Leading College Engineering Competition Teams as an Informal Learning Experience Itself

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Introduction

One of the most effective ways to enhance an undergraduate engineering experience and maximize the college journey is by joining an engineering competition team. These teams offer numerous benefits, including the opportunity to work collaboratively, develop problem-solving skills in high-pressure situations, and cultivate a diverse skill set essential for future engineers. Supporting these teams are governing bodies that provide a framework for teams such as Mini Baja SAE, Formula SAE, and Supermileage, among others, to thrive. With a large membership base, these teams offer invaluable experiences beyond traditional classroom learning, enriching members' educational journeys with practical, hands-on experiences. The role of these governing bodies is crucial, as they promote and sustain these teams, ensuring their success both in competition and in fostering the development of well-rounded engineers.

This research paper aims to explore the dynamics of leadership and governance within engineering competition teams [1], and to examine how these teams, along with the formal engineering curriculum, impact undergraduate students. Our study includes interviews with a range of undergraduate engineering students, primarily those who have been members of these teams for several years. Additionally, we have interviewed alumni who were once members of these teams but have since graduated, providing insight from individuals who have completed their college journey and are now working in the field of engineering. Through these interviews, we aim to identify patterns and specific factors related to the transfer of knowledge between engineering teams, both within and outside the classroom, as well as the knowledge and opportunities facilitated by the governing bodies overseeing these teams. The findings from this research could potentially inform improvements to the structure and operation of these teams or the curriculum, enhancing the overall experience and outcomes for students, and potentially influencing how these teams are led by students and have shared governance at the institutional level within colleges [2-3]. Pictures of these teams' vehicles are shown below in Figures 1-3.

Figure 1: Baja SAE Car

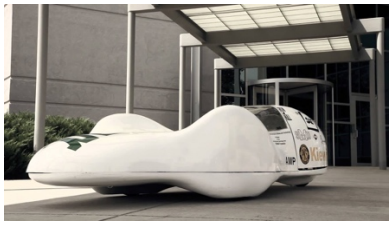

Figure 2: Supermileage car

Figure 3: Formula car

Context

A well-rounded undergraduate engineering student is poised to become a great future engineer. Engineering teams provide students with the opportunity to apply classroom knowledge to real-world scenarios, offering experiences beyond the scope of the curriculum. These teams challenge students to think independently and adapt quickly, fostering valuable skills. Additionally, they enable students to collaborate with diverse peers, fostering relationships that can be beneficial in their future careers.

The purpose of this research is to enhance both the curriculum and engineering teams to maximize the benefits for participating students, ensuring they develop into the best future engineers possible. By identifying areas for improvement, whether in terms of offering more practical knowledge or enhancing overall experiences that extend beyond the classroom, we aim to create a more enriching and impactful experience for students involved in these teams.
In addition to examining the balance between curriculum enhancement and team experience, this paper delves into the dynamics of unifying these teams under a single banner or body, and the potential benefits or drawbacks of such an approach. Experience programs that successfully unite diverse teams like these could serve as models for improving other departments on campus or even enhancing engineering curricula. By incorporating the principles and practices of these overarching bodies that collaborate with engineering teams, there is potential to enhance educational experiences across various disciplines.

Research Methods

The primary research method employed in this paper is qualitative, semi-structured interviews [4] with student participants, focusing on analyzing each student's unique experience. Following the interview process, an emerging thematic analysis [5] was conducted to identify patterns across participants, seeking similarities in responses and details to draw conclusions or raise further questions.

The initial step involved establishing a set of criteria to ensure a diverse range of student viewpoints. One key criterion was the team affiliation of the student, as each team presents distinct challenges that shape the member's experiences. For instance, the Baja team focuses on off-road events and durability, while the Formula team emphasizes speed and efficiency, resulting in contrasting experiences.

Another criterion considered was diversity in gender and background, recognizing that individuals from different backgrounds or genders may have distinct perspectives and thought processes. Similarly, students from varying academic majors were included to capture the diverse experiences shaped by their respective curricula. For example, a metallurgical engineering student highlighted the differences in their curriculum compared to other majors, showcasing how participation in an engineering team can offer unique experiences beyond the classroom.

Table 1 below provides an overview of the participants, identified by pseudonyms, their academic year, major, team affiliation, and current role within the team.

Table 1: Participants

Name*	Year	Major	Team	Role
Adam	Senior	Mechanical	Baja	Past Testing Lead
Brittany	Graduate	Metallurgical	Baja	Past President
Carl	Senior	Mechanical	Supermileage	Past President
Dan	Senior	Mechanical	Formula	Past President
Steve	Junior	Mechanical	Formula	President
Jace	Junior	Mechanical	Baja	Treasurer

*pseudonyms

The interview questions are designed to elicit experiences from both academic classes and involvement in engineering teams. The initial set of questions focuses on background information to understand each student's upbringing and how it might influence their responses. These questions, such as hometown and high school size, provide context and are summarized in Table 1.

