class, student's reported recognition of their engineering identity defined by Godwin increased [6].

EM, as defined by The Kern Entrepreneurial Engineering Network, is a student's ability to use curiosity, connections, and creating value to solve problems [13]. Many universities in the KEEN network have implemented EM activities throughout their curriculum [14]-[16]. Curricular experiences have been shown to have the largest impact on student's EM [17]. In the first year, many of the activities center around a design problem [18]-[20]. Students who participated in some of these activities have noted the projects increased communication skills, teamwork, ability to validate designs and examine customer value [18], [21]. In a survey administered to employers about the importance and proficiency of soft skills for entry-level engineers, communication and teamwork both had high levels of importance, but the proficiency of those skills for the entry-level engineers was rated low [22]. Teamwork and communication are skills frequently mentioned in job advertisements for engineers [23]. Many of the skills employers look for in new hires can be directly tied to EM including curiosity and creativity [22]. Additionally, greater engineering retention rates and GPAs were found in students who participated in an entrepreneurship program compared to students who did not [24].

The purpose of this paper was to determine if introducing a design sprint on the second day of class would increase first-year students' ability to strengthen their engineering identity and EM compared to students who did not complete the design sprint early in the semester. In past iterations of the course, students were introduced to the engineering design process through a formal lecture and followed the design process for a culminating wind turbine project, but did not iterate through all steps of the process within a single lesson or lab activity. The research project stems from faculty observations; during previous iterations of the course faculty observed that during the first half of the course, students were not connecting course material to engineering, did not believe they were completing engineering work, and were not as engaged as in the second half of the course. Faculty also identified the gap in EM skills and believed an early introduction to EM could improve their engineering identity. To our knowledge, there have been no studies examining how incorporating an EM activity early into a class may affect engineering identity. Therefore, the design sprint activity was introduced to mimic the full engineering design process, and it was hypothesized that this activity could heavily impact students' perception of both their engineering identity and EM.

Experimental Methods

In fall 2023, five sections (126 students) of an introduction to engineering class were taught at a predominantly undergraduate, private institution. The course consists of a series of in-class lab activities, each related to a different engineering discipline, and culminates in an interdisciplinary design project in which students create a tabletop wind turbine. Three sections (73 students) served as the experimental group while two sections (53 students) served as the control group. The study was approved by the university's IRB and consent was obtained from all participants.

Before the second day of class, students completed two surveys administered online via Qualtrics. The first survey asked questions related to engineering identity based on Godwin's model, which consists of three aspects of identity: interest, performance, and recognition [10]. Students responded to what extent they agreed or disagreed with 11 statements on a 0 (strongly disagree) to 6 (strongly agree) scale (Table 1). The scale and questions were in line with previous work exploring engineering identity [6], [10]. The second survey focused on the EM. Students assessed the following questions on a 5-point Likert scale with 1 not at all capable, 2 slightly capable, 3 moderately capable, 4 very capable, and 5 extremely capable:

(1) to what extent do you feel capable of exploring multiple solution paths when approaching a problem or challenge;

(2) to what extent do you feel capable of making connections between your engineering studies and your everyday life;

(3) to what extent do you feel capable of demonstrating empathy in identifying problems and exploring solutions (where empathy can be defined as the ability to take someone else's perspective so you can better understand their thoughts and emotions); and

(4) to what extent do you feel capable of creating solutions that meet customer need.

Table 1: Statements used to measure engineering identity, as defined by Godwin [10]. Students responded on a numeric scale from strongly disagree (0) to strongly agree (6).

Construct	Statement
Recognition	My parents see me as an engineer.
	My instructors see me as an engineer.
	My peers see me as an engineer.
Interest	I am interested in learning more about engineering.
	I enjoy learning engineering.
	I find fulfillment in doing engineering.
Performance	I am confident that I can understand engineering in class.
	I am confident that I can understand engineering outside of class.
	I can do well on exams in engineering.
	I understand concepts I have studied in engineering.
	Others ask me for help in this subject.

