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Work in Progress: Impact of Student Engineering Competition Teams on Engineering Identity

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Professional organizations provide undergraduate students with competition opportunities in which they engage in extracurricular activities to design and build different products every year. During these times, students are able to see practical applications of their studies, test their products in regional and possibly national and international competitions, build community through friendships, develop their identity, and increase their sense of belonging. A survey was conducted to measure identity in terms of recognition, interest, and the performance of civil engineering students before and after joining the competition teams. The current paper describes the effect of concrete canoe and steel bridge competition teams on identity. The results showed that these competition teams help develop the identity of the students as engineers.

Introduction

Engineering competition teams offer unique opportunities for undergraduate students to integrate concepts learned in the classroom to further develop their technical and non-technical skills outside of the classroom. Each year, students collaborate in a team to design, build and test different products per rules set forth by the professional organizations to compete against other schools. This allows them to get real hands-on experience, expand their network, and build lasting friendships with fellow students, faculty members, and mentors, which could lead to future career opportunities. Additionally, these teams provide an ideal environment for students to learn and practice leadership skills. Project managers work with team members to create a budget plan, secure funding, manage finances, establish work schedules, train less-experienced members, and coordinate with team officers, advisors, administrators, suppliers, and sponsors to obtain the necessary resources and successfully deliver the final product [1] - [2]. Since students voluntarily join competition teams, this provides a unique opportunity for the study of engineering identity.

The American Society of Civil Engineers (ASCE) sponsors various competitions. Concrete canoe and steel bridge are among the most popular ones. Each spring, student teams compete in regional symposia. The winners of each symposium and selected wild card teams advance to the finals. The concrete canoe competition consists of a project proposal in response to the Request for Proposal (RFP) by the competition committee, presentations, display, and paddling. The steel bridge competition includes the design and fabrication of a scale-model steel bridge, aesthetics, efficient assembly during the competition, and load testing.

Engineering identity refers to how engineers perceive and understand themselves as professionals [3]. Students need to see themselves as future engineers and be recognized as such by others to be successful [4]. Research has shown that self-identification as an engineer influences a sense of belonging and one's persistence, which are critical for retention [5] - [10]. A recent study by Godwin developed a framework to measure engineering identity for first-year engineering students. The framework included three key constructs: recognition, interest, and performance/competence [11] - [12]:

1- Feelings of recognition: students' beliefs that they are seen as good engineering students in the subject by peers, parents, and instructors.
2- Interest in the subject: students' desire and curiosity to think about the content and do well in engineering. Interest describes how motivated students are in the content and their engineering careers.
3- Performance/competence belief: performance refers to students' perceptions of their ability to perform well in their classes or when conducting engineering tasks. Competence describes students' beliefs in their ability to understand engineering concepts.

A follow-up study extended this research to examine identity development across the four years of undergraduate education. It was found that the developed tool can measure identity among students in different years of their education [13].

Procedure

A Google Forms survey was created based on the framework developed by Godwin [11] to assess the identity of students in areas of recognition, interest, and performance/competence before and after participation in the competition teams. This section of the survey, as shown in Table 1, included 26 questions, each based on a scale of strongly disagree, disagree, neutral, agree, strongly agree, and not applicable. Since not all the members were engineering majors, the "not applicable" option was added. The survey also collected demographic information such as gender, class level, duration of team membership, and whether either parent was an engineer. It concluded with two open-ended questions: one asking to describe any additional factors that contribute(d) to their self-identifying/being identified as an engineer, and another asking those who selected "not applicable" to explain their choice. The survey was distributed to the members of the concrete canoe and steel bridge teams at the end of the semester after their competitions had concluded. The concrete canoe team had 18 members while the steel bridge team had 11 members, with some individuals participating on both teams. A total of 20 students participated in the survey, with 65% from the concrete canoe and 35% from the steel bridge team. The participants included 60% male and 40% female, with 5% freshmen, 30% sophomores, 40% juniors, and 25% seniors. 15% of participants had a parent who was an engineer while 85% did not. One participant, who was not an engineering major but a member of the concrete canoe team, selected "not applicable" for all survey questions.

Table 1- Survey questions on identity

Construct		Statement
<u>Recognition</u>	- Parents	*Prior to my participation in the teams, my parents saw me as an engineer.* *Since my participation in the teams, my parents see me as an engineer.*
	- Instructors	*Prior to my participation in the teams, my instructors saw me as an engineer.* *Since my participation in the teams, my instructors see me as an engineer.*
	- Peers	*Prior to my participation in the teams, my peers saw me as an engineer.* *Since my participation in the teams, my peers see me as an engineer.*
	- Previous experience	*Prior to my participation in the teams, I have had experiences in which I was recognized as an engineer.* *Through my experience in the competition teams, I was recognized as an engineer.*
<u>Interest</u>		*Prior to my participation in the teams, I was interested in learning more about engineering.* *Since my participation in the teams, I have become more interested in learning about engineering.* *Prior to my participation in the teams, I enjoyed learning engineering.* *Since my participation in the teams, I enjoy learning engineering.* *Prior to my participation in the teams, I found fulfillment in doing engineering.* *Since my participation in the teams, I find fulfillment in doing engineering.*
<u>Performance/Competence</u>		*Prior to my participation in the teams, I was confident that I could understand engineering in class.* *Since my participation in the teams, I am confident that I can understand engineering in class.* *Prior to my participation in the teams, I was confident that I could understand engineering outside of class.* *Since my participation in the teams, I am confident that I can understand engineering outside of class.* *Prior to my participation in the teams, I could do well on exams in engineering.* *Since my participation in the teams, I can do well on exams in engineering.* *Prior to my participation in the teams, I understood concepts I had studied in engineering.* *Since my participation in the teams, I better understand the concepts I have studied in engineering.* *Prior to my participation in the teams, others asked me for help in engineering.* *Since my participation in the teams, others ask me for help in engineering.* *Prior to my participation in the teams, I could overcome setbacks in engineering.* *Since my participation in the teams, I can overcome setbacks in engineering.*