The questions related to academic coursework aim to uncover the classes and specific learning experiences that participants find valuable, both within their team projects and in their future careers. For the latter, the focus is on how these classes contribute to their professional development, including internships or other professional roles.

Team-oriented questions seek to extract important experiences and skills gained from participating in their respective teams. This could include problem-solving approaches, valuable experiences, or new skills acquired. Similarly, as with the academic curriculum questions, these delve into how these team experiences have influenced their professional careers.

A crucial aspect of the interview is understanding how these experiences contribute to students' professional growth and whether participation in these teams has helped advance their careers. Additionally, questions are aimed at uncovering the value that these teams and the overseeing college departments bring to the students' overall educational experience. This includes identifying what aspects of these programs are particularly beneficial and how they could be improved. Ultimately, the goal is to understand both the inner workings of these teams and the role of the governing bodies in ensuring their success, as well as why students choose to remain involved in these programs.

The interview procedures are straightforward, with each interview expected to last between ten to fifteen minutes. Initially, general questions are asked to gather basic information such as name, major, and other details to establish the participant's background. Following this, open-ended questions are asked one at a time, allowing participants to elaborate on their answers and share their experiences. The interviewer may also inquire about specific details or encourage participants to expand on any aspect they feel is significant. Additional detailed questions may be included as needed to uncover more information or address any details that the interviewer finds particularly relevant. Finally, at the end of the interview, Question 7 from Table 1 is asked to give participants the opportunity to add any additional details they believe are important for the research. The interview protocol used for each interview is listed in Table 2 below.

Table 2: Questions Used for Interviews

Baseline Questions

1. Name, Major, Hometown, and size of high school?

2. What *engineering competition* team are you currently apart or were apart of during your time in college?

3.What roles did you or currently are holding on this team and what roles did you hold in the past?

4. When are you expected to graduate or when did you graduate?

5. If graduated what are you doing now?

Open-ended Questions

1. Why did you join your respective *engineering competition* team and what kept you on the team after joining?
2. What did you wish to get out of joining this team and did you get what you wanted through working on said team?
3. What has been the most useful experience or lesson you have learned from being on your respective *engineering competition* teams?
4. Tell me about a time you used a skill or experience from your *engineering competition* team outside of school?
5. What aspects of being on said *engineering competition* team were the most important to you?
6. Do feel that your *engineering competition* experience has helped open doors or helped in your career goals? If so, in what ways?
7. What do you feel that you've used the most in the real world or in your career, your
    a. class knowledge, or your experiences you have gained from going through your
    b. major's curriculum?
8. Are there any other details you would like to add on before we conclude?

Summary of Results

Question 1 aimed to uncover the reasons why participants chose to join and remain on their respective engineering teams. A common theme emerged, highlighting two key factors that made these teams special to each student. Firstly, the camaraderie among team members was highly valued, with participants describing the teams as close-knit environments where they formed meaningful friendships and collaborated with large groups of people. Secondly, these teams provided an outlet for students to engage in design work freely, fostering creativity. Participants expressed appreciation for the opportunity to learn and work on projects aligned with their interests, which might not have been possible within a traditional classroom setting.

Question 2 aimed to understand what aspects of the program made the interviewee feel fulfilled and what they hoped to achieve by participating. Responses varied, with some seeking to expand

their technical knowledge, while others simply wanted to apply the knowledge gained in the classroom. However, a common pattern emerged: participants were primarily seeking an outlet to apply their classroom knowledge in practical, meaningful ways. They expressed a desire to engage in hands-on projects that allowed them to do something impactful and exciting with the knowledge they were acquiring in school.

Question 3 directly addressed the experiences or lessons learned from their participation in the engineering team. Responses varied, but a common thread emerged regarding the valuable experience of working on projects. Specifically, many participants highlighted the importance of learning how to approach and initiate projects. Two responses noted that while classroom instruction provides valuable theoretical knowledge, it often falls short in teaching students how to begin projects, especially those that are unfamiliar or complex. Participation in these teams was seen as a way to push members out of their comfort zones and into the realm of problem-solving, particularly in the initial stages of project development.

Questions 3 and 4 both inquire about the most valuable experiences from their respective teams and classes that have benefited them in their professional careers. Regarding their classes, a common theme emerged with participants highlighting specific courses or discussing the importance of time management skills. In contrast, when discussing their team experiences, participants tended to elaborate more, often listing multiple skills or experiences. On the team side, many responses emphasized the value of teamwork and project management. Participants described learning how to effectively plan and communicate with team members as crucial skills that have translated directly to their professional endeavors.

Question 5 aimed to uncover what participants considered most important to them in their team experiences. This open-ended question elicited various responses, with two major themes emerging: the value of the learning experience and the freedom to learn and be creative, a point that will be further explored in subsequent questions.

