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Assessing Student Engagement, Success, Leadership and Teamwork Skills with Respect to Team Role Selection and Execution

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Abstract

The importance of working in teams throughout the engineering education curriculum has been well documented in research. Therefore, most engineering curricula conclude with a team-based capstone design course. This study is inspired by such a course, where students work in multidisciplinary teams for two semesters in designing, building, and testing projects. The objective is to evaluate the process of students' self-placement in team roles and the impact of these roles on their engagement and perception of success during the project development experience, to investigate how student role placement, rotation and execution contribute to their development of leadership and teamwork skills. Results are presented from a mixed methods survey and data from three cohorts of students between 2021 and 2023, including questions on the students' course goals, role assignments, role rotations, and if their roles affected their engagement, success, or team's success. Most respondents started the year driven by the opportunity to gain experience and by the end of the course showed satisfaction with the opportunities for role placement, execution, and their individual and team success, though many had shifted to also be performance driven. The results encourage the strategy of allowing teams to define, assign, and determine the rotations of their roles, and the importance of conducting periodic assessments on their practices throughout the year to ensure fairness and success.

Introduction

Multi and interdisciplinary engineering capstone courses provide students an opportunity to work with design projects in teams from a variety of disciplines. Working in teams is an expected student outcome for all engineering programs and it relates to skills sought out by engineering employers [1]-[4]. Engineering students must function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives [3]. Successful teams require all members to be engaged with their shared and individual responsibilities [5]. Team roles can help with assigning these responsibilities effective and efficiently [6],[7]. Current trends have students preferring fluid roles rather than staying within bounded tasks [8]. All students should enjoy and be successful in their teams, while obtaining the experience they need for their careers and helping the team to perform at their highest level.

To evaluate team success, it is necessary to measure their project outcomes, their engineering performance, their cooperative learning experience, and stakeholder satisfaction [5],[7]. This study examines these measures from the perspectives of the students, with respect to their team roles and role execution. The goal is to determine how their opportunities for assuming their desired roles and their performance in those roles, affect their attitudes towards collaboration, their perception of team success, and their appreciation of the team experience. The results of this study should inspire strategies to increase the effectiveness of the team collaboration experience and identify indicators for early intervention, to help students experience the roles they want and excel in fulfilling them within their teams.

Research Questions

This objective of this study is to examine how students assign and fulfill their team roles, to explore the impact these activities have on their project engagement, perceptions of success, and development of leadership and teamwork skills. This objective is assessed through the following questions.

a. Do students make every effort to assume the roles that they want to experience?
    - Does inclusivity affect their opportunities at assuming their preferred roles?
b. Are students motivated to rotate their team roles?
    - Are students satisfied with their opportunities for assuming roles?
c. Does role fulfillment affect student engagement within their team?
d. Does role fulfillment affect student perception of team success?

Literature Review

Studies on team performance and collaboration have found that highly collaborative teams may have poor performance and teams with high performance may have low collaboration [5]. Achieving a successful collaboration requires an equitable distribution of tasks, continuous communication, and knowledge of the success of each member with their assigned activities. Team roles typically fall into two categories: behavior and task-oriented roles. Multiple studies have investigated the structures and impacts of behavior-based team roles on teams based on the Belbin team roles model [5],[6],[9]. Some suggest that having members that fulfill specific behavior roles impacts team success [5]. Others have studied whether the number of behavior roles a student fills has an impact on team success and if their perceptions of their role changes over time, but have not reached significant conclusions [6],[9].

A recent study on task-oriented roles found that students who reported dissatisfaction with the roles they fulfilled, reported less self-confidence in their ability to complete their engineering degree [10]. Students who had leadership roles were more likely to report satisfaction with their team role. The study also demonstrated that students are more likely to take on roles based on performance goal orientation, citing time constraints and proficiency as reasons why they focus on required tasks, while most other students preferred to fulfill roles that did not align with their strengths in order to learn new skills [10].

Copp et al. investigated how often students chose their role or were assigned their role by either their team or team advisor, but did not find significant differences between URM, gender, first generation, or low-income students [11]. Other research suggests that gender has an impact on the roles students assume on their team and that women are more likely to take on supporting roles over technical roles [12]. While choosing these roles may not have been a conscious choice, it could have a negative impact on women's feelings of belonging in engineering.

Various studies on team roles have utilized classroom observations, student reported data, interviews, focus groups and created their own surveys [10] - [12]. Instructors with large class sizes have turned to software assessment tools to measure the teamwork skills of individuals and the roles within the teams. For example, CATME and TeamUP provide a survey to gather self

and peer evaluations from individual team members as well as instructors [13],[14]. For the study presented below, it was necessary to create a customized assessment tool to determine how individuals fill functional or task-oriented roles in their teams and the impact of that process on their engagement and course experience.