Results

Figures 1 to 4 show the responses regarding recognition both before and after participation in the competition teams. Figure 1 illustrates the distribution of responses regarding recognition by parents. As seen, participation in the competition teams resulted in a slight increase in parental recognition of participants as engineers. For those who had an engineer parent, no change in recognition was reported. As shown in Figure 2, recognition by instructors improved significantly after participation, increasing from 70% at least agreeing and 25% neutral to 95% at least agreeing. The strongly agreed level increased from 20% to 35% while the agreed level rose from 50% to 60%. Recognition by peers also increased from 85% at least agreeing, 5% neutral, and 5% disagreeing to 95% at least agreeing as seen in Fig. 3. Figure 4 indicates that participation in competition teams led to a substantial increase in recognition compared to previous experiences, increasing from 55% at least agreeing, 5% neutral, and 35% disagreeing to 85% at least agreeing and only 10% disagreeing.

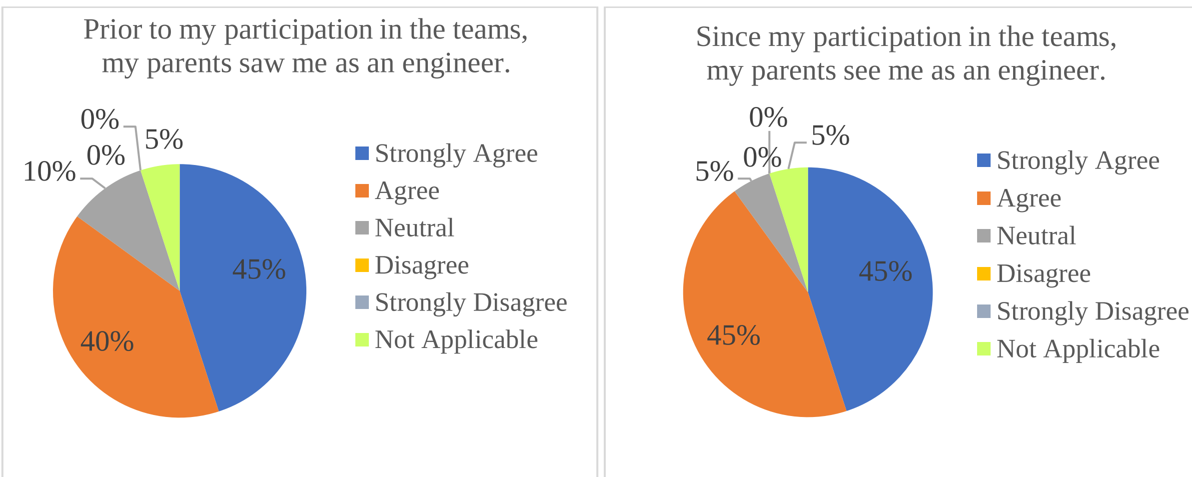


Figure 1- Response distribution for recognition by parents

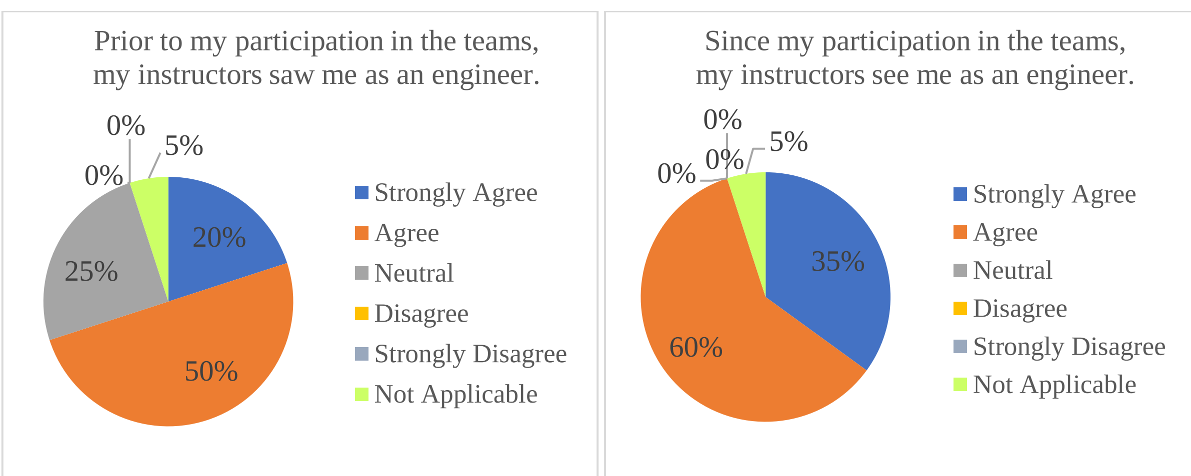


Figure 2- Distribution of responses regarding recognition by instructors

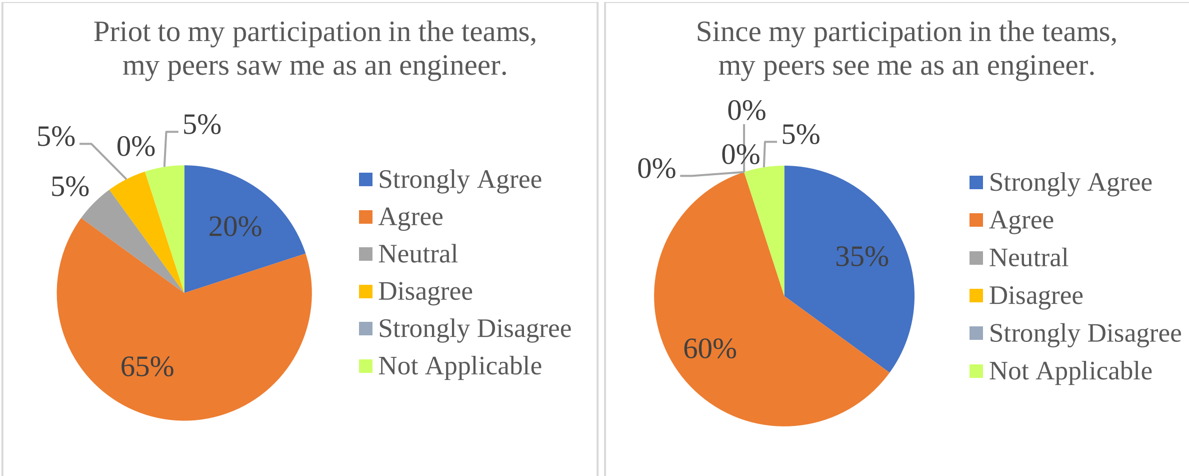


Figure 3- Response distribution for recognition by peers

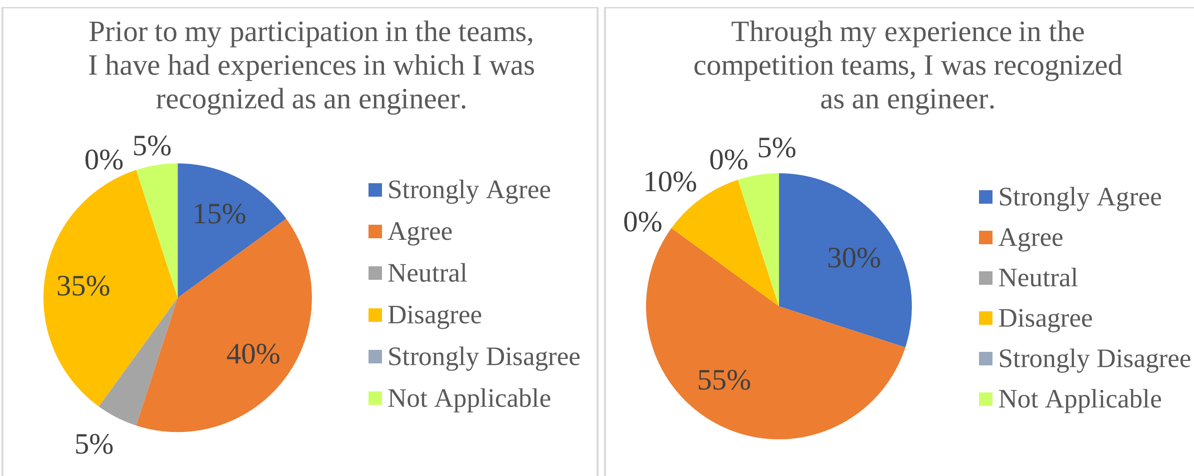


Figure 4- Response distribution for recognition relative to any previous experience

To further investigate how gender and class level affect recognition by instructors, peers, and relative to previous experience, the ratio of participants who at least agreed after participating in the teams to that of before participating was calculated and is presented in Table 2. The "not applicable" response was excluded to provide a more accurate comparison. Additionally, freshmen were not included since only one female freshman participated in the survey. Lastly, "N/A" indicates that no senior females participated in the survey.

As seen in the table, participation in the teams enhanced recognition for both males and females, with the largest increase observed in recognition relative to previous experience, especially among women, followed by recognition by instructors. Among males, juniors showed the highest margins of improvement across all areas of recognition. For females, sophomores had the highest margin for recognition relative to previous experiences, while juniors showed the highest margin in recognition by instructors and peers. The high margin for both male and female juniors in recognition by instructors and peers is attributed to their enrollment in civil engineering courses at this level, which allows them to interact more with their instructors and peers. Participation in the teams did not affect the recognition by instructors or peers for both male and female sophomores. Sophomores mainly take core engineering courses, which may limit their engagement with their civil engineering instructors and peers.