On the second day of class, the experimental and control group completed separate activities. The experimental group completed a design sprint activity. The design sprint was inspired by Stanford University’s d.school’s wallet project [25]. In the 85-minute class, students were tasked with identifying a problem about another classmate’s dorm/home through a short interview. Individually, students wrote a “How might we statement” for a problem identified through the interview process. The short statement took the form of “How might we help/encourage (specific person x, brief description of x) to (verb statement of what x needs)”. Students shared the statements with the class, and a vote was taken to decide which problems to pursue as a class. Individually, students were given time to brainstorm potential solutions, and then iterate as a team on the ideas to generate one solution to prototype. Using material provided such as popsicle sticks, Play-Doh, and construction paper, teams built a prototype of their idea. Following feedback from the intended user, a second iteration was built. Finally, the teams pitched their idea to the class with a 30-second infomercial. Students were guided through the design process with prompts and a handout. For more information on the design sprint, please reference [26].

The control group completed an environmental engineering activity, which was modified from NASA's water filtration challenge [27]. A short lecture was provided at the beginning of the class that included an overview of environmental engineering, what water distribution systems are, where water is sourced from locally, and the concept of turbidity. In teams of four, students were tasked with designing and testing a water filter using a 1 L bottle and commonly available materials including cheesecloth, sand, gravel, coffee filters, and cotton balls. Student teams first sketched their proposed design, and then built filters using the provided materials. After 30 minutes, teams tested their filters measuring the turbidity of prefabricated dirty water. The class ended with a debrief on the activity and a description of how water treatment facilities work.

The surveys were administered again in week five of the 14-week semester before the final design project for the class was introduced. The second survey was purposely delayed after the intervention to avoid recency bias. In addition to the Likert questions for the EM, students had the option to identify a specific example of how their ability to explore multiple solution paths, make connections to the real world, demonstrate empathy, and create solutions to meet customer needs was impacted by the class.

In week eight, the experimental group completed the environmental engineering activity, and the control group completed the design sprint. The surveys, including the option to identify specific examples, were administered for a final time in the last week of class.

Analysis

As the data was not normally distributed, nonparametric tests were used for analysis. Change scores were calculated across time, and a Wilcoxon signed-rank test was used to determine if there was a difference in dependent measures between the control and experimental groups. To examine time change differences within a group, a Friedman test was conducted. The analysis was conducted in SPSS v27 (IBM Corp, Armonk, NY), with significance set at $p<0.05$.

To analyze the qualitative data, deductive coding was used to create a codebook with specific words related to the design sprint, water filter activity, and final design project of the class which consisted of building a wind turbine. The percentage of respondents who used the various codes was calculated for the second and third surveys.

Results and Discussion

A total of 126 students were eligible for the study, with 91 students (72.2%) (54 out of 73 experimental, 37 out of 53 control) completing all three engineering identity surveys and 85 students (67.5%) (51 out of 73 experimental, 34 out of 53 control) completing all three EM surveys.

Student Demographics

Due to the uneven number of sections (5), there were differences in the number of students between the control and experimental groups. Students were distributed across sections by program counselors to accommodate course schedules; however, in analyzing student demographics, there were some differences, with more students in the experimental group identifying as female (25.9% vs. 18.9%, p=0.590), first-generation (29.6% vs. 21.6%, p=0.371), and non-white (61.1% vs 35.1%, p=0.007) compared to the control group.

Engineering Identity

There was no significant difference between the experimental and control groups for the change scores between the first and second surveys for engineering identity (p=0.514), performance (p=0.224), recognition (p=0.621), or interest (p=0.691), though the median of scores either remained constant or increased between the first and second survey for both groups (Figure 1).

Engineering identity (p=0.010) and performance (p=0.021) scores significantly differed across time points in the experimental group, while no metric significantly changed across time in the control group. All aspects of engineering identity increased from the first to the final survey, except for interest in the control group which remained constant.