Questions 6 and 7 were similar to the previous ones but focused more on specific experiences. Participants seemed to struggle with identifying experiences beyond basic skills like time management and working in specific classes or labs. Regarding their team experiences, responses echoed those from Question 4, highlighting numerous instances where they solved open-ended problems or collaborated with teams to develop solutions, emphasizing the use of communication skills. These experiences not only advanced their careers by providing interview-worthy experiences but also helped them build relationships that could benefit them in their future careers.

The final set of open-ended questions aimed to allow participants to express their thoughts freely. One question asked, "If there was one thing you could change in the curriculum to help you in your respective team and in your professional career, what would it be?" Responses to this question were consistent, with the major themes including a desire for more hands-on and open-ended work. Participants expressed a need for assignments that required them to come up with solutions to problems without a set answer. Additionally, they expressed a desire to engage more deeply with the engineering process, from prototyping to product completion. Lastly, participants

emphasized the importance of teamwork and group-based projects that dealt with open-ended problems, where communication and problem-solving skills were essential.

The last open-ended question asked, "What is the most important aspect of all the engineering teams that, if taken away, would make participation no longer worthwhile?" This question revealed another consistent pattern: the importance of freedom in design and the ability to fail. Participants emphasized how the freedom to design and learn, as well as the freedom to fail in the process, taught them more than simply following a set of rules or instructions.

Findings and Themes

Two recurring themes emerged consistently among participants regarding these engineering teams: 1) **teamwork** and 2) **open-ended, project-based work**. Many interviewees highlighted the importance of having the freedom to fail and experiment, viewing it as a key aspect provided by these departments. This environment was seen as a safe space that truly challenged students' critical thinking skills in situations where there isn't a single correct answer. Additionally, these departments were noted for allowing students to behave as professionals, not just as students.

In addition to emphasizing more team-based projects, there was considerable discussion about the value of open-ended projects. Open-ended projects are those without a predetermined solution, allowing for creativity and problem-solving. Currently, the curriculum for mechanical engineers includes only two classes, Sophomore Design and Mechatronics, which offer opportunities for open-ended projects before students undertake their senior design project—the final design project before graduation. These two classes focus on the prototyping process, reviewing, and creating solutions, but they only span two semesters in a typical eight-semester undergraduate career. Having just two classes to prepare for a real project is insufficient and limits students' ability to develop problem-solving and engineering skills. This limitation is largely due to many classes being heavily focused on textbook information, where the primary objective is to teach a specific subject and solve problems within that subject area.

Several other suggestions included providing more hands-on opportunities or classes that teach skills like machining or welding. Currently, there is only one freshmen-level class at the school that offers this type of hands-on learning. Another suggestion was to offer more classes that focus on real-world problems or discuss the practical applications of the concepts being taught. The departments overseeing these teams excel in providing a hands-on approach, allowing teams to operate under real-world constraints such as budgeting and planning, without the fear of real-world consequences like being fired.

Many participants expressed that their time with their respective engineering teams was instrumental in developing their project and teamwork skills, making them more confident in their professional careers, whether in jobs or internships. This highlights the significant professional development opportunities available through participation in these teams, suggesting that students who do not join or cannot join due to time constraints may miss out on valuable experiences that could benefit their entire engineering career.

Communication is a critical skill for engineers, as they often need to collaborate with other engineers and stakeholders. In many engineering roles, engineers also function as managers or coordinators, making effective communication essential for their daily tasks. Furthermore, engineering work is typically project-based, with many projects lacking a predefined solution. Engineers are responsible for defining the parameters of these projects and determining what a successful solution looks like.

Discussion and Implications

This research underscores a clear demand from students who have had the opportunity to develop crucial skills through these teams, indicating a desire for more similar opportunities within the curriculum. These departments are providing valuable chances for students to grow, emphasizing the importance of learning through both success and failure. Unlike the classroom, where the focus is often on passing exams, these teams offer a unique environment where failure is not only accepted but expected, leading to some of the most profound learning experiences.

While there is a transfer of knowledge from the curriculum to these teams, it appears to be primarily textbook-based information. The true development of professional skills and experiential learning occurs within the team environment. Given the limited opportunities within the curriculum to develop these skills, students on these teams must rely on their team experiences to supplement their classroom education.

Future Work

Further research could be conducted by the school or, more specifically, the Mechanical department to identify specific projects that could be implemented to enhance teamwork and problem-solving skills for all students, not just those on these teams. Additionally, this research suggests the possibility of integrating aspects of team structure into the curriculum to create more well-rounded engineers.

Future research could compare the skills and experiences of students who participate in engineering competition teams with those who do not, to understand the specific benefits gained from team participation. This comparative analysis could provide insights into the unique learning opportunities provided by these teams and how they contribute to students' overall engineering education. Additionally, such research could explore the long-term impact on career development and success for both groups of students.

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