Engineering Identity through Litter Pickup as Service Learning

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Abstract

This Complete Research paper describes the impacts of a service-learning litter pickup project on engineering identity in the first year. Service-learning projects have been shown to increase student learning and improve student attitudes toward academics and community engagement. It was hypothesized that service learning may also improve students' engineering identity, as measured by recognition, interest, and performance indicators. Students were surveyed before, immediately after, and 10 months after a litter pickup service-learning project that was incorporated into a required first-year computing course. All engineering identity constructs were scored highly (median above 4 on a 0–6 scale), regardless of the survey time point. There was a significant improvement in the construction of recognition ($p=0.003$), but no significant change in interest ($p=0.184$), performance ($p=0.442$), or overall engineering identity ($p=0.177$). Engineering identity constructs were significantly different across gender and major, but not across other demographics, which included race and first-generation status. Identity construct scores decreased from the first to the second year, though not statistically significant. Results show the service-learning project had a positive impact on student engineering identity in the first year, but that further study is needed to maintain and improve students' perception of engineering identity between the first and second years.

Introduction

Engineering identity, a person's level of belief that they are an engineer, has been studied extensively as it is has shown to be linked to retention in the engineering profession [1], [2]. Various theories have been applied to describe and define identity in an engineering context including multiple identity theory, sociocultural theory, social identity theory, and identity stage theory [3], [4]. Utilizing these theories, many studies have sought to quantify identity in engineering [5]–[8]. Herein, we define engineering identity as students' self-assessment of their interest, performance/ability, and recognition (by others) in engineering, as established in Godwin [8].

Engineering identity can be strengthened by engineering-related experiences [9]. Many interventions have been tested to improve engineering identity in students, including summer bridge programs [10], problem-based learning [11], curricula that include real-world case studies [12], and service-learning projects [10].

Some of the most formative engineering experiences are in the first year of an undergraduate curriculum, and it is, therefore, an ideal time to shape students' perceptions of engineering and strengthen their engineering identity. The undergraduate dropout rate is greatest during the first year, especially for engineers [13]. Engaging first-year students and building a community of inclusion is particularly important for building engineering identity and retention [6]. For example, Knight et al. [10] found a statistically significant increase in first-year engineering identity in underrepresented students that participated in an inclusive summer bridge program.

Service learning can be defined as experiential learning in which students participate in community-based work [14], [15]. Incorporation of service-learning projects in curricula may improve students' attitudes toward self and school, civic engagement, social skills, and academic performance [16]–[19], which can strengthen engineering identity. For example, community service and volunteering for service-learning projects were associated with engineering identity in the post-assessment of a summer bridge program [10]. However, the study was limited in sample size and called for further research in engineering identity and the development of methods to emphasize the service-oriented side of engineering.

In this context, our research seeks to determine how engineering identity can be improved through students solving a sociotechnical problem, plastic pollution, with a service-learning litter pickup and data collection activity. The litter pickup project utilized in this study was discussed in prior research related to students' perceptions of an engineer's role in solving sociotechnical issues [15]. Three surveys were administered using Godwin's framework [8] to investigate two research questions: (1) How is engineering identity affected by a litter pickup service-learning project? (2) How does engineering identity change across first and second-year students, and is this related to demographics including gender, race, first-generation status, and major?

Methods

The study was conducted on 103 first-year engineering students enrolled in an introduction to computing class in Spring 2022 at the University of Portland, a private northwest university. The engineering majors consisted of mechanical, electrical, civil, and undeclared engineers.

Service-Learning Project

During the course, the students were required to complete a service-learning project focused on litter pickup. Students collected litter from the neighborhood surrounding campus and quantified their pickups using a litter-tracking app called Litterati [20]. Students processed the collected data in MATLAB to quantify patterns and identify potential solutions. The project culminated in an instructor-led discussion on societal and technical solutions to plastic pollution. Additional details on the service-learning project are provided in Wolfand et al. [15], [21]. Briefly, the litter pickup project was chosen to introduce students to the idea of solving sociotechnical problems with implications in the real world. Previous results showed that students who participated in the project had a more comprehensive understanding of the societal implications of plastic pollution and were more likely to agree that engineers have the skills, knowledge, and responsibility to solve sociotechnical problems.