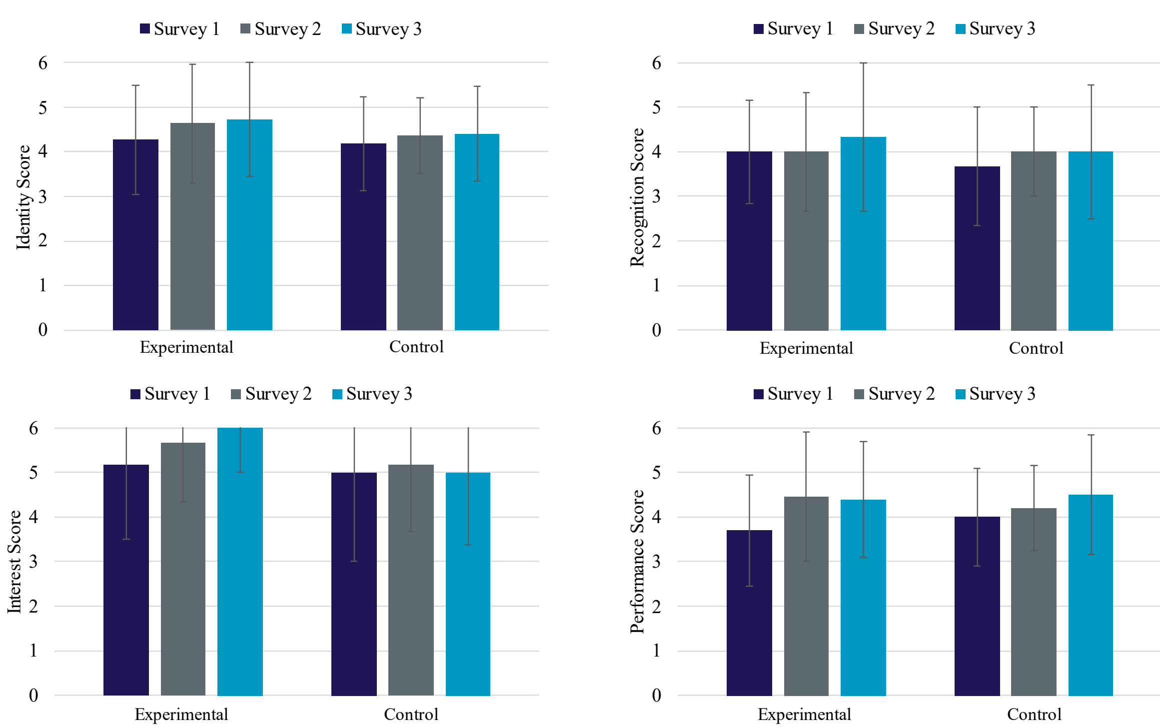

Figure 1: Overall identity, recognition, interest, and performance scores for all three surveys, experimental and control groups. Median +/- interquartile range presented.

Results indicate that the early exposure to the EM design sprint activity had little impact on students' perception of engineering identity. Instead, their experiences throughout the entire semester, regardless of the order of lessons, seemed to improve their overall view of identity. It should be noted that initial identity scores, administered after the second day of class, were already quite high, with the median of all constructs (identity, recognition, interest, and performance) above 3 (which correlates to 'slightly agree' in the Likert-type scale) (Figure 1). Students' reported interest in engineering was particularly high, with a median above 5 out of 6. These results are not surprising in that students have already self-selected as engineering majors. Students' perception of engineering identity increased throughout the 14-week course across all constructs, which is in line with our previous work [6]. These results suggest that the requirement of the first-year engineering course improves students' perception of engineering identity, which is promising as identity is linked strongly to student retention [2], [3]. A study that examined changes in student's self-efficacy in a first-year engineering class when exposed to EM concluded the amount of exposure to EM did not make a difference, but instead, the increase from the beginning to the end of the semester may be due to involvement in an introductory engineering class [28].