Context

IPPD is an educational capstone design program where students from thirteen engineering and computer science programs work in multidisciplinary teams for two semesters in designing, building and testing projects from industry sponsors [15]. The program is based on a two-semester course sequence with a process-oriented focus. Student success is determined through the quality of their project deliverables, the quality of their individual contributions and their effort towards the collaboration experience. During the first week of class, students are placed in project teams by the program staff, based on their preferences and project needs. Team size has varied from three to seven students per team. Each team is advised and evaluated by a designated faculty member from the college of engineering. The course is taught by the IPPD faculty.

After team formation, students learn about the recommended team roles that they should assign within the team, which are listed in Table 1. Students are told that these roles are expected, with emphasis on leadership and meeting tasks, but the list provided is not enforced and students are free to assign roles as they deem appropriate. Students are also strongly encouraged to rotate roles throughout the project year to provide them with multiple learning experiences and multiple perspectives of the team dynamics. The encouragement is described as wanting them to enjoy the course and be successful within their team, while also optimizing the experience they need for their careers. Historically, the frequency of role rotation between teams varies from zero to weekly, depending in part by student preference and the strategies utilized by the team faculty.

Table 1: List of Roles Students are Encouraged to Fill within their Teams

Team Leader	Meeting Facilitator	Meeting Scribe	Meeting Timekeeper	Blog Editor
Template Manager	Finance and Travel Coordinator	Research Librarian	* Teams may define additional roles.	

Methodology

A three-iteration exploratory mixed-methods survey was developed to collect data from the students, named respectively as Early Fall, Late Fall and Spring. Early Fall was distributed right after teams assigned roles, to assess their intentions and expectations. Late Fall and Spring were distributed at the conclusion of the fall and spring semesters respectively, to assess their progress and accomplishments. The surveys were shared through a Qualtrics anonymous link, where students had to acknowledge their voluntary participation and that these were not considered for the course grade. These surveys were reviewed and approved by the Institutional Review Board prior to data collection.

The surveys begin with questions related to their identity and demographics, followed by questions related to their course goals, their role preferences throughout the course sequence and

their team's role assigning process. The Late Fall and Spring surveys asked for their respective results with respect to those preferences, including the roles they have experienced, their satisfaction with their roles and rotation frequency, and their view on the success of the team with respect to the role assignments and team dynamics. As an exploratory study, the questions allow for interpretation to encourage an open response. For more details on the survey, readers are encouraged to refer to the previous work [16].

Data Collection

This paper includes the results from seven survey iterations shared with IPPD students from three academic years between fall 2021 and fall 2023, as described in Table 2. In 2021, only the Late Fall survey was distributed.

Table 2: Surveys Shared per Academic Year and Date

Academic year	2021 – 2022		2022 – 2023			2023 – 2024	
Dates	December	April	August	December	April	August	December

These three academic years had a combined total of 229 students, who produced 423 valid completed surveys. A survey response was considered valid if it answered at least half of the questions. The 2021-2022 survey results proved that it was necessary to request identifiers to cross-reference answers within teams and to verify how their answers changed throughout the year [15]. Therefore, the subsequent surveys asked for their initials, which some students provided. These initials were not used to determine the unique students who participated each year. Hence, the demographics were approximated based on the maximum number of valid submissions in each academic year. Table 3 summarizes the demographic information for the respondents. The questions for gender and race were of type open answer, which for anonymity, were grouped into larger categories.

Table 3. Approximate Demographics for the 200+ Survey Participants during 2021 – 2023

Number of Students and valid Responses	2021 – 2022 (59 students)		2022 – 2023 (78 students)		2023 – 2024 (92 students)
	Early Fall = n/a Late Fall = 45 students Spring = 44 students		Early Fall = 76 students Late Fall = 54 students Spring = 63 students		Early Fall = 84 students Late Fall = 57 students Spring = n/a
Gender	Male and/or Man		Female and/or Woman		Other
	68%		27%		5%
Race	White	Asian	Latin	Black	Other
	52%	20%	20%	2%	6%

Percentage of Students per Engineering Programs

Agricultural & Biological	Biomedical	Chemical	Civil and Environ.	Computer Science, Digi. Arts & Sci.	Electrical and Computer	Industrial	Materials Science	Mechanical and Aerospace
4%	3%	5%	Less than 1%	33%	24%	2%	1%	27%

Results and Data Analysis

Starting in Spring 2022, students were asked to choose whether their course goals were Performance driven (for example, good grades, successful project, excellent team performance), Experience driven (for example, maximize learning skills or topics, explore multiple designs versus optimizing for delivery) or Other, for which everyone wrote having both as goals. Table 4 shows the results of this question for each survey iteration, which show that most students started Experience driven, though as the course progressed there was a decrease in that percentage. These results showed that most students started the years wanting to maximize their potential experience but as they progressed, they equally prioritized the project outcomes. If recurrent, this trend could be concerning with respect to allowing students to focus on their skill development experience to become successful engineering leaders and team collaborators.