Assessment

Before (*Pre*) and after (*Post 1*) the service-learning project, students completed a survey, administered online via Qualtrics, focused on engineering identity. The survey used Godwin's framework to define engineering identity as a student's beliefs about their performance, recognition from others, and interest in engineering [8]. Students were asked to respond to what extent they agree or disagree (on a scale of 0–6) with eleven statements (Table 1). The statements were grouped to form three constructs: recognition (three items), interest (three items), and performance (five items). A construct number was obtained by averaging the scores

within the construct for each student. Scores from all 11 items were averaged together to obtain an overall engineering identity score for each student. Additional questions on student demographics including major, gender, race, and first-generation college student status were also included (Table 2). The same cohort of students was presented with the engineering identity survey at the end of their first semester of their sophomore year (approximately 10 months after the first survey was completed; Post 2). The study was approved by the university's IRB and all students consented to participate.

Table 1: Statements used to measure engineering identity, as defined by Godwin [8]**. Students were offered a numeric scale from strongly agree (6) to strongly disagree (0).**

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.

Table 2: Survey questions related to student demographics.

Survey Question	Possible Responses
What is your major?	Civil Engineering, Electrical Engineering, Mechanical Engineering, Undeclared, Other (please specify)
Which gender do you identify most with?	Male, Female, Nonbinary, Prefer not to answer, Not included (please specify)
Which of the following best describes you?	Asian or Pacific Islander, Black or African American, Hispanic or Latino, Native American or Alaskan Native, White or Caucasian, Multiracial or Biracial, A race/ethnicity not listed here (please specify), Prefer not to answer
Do you identify as a first-generation college student?	Yes, No

Statistical Analysis

Before statistical analysis, data was checked for normality. As the data was not normally distributed, nonparametric tests were used for analysis. A Wilcoxon signed-rank test was used to determine if there was a change in dependent measures pre- and post-service-learning project. To compare all three time points, Friedman's two-way analysis of variance by ranks was conducted on the dependent measures. In the event of significance, post hoc pairwise comparisons with Bonferroni correction used was conducted. Demographic differences were analyzed with a Mann-Whitney U test or Kruskal-Wallis test (depending on the number of dependent measures) at each time point, with Bonferroni correction used on post hoc tests, using all data as matched data was not necessary. The analysis was conducted in SPSS v27, with significance set at $p<0.05$.

Results and Discussion

A total of 103 students were eligible for the study, and 77 students completed both the *Pre* and *Post 1* service-learning project survey while 48 students completed the survey at all time points (*Pre*, *Post 1*, and *Post 2*) (Figure 1). Of those who were eligible for the study, 11 (10.6%) left the university, and 7 (6.8%) stayed at the university but transferred out of the engineering program during the study time frame.