The experimental group had a statistically significant increase across certain metrics (see above), whereas the control group did not have this statistical increase, though qualitatively, results either stayed the same or increased (Figure 1). The difference between groups could be attributed to the difference in the lesson sequence (design sprint before the environmental engineering activity and vice versa) or due to other differences in the groups, for example being more first-generation.

Entrepreneurial Mindset

There was no significant difference between the experimental and control groups for the change scores between the first and second surveys related to the EM (multiple solutions, $p=0.294$, make connections, $p=0.666$, empathy, $p=0.610$, customer needs, $p=0.530$). The change scores decreased for all questions for both groups from survey 1 to survey 2.

Similar to engineering identity, the introduction of a design sprint early in the semester did not seem to affect a student's EM. There was a decrease in the percentage of students who either agreed or strongly agreed with the EM questions from survey 1 to survey 2 for both groups (Figures 2-5). Students were taught technical concepts through a series of labs between the first and second surveys. The technical content may have decreased students' confidence in engineering problem-solving, which is an area for further exploration. The percentage of students who answered agree or strongly agree then increased for the final survey, after they completed the wind turbine design project. An interesting finding is that although the EM scores dropped between surveys 1 and 2, the engineering identity scores did not. Students may feel they identify more with being an engineer after the content learned in class but don't feel as capable as when they started the semester.

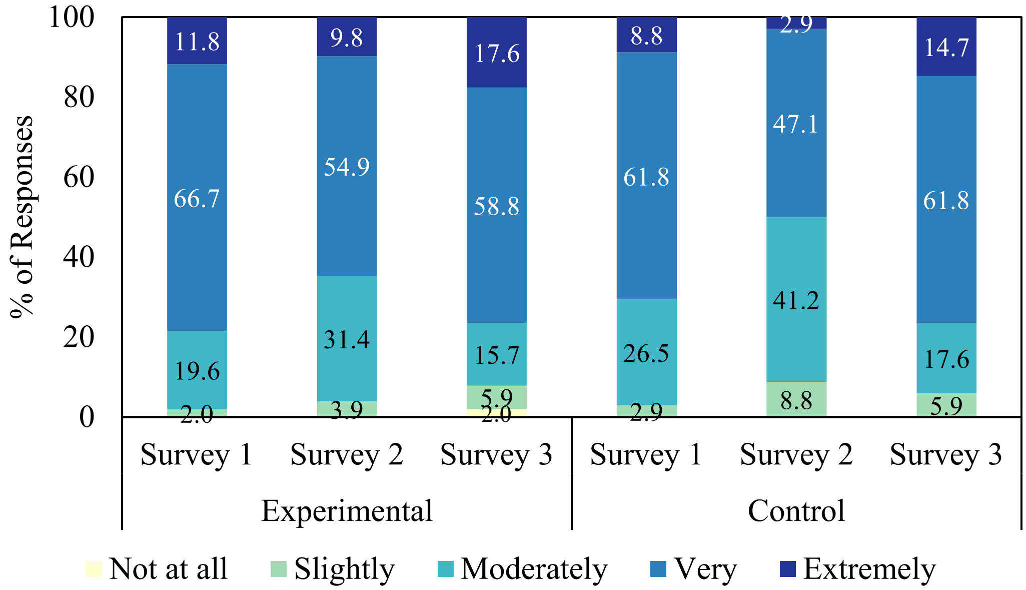

Figure 2: Percent distribution of student responses when asked "to what extent do you feel capable of exploring multiple solution paths when approaching a problem or challenge." for all three surveys, experimental and control groups.