Table 4: Respondents' Course Goals per Survey Iteration

Survey iteration	Spring 2022	Early Fall 2022	Late Fall 2022	Spring 2023	Early Fall 2023	Late Fall 2023
Performance driven	5 (11%)	19 (25%)	16 (30%)	13 (21%)	19 (23%)	15 (26%)
Experience driven	17 (39%)	49 (64%)	33 (61%)	24 (38%)	62 (74%)	38 (67%)
Other (both)	22 (50%)	8 (11%)	5 (9%)	25 (40%)	3 (4%)	4 (7%)

Table 5 shows the roles participants stated as wanting to experience at each period, across all seven survey iterations, with the Spring version asking for roles they wish they *had* experienced.

Table 5: Number of Respondents who Wanted to Experience each Team Role

Early Fall (160 responses)				
Team Leader 116 (72%)	Meeting Facilitator 104 (65%)	Meeting Scribe 75 (47%)	Meeting Timekeeper 68 (43%)	Blog Editor 75 (47%)
Template Manager 47 (29%)	Finance and Travel Coordinator 71 (44%)		Research Librarian 60 (38%)	Others 2
Late Fall (183 responses)				
Team Leader 104 (57%)	Meeting Facilitator 108 (59%)	Meeting Scribe 67 (37%)	Meeting Timekeeper 61 (33%)	Blog Editor 54 (30%)
Template Manager 44 (24%)	Finance and Travel Coordinator 40 (22%)		Research Librarian 46 (25%)	Others 5
Spring (107 responses)				
Team Leader 70 (65%)	Meeting Facilitator 65 (61%)	Meeting Scribe 41 (38%)	Meeting Timekeeper 29 (27%)	Blog Editor 32 (30%)
Template Manager 25 (23%)	Finance and Travel Coordinator 18 (17%)		Research Librarian 36 (34%)	Others 6

Results for Early Fall show 72% of the students wanted to experience leadership and 65% wanted to experience the Meeting Facilitator role, which based on the responsibilities, many consider as the subleader. For example, many respondents mentioned wanting this role to develop the skills of planning and managing efficient meetings, or for other leadership responsibilities. Multiple roles were selected by over 40% of respondents, again showing that most students start the year being Experience driven. As the year progresses, a majority still have the desire to experience leadership positions. For roles that have less responsibilities, it is expected to see a decline in interest as the year progresses. For example, templates are reused during the year, blog writing and timekeeping can turn unexciting, and most teams travel in fall. More so, an interest in these roles for Spring could imply an interest in less responsibilities.

Table 6 shows the number of respondents who held each role during each period across all years. The results reveal that by the end of the year, about half of the respondents had experienced the team leader role, meaning they made the effort required to experience that desired role; however, the percentage is lower than the number of students who started the year wanting that role. When evaluating only the Spring surveys, about 10% of the students who still wanted the role at that time did not have that experience, whereas most other roles had more students designated than the number who wanted to fulfill those roles. Future analysis should provide insight into the reasons why some students who wanted the leadership role were not able to assume that role.

Table 6: Number of Respondents who Experienced each Team Role

Late Fall (183 responses)				
Team Leader 66 (36%)	Meeting Facilitator 80 (44%)	Meeting Scribe 80 (44%)	Meeting Timekeeper 76 (42%)	Blog Editor 48 (26%)
Template Manager 54 (30%)	Finance and Travel Coordinator 48 (26%)		Research Librarian 48 (26%)	Others 3
Spring (107 responses)				
Team Leader 60 (56%)	Meeting Facilitator 64 (60%)	Meeting Scribe 51 (48%)	Meeting Timekeeper 39 (36%)	Blog Editor 42 (39%)
Template Manager 34 (32%)	Finance and Travel Coordinator 26 (24%)		Research Librarian 41 (38%)	Others 6

Introduced in Spring 2022, students were asked if they were an active participant during their role assignment, to learn about the assignment process within their teams and determine the number of students who self-promoted for their preferred roles. The average across these survey iterations of respondents who stated being an active participant in their role assignment was 88%, though this number excludes the 2022 Early Fall survey given that number was an outlying 74% due in part to 20% classified as *other* for not having an answer or having an ambiguous answer (for the rest of the survey iterations the average of *other* was 3.7%; the question wording was consistent for all). The responses for being an active participant included many who expressed not initially assuming their preferred roles but expecting to do so given their team's

role rotation frequency, which they had agreed to implement. These responses also included those who expressed feeling an obligation to assume certain roles but in agreement to that opportunity, and those who were able to choose some of the roles they had to accept.