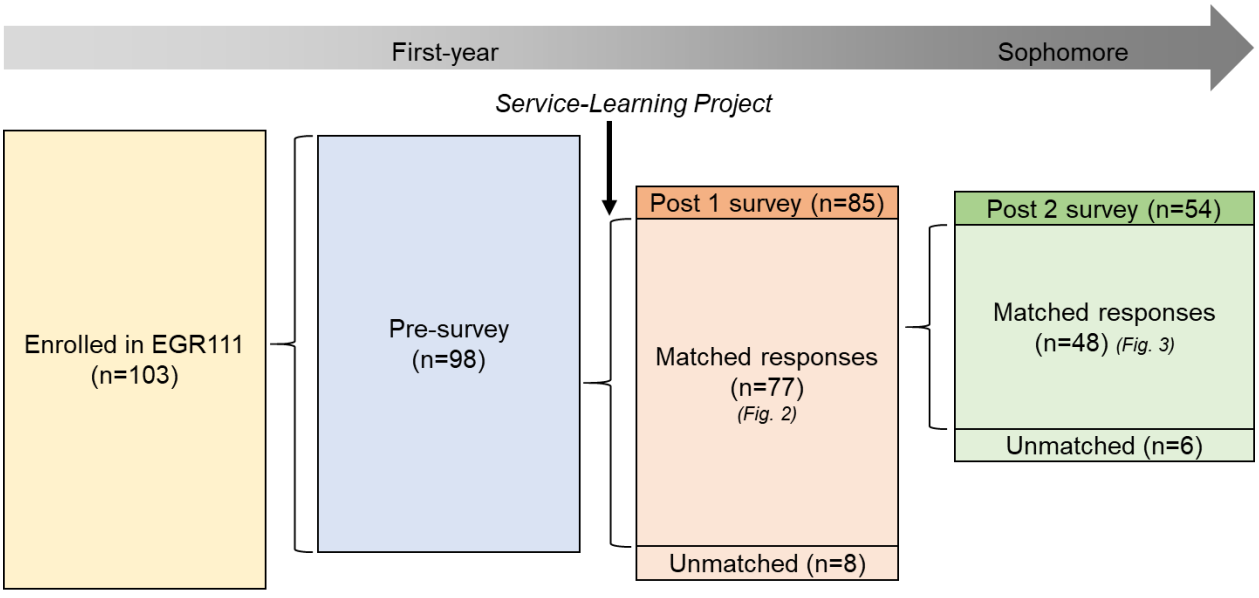

Figure 1: Flow chart of the study population.

Engineering Identity Pre and Post-Service-Learning Project

There was a significant improvement in the construct of recognition ($p=0.003$) and overall engineering identity ($p=0.048$) after the service-learning project (Figure 2). There was no significant change in interest ($p=0.791$) or performance ($p=0.215$) pre- and post-service-learning project, however, these scores also increased on average (Figure 2). These results suggest that the inclusion of the service-learning project may have strengthened students' engineering

identity in the first-year course. One of the goals of first-year engineering experiences may be to strengthen engineering identity, which is strongly linked to retention [22], [23]. Recognition has been shown in the past to be the strongest construct related to engineering identity in first-year students [24]. The improvement observed in this case in the first year could lead to an overall improvement in the student's engineering identity throughout their undergraduate career.