Table 2- Effect of gender and class level on recognition

	Male				Female			
	Overall	Sophomore	Junior	Senior	Overall	Sophomore	Junior	Senior
Recognition by instructors	1.33	1.00	1.67	1.25	1.40	1.00	1.50	N/A
Recognition by peers	1.09	1.00	1.25	1.00	1.17	1.00	1.50	N/A
Recognition relative to previous experience	1.38	1.00	1.67	1.25	2.00	3.00	1.50	N/A

Figures 5 to 7 display the distribution of responses for interest before and following the participation in the competition teams. As seen in Figure 5, participation in competition teams did not affect students' interest in engineering; however, Figure 6 indicates a slight improvement in the enjoyment of learning engineering, with responses shifting from 45% strongly agreeing, 45% agreeing, and 5% disagreeing to 50% strongly agreeing, 40% agreeing, and 5% neutral. Figure 7 reveals a significant increase in the fulfillment gained by doing engineering with responses increasing from 65% at least agreeing, 25% neutral, and 5% strongly disagreeing to 95% at least agreeing following participation in the competition teams. The percentage of students who strongly agreed grew from 20% to 40%, while those who agreed increased from 45% to 55%.

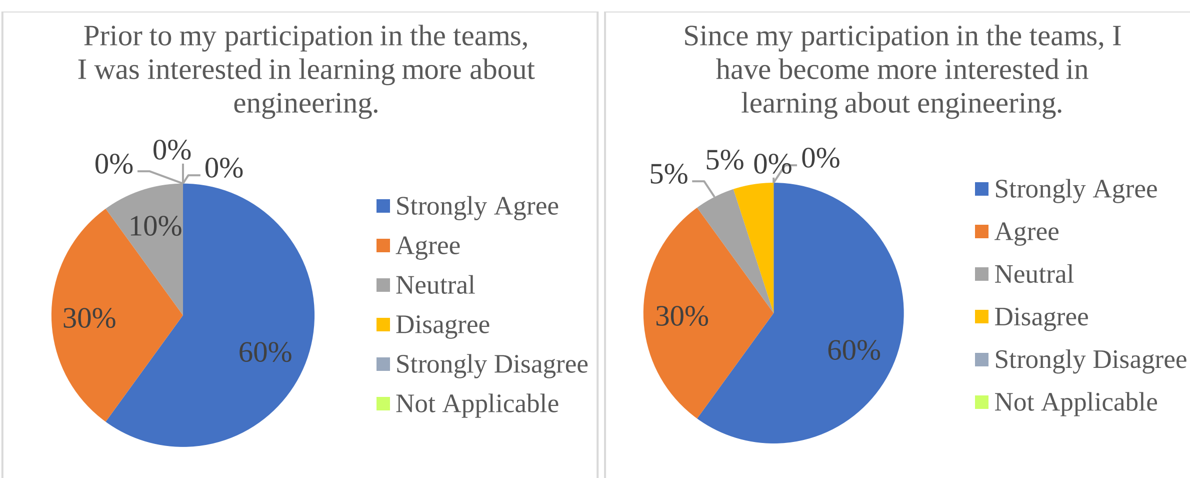
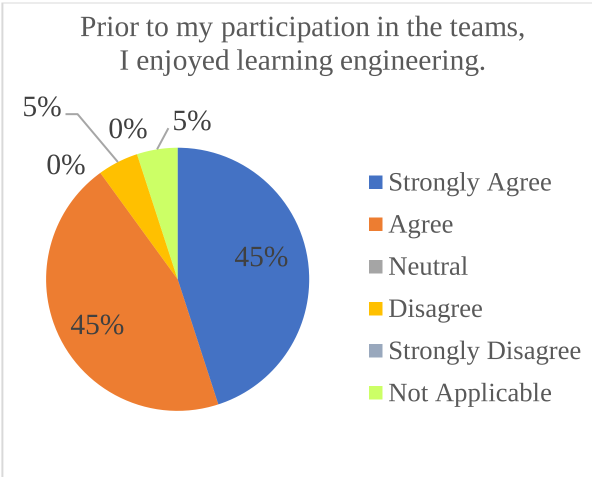


Figure 5- Distribution of responses for interest in learning about engineering



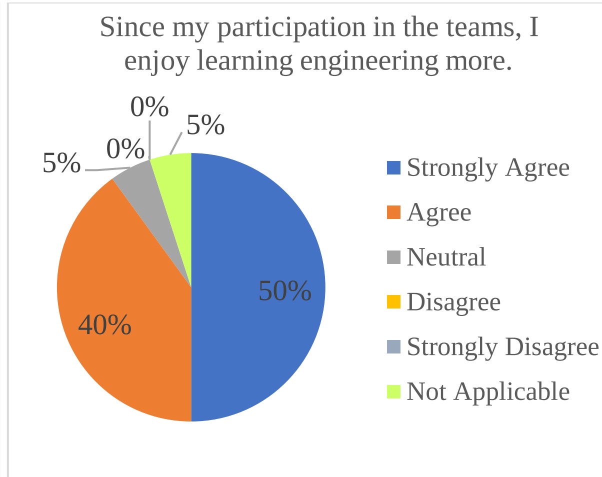
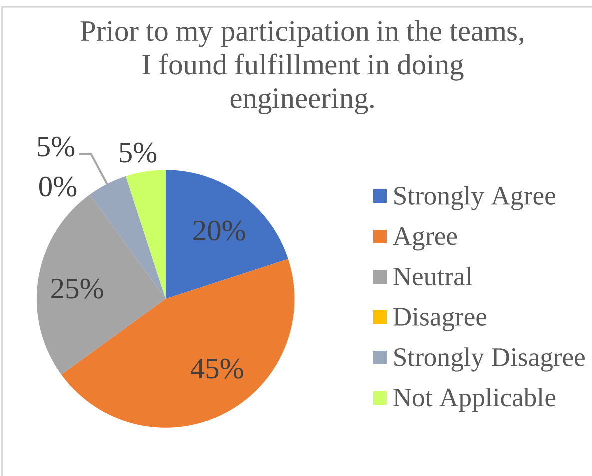