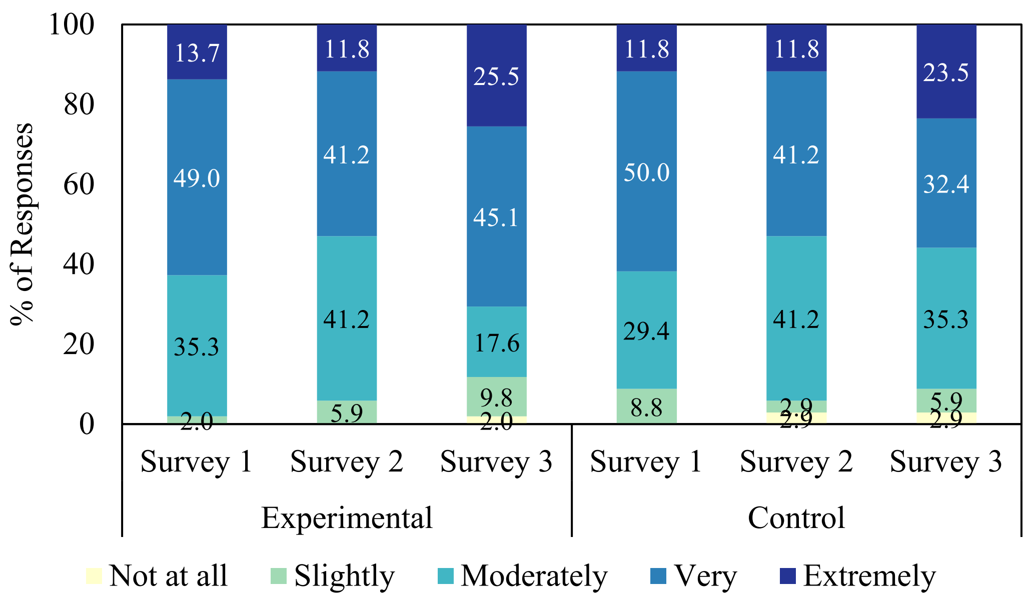

Figure 3: Percent distribution of student responses when asked "to what extent do you feel capable of making connections between your engineering studies and your everyday life." for all three surveys, experimental and control groups.

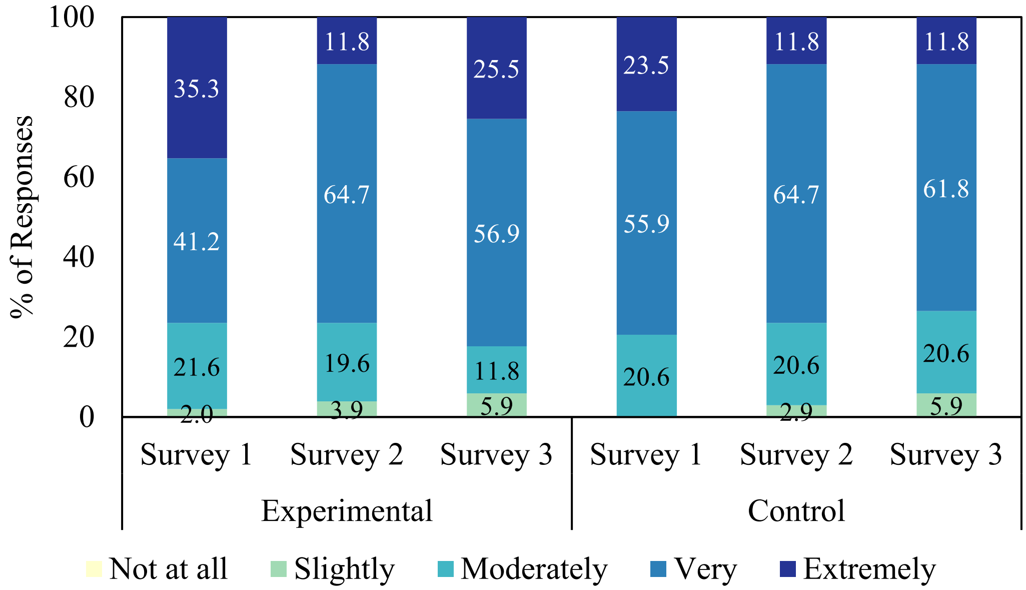

Figure 4: Percent distribution of student responses when asked "to what extent do you feel capable of demonstrating empathy in identifying problems and exploring solutions (where empathy can be defined as the ability to take someone else's perspective so you can better understand their thoughts and emotions)." for all three surveys, experimental and control groups.