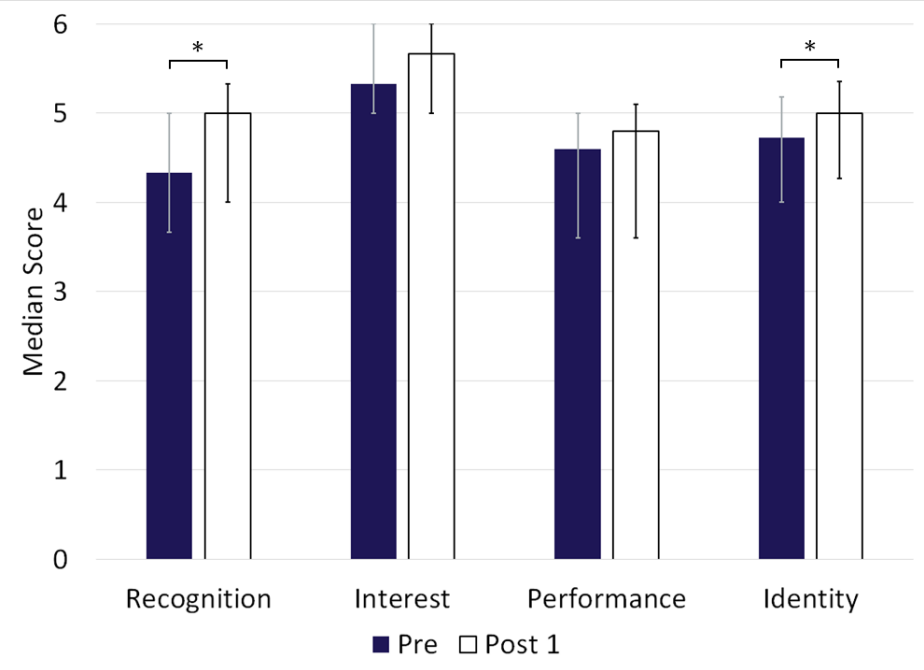

Figure 2: Median scores for pre and post-service-learning project (n=77). Error bars represent quartiles, and asterisks (*) indicate significance ($p<0.05$).

Engineering Identity Pre, Post Service-Learning Project, and Post first semester sophomore year

There was a significant change in the construct of recognition ($p=0.003$) over the three time points throughout the study (Figure 3). Post hoc analysis indicated a significant difference between *Pre* and *Post 1* time points ($p=0.009$), again indicating there was an improvement in recognition of engineering identity before and after the service-learning project. There was no significant change in interest ($p=0.184$), performance ($p=0.442$), or overall engineering identity ($p=0.177$) across the three time points (Figure 3), suggesting the first-year and first-semester-sophomore year curriculum has little impact on students' engineering identity beyond the recognition construct.

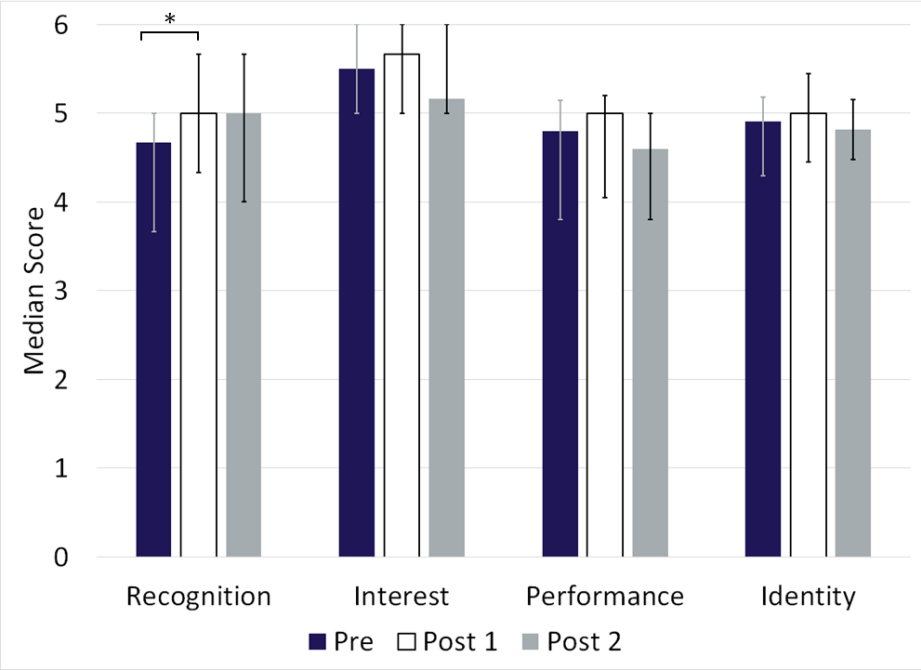

Figure 3: Median scores for pre (*Pre*) and post (*Post 1*) service-learning project and end of first semester sophomore year (*Post 2*) (n=48). Error bars represent quartiles, and asterisks (*) indicate significance ($p<0.05$).

On average, all construct scores decreased after the student's first semester sophomore year (*Post 2*), though not statistically significant. The results for the lower identity score after the first sophomore semester support results from a large-scale survey (n=4183) that showed sophomores, reported the lowest overall engineering identity scores compared to other class years using Godwin's survey [25]. In addition, Godwin and Lee [26] saw the lowest engineering identity score across all years in the sophomore year at a large public university. This is the first semester that is not common across all engineering disciplines at the University of Portland. The increased academic demand on students compared to the first year may have caused some of the decreases in self-reported engineering identity constructs. Examining specific discipline changes will be the subject of future work.