Figure 6- Response distribution for the enjoyment of learning engineering



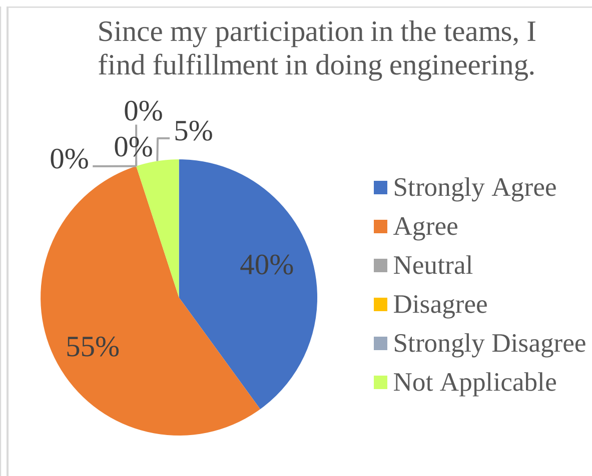


Figure 7- Response distribution regarding fulfillment from engaging in engineering

Table 3 shows the ratio of participants who at least agreed that they found fulfillment in engaging in engineering after participating in the teams to before they participated, categorized by gender and class level. Participation in the teams significantly enhanced fulfillment for both males and females. Additionally, sophomores, particularly women, have the highest margin of increase in finding fulfillment from engaging in engineering among both groups. This is likely due to sophomores primarily taking core engineering courses, with the competition teams serving as their first significant exposure to civil engineering and opportunities to take on officer roles.

Table 3- Effect of gender and class level on finding fulfillment from engaging in engineering

Male				Female			
Overall	Sophomore	Junior	Senior	Overall	Sophomore	Junior	Senior
1.50	2.00	1.67	1.25	1.40	3.00	1.00	N/A

Figures 8 to 13 show the responses related to performance and competence before and after participation in the competition teams. Figure 8 indicates that participation in the competition teams drastically increased confidence in understanding engineering in class from 70% at least agreeing, 20% neutral, and 5% disagree to 95% at least agreeing. Similarly, confidence in understanding engineering outside of class significantly improved from 45% at least agreeing, 40% neutral, 5% disagreeing, and 5% strongly disagreeing to 90% at least agreeing and 5% neutral, as seen in Fig. 9. On the strongly agreed level, the rise is from 5% to 25%. The agreed level increase is from 40% to 65%. Figure 10 shows that participation in the teams had no impact on exam performance. Per Figure 11, understanding engineering concepts has slightly improved following participation in the teams. Figure 12 indicates an increase in peers seeking help from competition team members, with agreement to the statement rising from 50% at least agreeing, 20% neutral, and 25% disagreeing to 60% at least agreeing, 25% neutral, and 5% disagreeing. Figure 13 illustrates that participation in the competition teams has overwhelmingly enhanced students' ability to overcome challenges and setbacks in engineering, with agreement to the prompt statement rising from 70% at least agreeing, 20% neutral, and 5% disagreeing to at least 95% agreeing. Notably, the percentage of students strongly agreeing rose from 15% to 30%, while those agreeing increased from 55% to 65%.

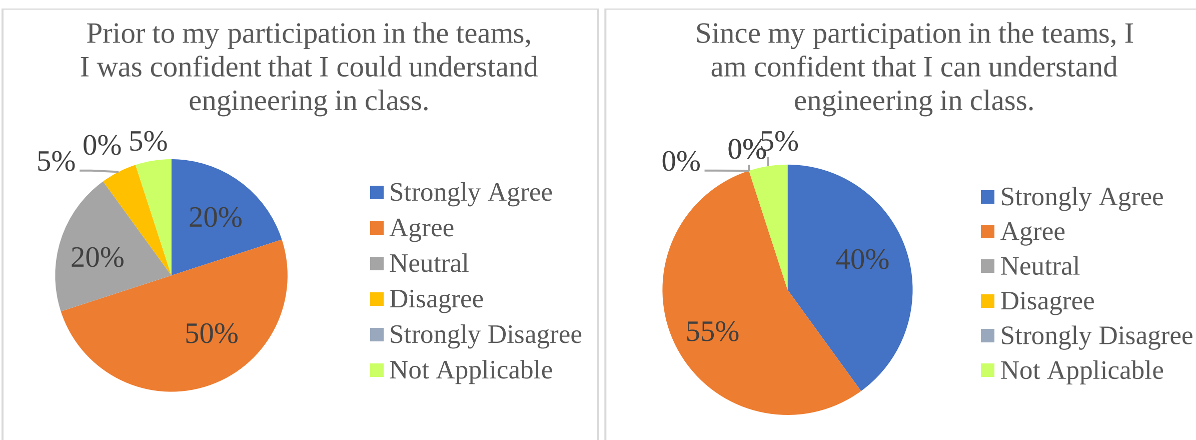


Figure 8- Distribution of responses regarding confidence in understanding engineering in class