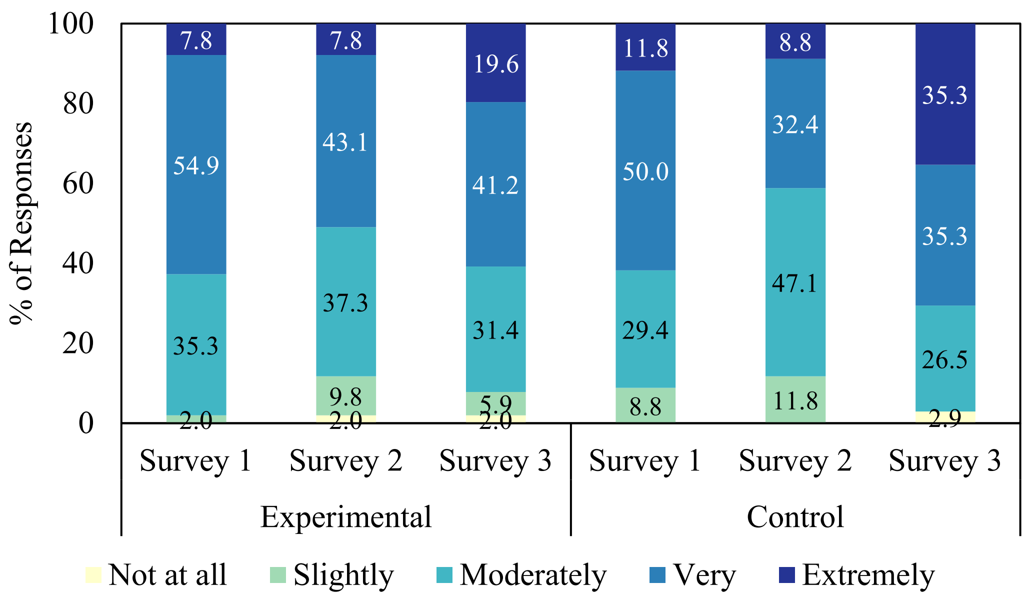

Figure 5: Percent distribution of student responses when asked "to what extent do you feel capable of creating solutions that meet customer need." for all three surveys, experimental and control groups.

Examining the qualitative data from survey 2 showed that both the design sprint and environmental engineering activity were seen as entrepreneurial activities by the students (Table

2). When asked to describe specific examples of how their ability to explore multiple solution paths increased from the class, a larger percentage of students in the control group cited the water filter activity compared to the experimental group. The design sprint activity did show up as a higher percentage of respondents when asked to describe a specific example to create solutions that met customer needs compared to the water filter activity. The control group participated in an activity that, while not designed with the EM in mind, did make connections for students. Although not intended, both activities (design sprint and water filter activity) had an impact on student's EM.

Table 2: The percentage of responses in survey 2 that mentioned the design sprint (experimental group) or the environmental engineering activity (control group) as the specific example for the EM questions.

	Experimental	**Control**
Explore multiple solution paths	17.6%	23.5%
Make connections between engineering and everyday life	3.9%	14.7%
Demonstrate empathy in identifying problems and exploring solutions	13.7%	8.8%
Create solutions that meet customer need	19.6%	5.9%

By the third survey, the majority of the students in both groups used the wind turbine final project as their example for all but one question (making connections between engineering and their everyday life). It is believed a recency effect contributed to the responses [29]. This was to be expected as students had just finished and presented their design project on the wind turbine during the week the survey was administered. Although a few students mentioned the design sprint or water filter activity in the final survey, the wind turbine project was the most recent assignment completed by the students and, therefore fresh in their minds.