When examined more closely, the data suggest there are some differences in students' self-reported engineering identity across demographic groups. There was a significant difference in recognition across genders in the *Pre* ($p=0.045$), *Post 1* ($p=0.011$), and *Post 2* ($p=0.007$) surveys (Figure 4). Due to only one student identifying as nonbinary, gender was compared only between female and male.

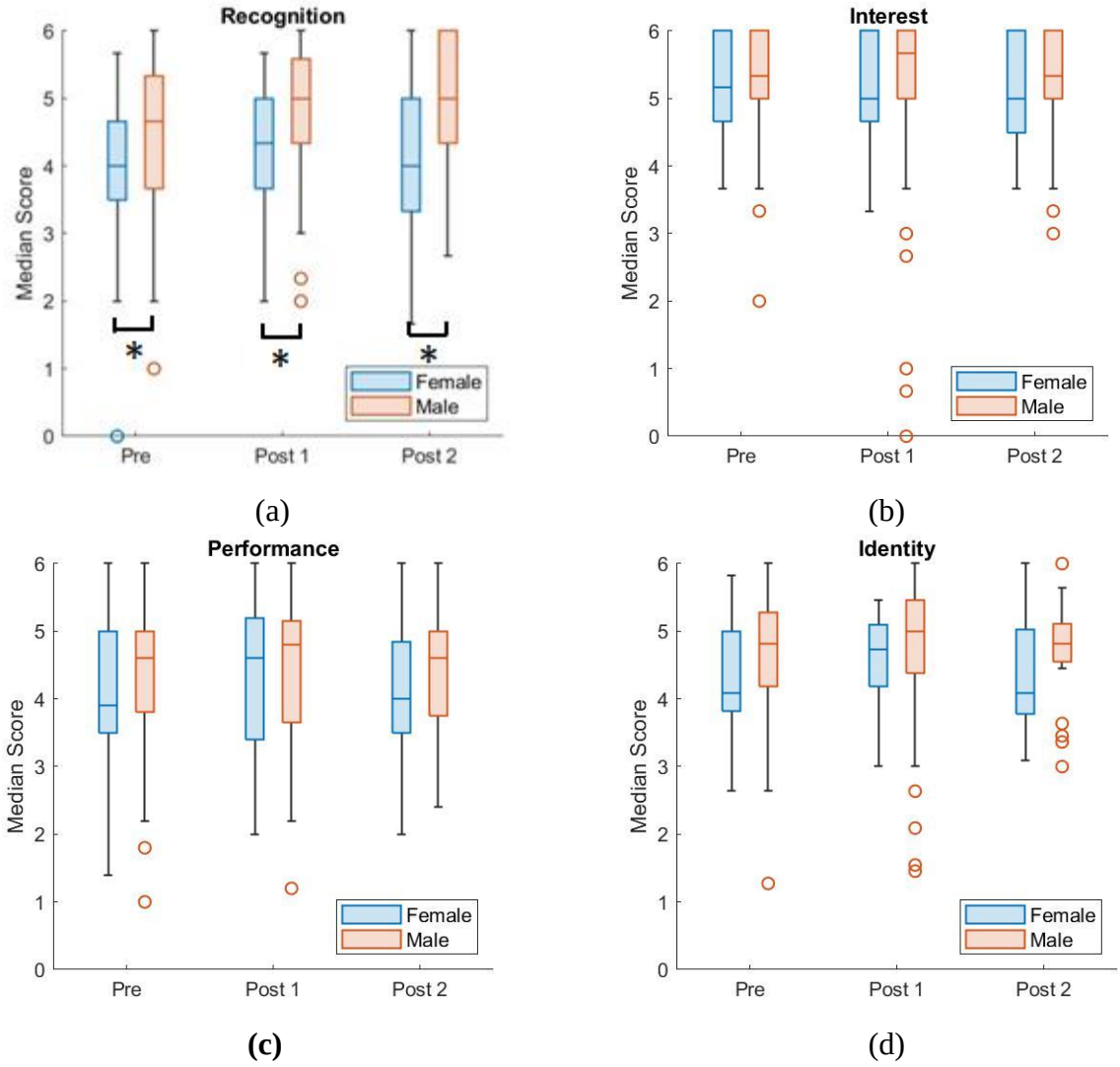

Figure 4: Median scores for pre (Pre, $n_{female} = 24, n_{male} = 74$) and post (*Post 1*, $n_{female} = 22, n_{male} = 63$) service-learning project and end-of-first-semester sophomore year (*Post 2*, $n_{female} = 17, n_{male} = 37$) for a) recognition, b) interest, c) performance, d) identity. The bottom and top edges of the box indicate the 25th and 75th percentiles, respectively. The whiskers extend to the minimum and maximum, not including outliers, and the asterisks (*) indicate significance (p<0.05).

For all time points, female students had lower median scores for all constructs, though only significant for recognition (Figure 4). Results for the recognition construct are consistent with a survey of over 600 engineering students in 2012 that showed that female students are less likely to identify as engineers as compared to males [6]. The difference between male and female engineering identity, with females reporting lower, has also been shown in a larger scaled survey using Godwin's construct [25]. While there was an increase in median score for women pre- and post-service-learning project, the score was still lower than for males. In a study by Lakin et al.

[27], first-year female engineers were more likely to express altruistic professional goals compared to men. The service-learning project presented here may have improved female recognition, but still not to the level of male students; the increase was proportional to the increase in male student scores. Future work should focus on incorporating more experiences to improve the identity of female engineers.

There were no differences in engineering identity scores across race and first-generation status. Across majors, only electrical engineering was higher than civil engineering in performance pre- (electrical n=23, civil n=22, p=0.004) and post-service-learning project (electrical n=22, civil n=18, p=0.033). It is unclear what the reason for the difference in majors is at the first-year level, as there are no discipline-specific classes in the first year. The difference in self-reported engineering identity may be due to the inherent interests of the students; for example, electrical engineers often (anecdotally) have more experience with coding compared to civil engineers. No data was collected on prior programming experience, which may have made a difference in the reported performance construct.