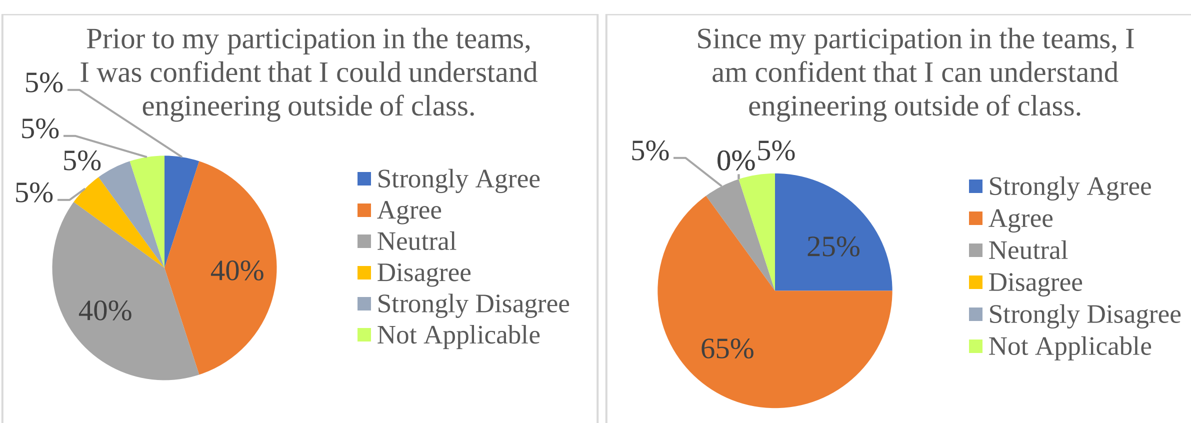


Figure 9- Response distribution regarding confidence in understanding engineering outside of class