Limitations

There are several limitations to the study. As mentioned earlier, there were uneven sample sizes due to the constraint of having five sections. Five different faculty taught the course, introducing differences in how the material was disseminated, though all sections had the same content. Instructors have been shown to influence the EM development of students [17]. Due to the nature of the course, the timing of the surveys, and other content indirectly linked to EM, it is hard to state any change that occurred in either engineering identity or EM was a direct cause of the intervention.

Future Work

While the design sprint did not change student's EM in the current offering, the design sprint will be implemented in future offerings of the course on the second day of class for all students. To increase student's awareness of EM, more specific language should be used when introducing the students to the activity, in particular around the 3Cs. Although not the focus of the paper, future work should examine how engineering identity and EM development are different across demographics, including gender, first-generation status, and race. Additional work could focus on correlating EM and engineering identity to retention.

Conclusion

The impact of the placement of a design sprint activity was investigated in a first-year introduction to engineering course on students' EM and engineering identity. Regardless of whether the design sprint activity was conducted in the beginning or mid-semester, student survey results suggest that there was no increase in the EM. This contrasts with students' engineering identity; students' perception of engineering identity significantly increased during the semester for the group of students exposed to the design sprint early on. Students who completed the design sprint later in the semester reported an increase in engineering identity metrics, but it was not statistically significant. Interestingly, survey results indicate both the design sprint and an environmental engineering water filter challenge provided students an opportunity to reflect on the EM. Findings support other work that shows an increase in engineering identity in first-year engineering experiences. Future work will examine how engineering identity and EM differ across demographics and students' selected majors.

Resources

A "Card" – i.e., an information repository – has been created for this paper on the Engineering Unleashed website [26]. The card contains instructor notes and the class activity handout to complete the design sprint. The materials can be freely used in courses under the Creative Commons CC BY-NC license [30].

Acknowledgment

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References

[1] B. M. Capobianco, B. F. French and H. A. Diefes-Dux, "Engineering identity development among pre-adolescent learners," *J Eng Educ,* vol. 101, *(4),* pp. 698-716, 2012.

[2] H. M. Matusovich, R. A. Streveler and R. L. Miller, "Why do students choose engineering? A qualitative, longitudinal investigation of students' motivational values," *J Eng Educ,* vol. 99, *(4),* pp. 289-303, 2010.

[3] B. E. Hughes *et al*, "Do I think i'm an engineer? understanding the impact of engineering identity on retention," in *2019 ASEE Annual Conference & Exposition,* 2019.

[4] A. D. Patrick and A. N. Prybutok, "Predicting persistence in engineering through an engineering identity scale," *International Journal of Engineering Education,* vol. 34, *(2a),* 2018.

[5] J. Chen *et al*, "Exploring Students' Perception of the Influence of PBL Elements on the Development of Engineering Identity," *IEEE Transactions on Education,* 2023.

[6] J. M. Wolfand, K. Bieryla and C. Ivler, "Engineering identity through litter pickup as service learning," in *2023 ASEE Annual Conference & Exposition,* 2023.

[7] D. Knight *et al*, "The impact of inclusive excellence programs on the development of engineering identity among first-year underrepresented students," in *2013 ASEE Annual Conference & Exposition,* 2013.

[8] N. Delatte *et al*, "Implementation and assessment of case studies in the engineering curriculum," in *2010 Annual Conference & Exposition,* 2010.

[9] A. Clark *et al*, "Tracking first-year engineering students' identity metrics," *IJEE International Journal of Engineering Education,* vol. 36, *(5),* 2020.

[10] A. Godwin, "The development of a measure of engineering identity," in *ASEE Annual Conference & Exposition,* 2016.