Conclusion

Survey results show that constructs of engineering identity (recognition, interest, and performance) are relatively high (median over 4 on a 0–6 point scale) for the surveyed population of engineering first-year students. We hypothesize this is due to the requirement to declare an engineering major at the entrance to the school; all students enrolled in the second semester required course were declared engineering majors. There was a significant increase in the engineering identity recognition construct after a service-learning project related to plastic pollution, but no significant increases in the other constructs (interest, performance, and overall identity). While the service-learning project may play a factor in this increase, other factors such as the collaborative nature of the course, or involvement in engineering-related activities such as extracurricular clubs may have also played a role. Future studies are needed to distinguish which if any of these factors may have caused the improvement in recognition.

Engineering identity scores decreased between the first year and second year of the program, though this decrease was not statistically significant. This could be due to the more intensive required coursework experiences in the second year such as *Circuits* and *Statics*, compared to the required introductory courses (*Introduction to Engineering* and *Introduction to Programming*) in the first year.

There was a statistical difference in engineering identity scores across gender, and for some majors, but no differences between other demographics: race and first-generation status. Gender differences (lower scores for females versus males) have been observed in many other studies. We hypothesized that the service-learning project may positively impact females more than males, but this was not the case; all scores increased proportionally equally. Differences in scores by major are difficult to conclude due to small sample sizes, but the results could impact the curricula of those specific majors, which diverge after the first year, and thus will be explored in future work. Future teaching modules will continue to integrate sociotechnical problem-solving,

including service-learning projects, into the first-year curriculum. Other potential interventions to strengthen engineering identity and retention in the first year will continue to be explored.

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