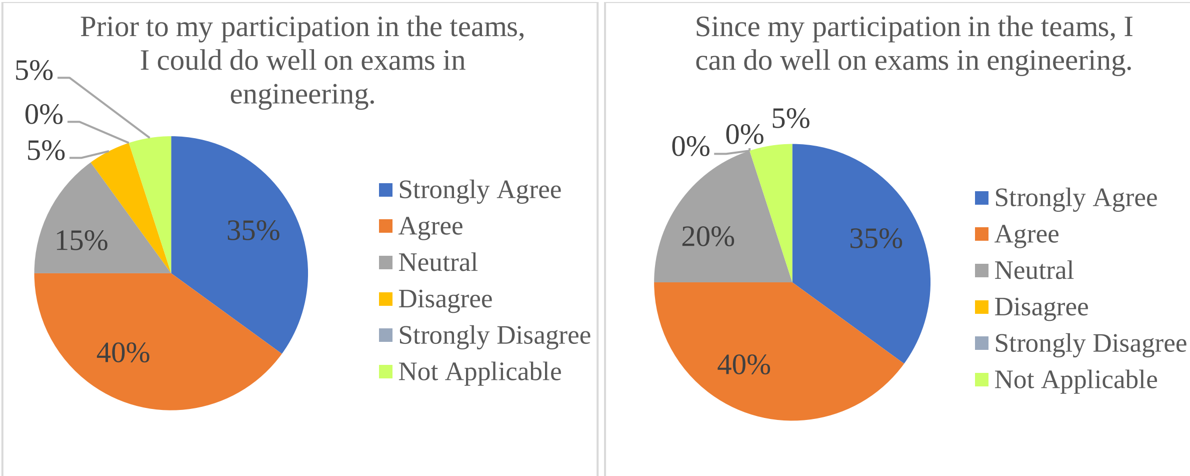


Figure 10- Response distribution for confidence in performing well on exams

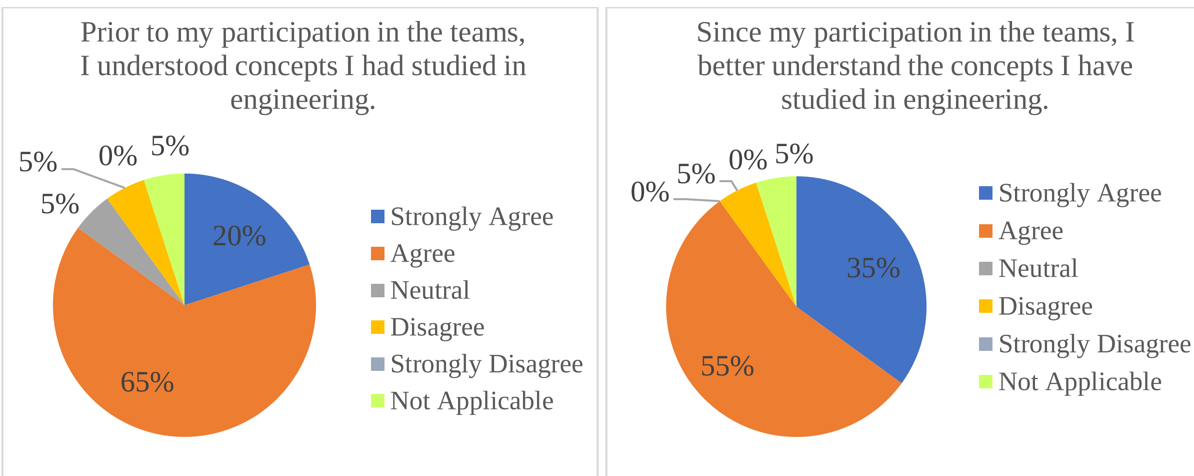


Figure 11- Response distribution regarding understanding engineering concepts

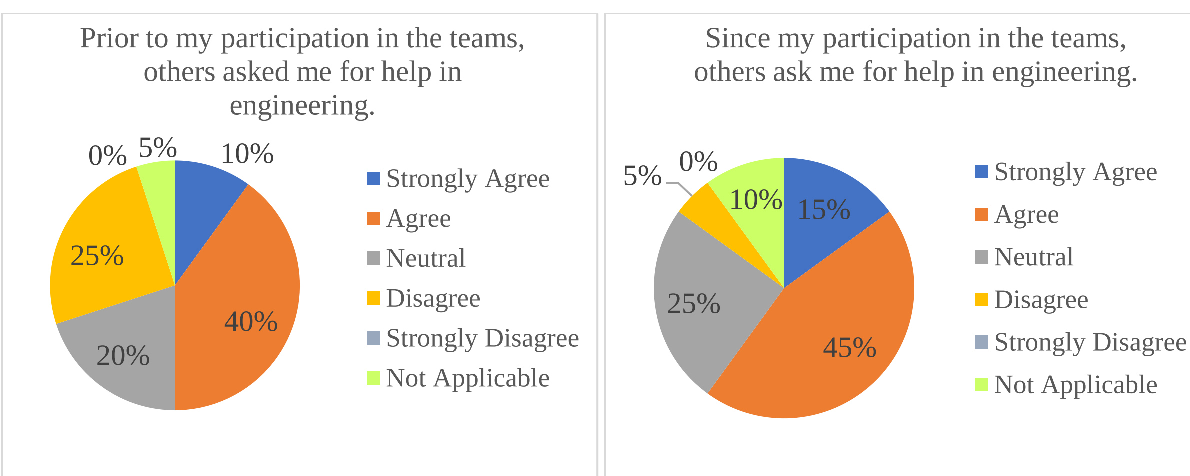


Figure 12- Response distribution for being approached by others for help in engineering

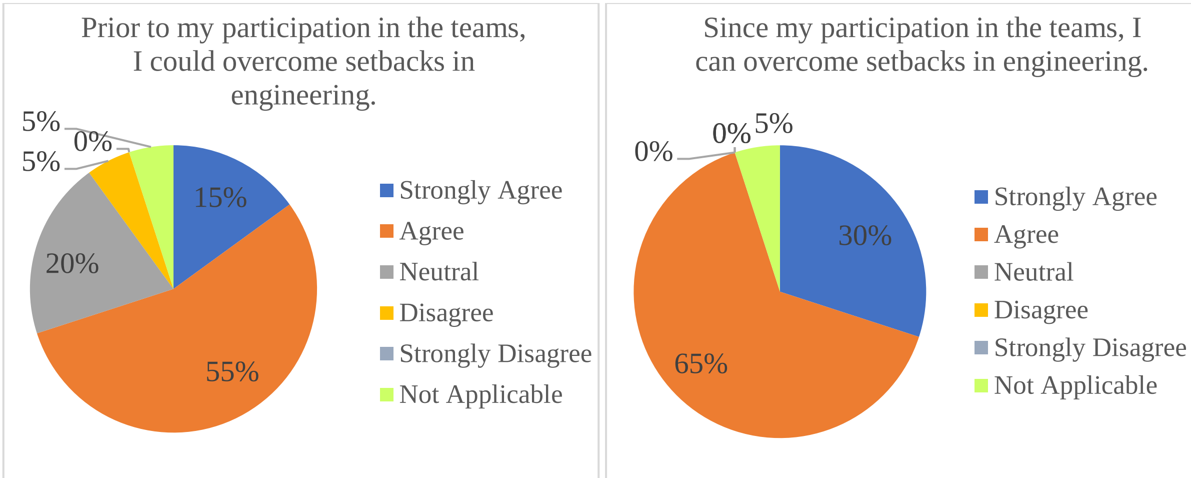


Figure 13- Distribution of responses for overcoming challenges in engineering

Table 4 presents the ratio of the participants who at least agreed after participating in the teams to before participation, in regards to performance/competence in understanding engineering both in and outside of class, as well as overcoming challenges and setbacks in engineering, based on gender and class level. As shown in the table, following participation in the teams, confidence in all areas increased for both genders, with a notable rise for females. Specifically, females showed significant improvement in their confidence in understanding engineering outside of class and overcoming challenges. For both genders, the largest increase in confidence was seen in understanding engineering outside of class. Among females, sophomores and juniors had the same increase across all areas. Among males, sophomores demonstrated the largest margin in gaining confidence in understanding engineering both in and outside of class while juniors showed the highest margin of confidence in overcoming challenges.