[11] D. Verdín, "The power of interest: minoritized women's interest in engineering fosters persistence beliefs beyond belongingness and engineering identity," *International Journal of STEM Education,* vol. 8, *(1),* pp. 33, 2021.

[12] A. Godwin and A. Kirn, "Identity-based motivation: Connections between first-year students' engineering role identities and future-time perspectives," *J Eng Educ,* vol. 109, *(3),* pp. 362-383, 2020.

[13] D. Rae and D. E. Melton, "Developing an entrepreneurial mindset in US engineering education: an international view of the KEEN project," *The Journal of Engineering Entrepreneurship,* vol. 7, *(3),* 2017.

[14] J. Blake Hylton *et al*, "Working to instill the entrepreneurial mindset across the curriculum," *Entrepreneurship Education and Pedagogy,* vol. 3, *(1),* pp. 86-106, 2020.

[15] R. S. Harichandran *et al*, "Developing an Entrepreneurial Mindset in Engineering Students Using Integrated E-Learning Modules." *Advances in Engineering Education,* vol. 7, *(1),* pp. n1, 2018.

[16] D. R. Riley *et al*, "First-year engineering students' conceptualization of entrepreneurial mindset," *Entrepreneurship Education and Pedagogy,* vol. 6, *(1),* pp. 87-109, 2023.

[17] A. Jackson *et al*, "Exploration of the experiences that shape engineering students' entrepreneurial mindset development," *Entrepreneurship Education and Pedagogy,* vol. 6, *(1),* pp. 60-86, 2023.

[18] A. L. Gerhart *et al*, "Combining discipline-specific introduction to engineering courses into a single multidiscipline course to foster the entrepreneurial mindset with entrepreneurially minded learning," in *2014 ASEE Annual Conference & Exposition,* 2014.

[19] M. J. Jensen and J. L. Schlegel, "Implementing an entrepreneurial mindset design project in an introductory engineering course," in *2017 ASEE Annual Conference & Exposition,* 2017.

[20] M. V. Huerta *et al*, "Cultivating the entrepreneurial mindset through design: Insights from thematic analysis of first-year engineering students' reflections," in *2017 ASEE Annual Conference & Exposition,* 2017.

[21] J. A. Riofrio *et al*, "Innovation to entrepreneurship in the first year engineering experience," in *2015 ASEE Annual Conference & Exposition,* 2015.

[22] M. Hirudayaraj *et al*, "Soft skills for entry-level engineers: What employers want," *Education Sciences,* vol. 11, *(10),* pp. 641, 2021.

[23] G. C. Fleming *et al*, "What engineering employers want: An analysis of technical and professional skills in engineering job advertisements," *J Eng Educ,* 2024.

[24] M. W. Ohland *et al*, "The effect of an entrepreneurship program on GPA and retention," *J Eng Educ,* vol. 93, *(4),* pp. 293-301, 2004.

[25] Hasso Plattner Institute of Design, Stanford University, "The Wallet Project," Available: https://dschool.stanford.edu/resources/the-gift-giving-project.

[26] K. Bieryla, "Design Sprint – Dorm Life Edition," 2024. Available: https://engineeringunleashed.com/card/4032.

[27] NASA Jet Propulsion Laboratory, "Water Filtration Challenge," Available: https://www.jpl.nasa.gov/edu/teach/activity/water-filtration-challenge/.

[28] J. Thomas, L. E. Boucheron and J. P. Houston, "Measuring self-efficacy in diverse first-year engineering students exposed to entrepreneurial minded learning," in *2018 IEEE Frontiers in Education Conference (FIE),* 2018.

[29] D. Dickey and C. Pearson, "Recency effect in college student course evaluations," *Pract Assess Res Eval,* vol. 10, *(1),* 2005.

[30] Creative Commons, "Attribution-NonCommercial 4.0 International (CC BY-NC 4.0)," Available: https://creativecommons.org/licenses/by-nc/4.0/.