Table 4- Effect of gender and class level on performance/competence

	Male				Female			
	Overall	Sophomore	Junior	Senior	Overall	Sophomore	Junior	Senior
Confidence in understanding engineering in class	1.33	2.00	1.25	1.25	1.40	1.50	1.50	N/A
Confidence in understanding engineering outside of class	1.71	2.00	1.67	1.67	3.00	3.00	3.00	N/A
Overcoming challenges in engineering	1.09	1.00	1.25	1.00	2.33	3.00	3.00	N/A

14 students responded to the open-ended question about other factors contributing to their self-identifying or being identified as an engineer. Their responses are as follows:

“Before being on the competition team, although I feel like my parents and peers saw me as an "engineer", I didn't always see myself as one. Since being on the team, I feel like I can see myself as more of an engineer and it has given me additional confidence in selecting engineering as a major and career path.”

“I’m not sure, there has never been specific things that have influenced my identity as an engineer. I’ve known for quite a while that I’ve wanted to be one and since studying engineering that hasn’t changed.”

“I work well with other on group project and can contribute my ideas as well as listen to other members ideas.”

“Being able to move into roles of technical leadership & design on the competition teams resulted in more confidence with regards to engineering capabilities.”

“I am majoring in an engineering field, have completed an engineering internship, and am involved in engineering orgs”

“I find my class rank greatly impacts my self-identification as an engineer. As a freshman, I don't really feel like an engineer but more of a student studying engineering.”

“I feel like confidence and belief in myself as well as from others has kept me feeling strong about my ability to become a good engineer. As with anyone, nobody is perfect, but I feel like I have a strong ability to continue to grow.”

“Tendency to ask questions on how or why things work the way they do. Ask further details regarding a topic”

“I mostly just think the teams have been a better introduction into the professional world as far as ASCE and helped me to get to know the professors in the college quicker.”

“Working on projects with peers”

“After getting my first real engineering internship I felt more like a real engineer”

“Overcoming problems”

“As a women in engineering, sometimes I feel undervalued and that I am falling behind my male counterparts. Oftentimes, I feel like I have to work harder to keep up with them. However, I find community within the other women in engineering that is invaluable. I am made to feel incapable in some instances by my male peers.”

“I feel being around the Steel Bridge team and competition allowed for me to have a better understanding of the terminology being used as well as gaining a better understanding for the criteria being learned in the classroom relating to real life application. These features here helped me pursue my role of being an engineer more in wanting to succeed in the position.”

The open-ended question also revealed that students’ confidence in their abilities, overcoming challenges, and personal growth are significant in shaping their engineering identity. Factors such as completing internships, class rank, technical leadership roles, and involvement in engineering organizations contribute to a stronger engineering identity. Working on group projects and engaging with peers help students contribute ideas, solve problems, and foster a sense of belonging. A natural tendency to ask questions and delve deeper into how and why things work reinforces students' interest and identity in engineering. Students value opportunities to apply classroom knowledge to real-life situations, which enhance their understanding of engineering concepts and terminology. The response from a female participant in the steel bridge team highlighted the challenges of feeling undervalued compared to male counterparts but emphasized the importance of support networks among female peers in building confidence and perseverance. It should be noted that the concrete canoe team had a higher representation of female students, with 39% of its members being women and a female co-project manager, whereas the steel bridge team was predominantly male, with only 18% female representation.

Conclusions

This study demonstrates that participation in engineering competition teams, specifically concrete canoe and steel bridge, significantly contributes to the development of students' engineering identity. Using a framework centered on recognition, interest, and performance/competence, survey results showed clear benefits in these areas following team involvement. Specifically:

Recognition: Students, specifically juniors, reported increased recognition as engineers from peers and particularly instructors after joining competition teams. This was reflected in a stronger sense of validation and acknowledgment of their engineering capabilities.

Interest: While students' baseline interest in engineering remained high, participation in competition teams enhanced their enjoyment and fulfillment in engaging with engineering activities, particularly for sophomores, signaling an enriched academic and professional experience.

Performance/Competence: Students gained confidence in their understanding of engineering both in and outside the classroom and, significantly, in their ability to overcome challenges. Specifically, female students showed significant improvement in their confidence in understanding engineering outside of class and overcoming challenges. However, participation in teams did not impact students' confidence in exam performance.

Additional Insights: Open-ended responses highlighted the transformative role of competition teams in fostering leadership skills, teamwork, and practical application of classroom knowledge. Students value the opportunity to connect with peers, which fosters a sense of belonging and community. Challenges related to gender disparities in engineering were noted, underscoring the importance of support networks for female engineering students.

Overall, engineering competition teams provide an enriching environment that integrates technical and non-technical skills, enhances self-identification as an engineer, and supports professional development. These findings suggest that such extracurricular activities are critical for fostering engineering identity and retention among undergraduate students, emphasizing the value of continued support and expansion of competition team opportunities in engineering programs.

Limitations and Future Work

The current study was conducted at a small private university in the Midwest, with a survey response rate of approximately 70%. Among the freshmen, only one female participated and no female seniors responded. The small sample size, along with the limited participation of freshmen and lack of female senior participants, limit the generalizability of the findings. Furthermore, an expansion of the study to other engineering majors and a broader range of demographics, geographical regions, and institutions such as public universities, urban campuses, non-Midwestern locations, and larger schools is needed to further investigate the impact of competition teams on engineering identity.

Future work will focus on increasing the sample size to include a more diverse group of students, particularly in terms of gender and class level. Additionally, tracking students over multiple years will provide a more comprehensive understanding of how engineering identity evolves throughout the undergraduate experience. Finally, it would also be beneficial to examine the impact of different types of engineering competition teams across various engineering disciplines to determine whether the effects are consistent across all fields of study.

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