Conversely, the average of respondents across all survey iterations who answered No was 10%. These are students who expressed something to the effect of having their roles chosen by a teammate or team faculty, or they felt obligated for the sake of team success. Faculty assignments typically seek a change in team leadership. To contrast with these results, the Spring survey iterations asked, "Did you get the opportunity to assume all the roles you wanted?". The results for 2022 were 40 yes and 4 no, and for 2023 were 56 yes and 6 no. That is, just under 10% for both, which is in agreement with the result described above. While it is realistic to expect a certain percentage of any team to have members that are not happy with their roles and this capstone course is promoted as a "real-world experience", academic courses should strive to provide all students with the experiences they hope to achieve. Therefore, as future work, a deeper dive into this data will attempt to uncover whether these specific students were able to experience any of the roles they wished and how their answers varied throughout the course year. Additionally, while no significant correlations were found between roles desired and assumed with respect to demographics, a deeper dive into their comments might provide further insight.

Regarding role rotations, the Early Fall survey iterations asked if their teams had agreed to rotate roles or if they had a preference. The results in Table 7 indicate that both years had an overwhelming majority with the intention or the hope to rotate. The specific reasons for 2022 having so many students not aware of their team's intention are unknown, though they align with the result above where 20% did not provide clear answers regarding their active participation during role assignment. Nonetheless, it is clear there that an overwhelming majority aspired to implement role rotations. Therefore, it is again evident that most students start off Experience driven, seeking to maximize their opportunities to contribute to their team experience.

Table 7: Early Fall results for "Will Your Team Rotate Roles?"

Early Fall 2022 (76 responses)			
Yes 46 (60%)	No 2 (3%)	Don't know… 28 (44%)	…but I hope we do 16 (21%) …and I hope we don't 12 (16%)
Early Fall 2023 (84 responses)			
Yes 70 (83%)	No 3 (3%)	Don't know… 11 (13%)	…but I hope we do 8 (10%) …and I hope we don't 2 (2%)

To verify that fulfilment, the Late Fall and Spring iterations ask students if their teams had rotated roles, with follow up questions on the number of rotations (unfortunately a logistical error damaged some of the follow up questions in the Spring iterations).

Table 8 includes the results, which indicate that most students were satisfied with their team's rotation frequency, with a small percentage did not have the opportunity to assume the roles they wanted to experience. While Table 7 showed that over 80% of respondents expected or hoped to rotate roles, Table 8 shows that between 37% and 53% of respondents had their teams do structured rotations. Those classified as *Other*, expressed something to the effect of having unstructured rotations for some roles or positions, with a mix of positive and negative situations on members having to take on tasks for the sake of project completion. In either case, it was clear that the team did not have a system to allow everyone to experience all the roles they wanted. Future analysis should provide insight into the reasons behind this discrepancy and whether an early intervention to provide a rotation structure could avoid team performance issues.

Table 8: Results for "Did your team rotate team roles?"

Late Fall 2021 (45 responses)					
Yes 19 (42%)	How often? Once: 10 2x or 3x: 2 Biweekly: 2 Weekly: 5	How often do you wish you rotated? Once: 8 2x or 3x: 3 Biweekly: 3 Weekly: 3 No Pref.: 2	No 26 (58%)	Do you wish you rotated? Yes 9 No 17	Other 0
Spring 2022 (44 responses)					
Yes 18 (41%)			No 19 (43%)		Other 7 (16%) (unstructured rotations for some roles or positions)
Late Fall 2022 (54 responses)					
Yes 20 (37%)	How often? Once: 4 2x or 3x: 8 Biweekly: 6 Weekly: 2	How often do you wish you rotated? Once: 1 2x or 3x: 13 Biweekly: 4 Weekly: 2	No 19 (35%)	Do you wish you rotated? Yes 4 No 14	Other 15 (28%) (unstructured rotations for some roles or positions)
Spring 2023 (63 responses)					
Yes 24 (38%)			No 21 (33%)		Other 17 (27%) (unstructured rotations for some roles or positions; 2% did not respond)
Late Fall 2023 (57 responses)					
Yes 30 (53%)	How often? Once: 4 2x or 3x: 6 Biweekly: 12 Weekly: 6	How often do you wish you rotated? Once: 0 2x or 3x: 4 Biweekly: 13 Weekly: 7	No 16 (28%)	Do you wish you rotated? Yes 6 No 10	Other 11 (19%) (unstructured rotations for some roles or positions)

To evaluate student engagement with their team with respect to their assigned roles, the Spring survey had two questions: (1) Comment on whether the team appreciated the contributions you made within your role(s) as defined by the team, and (2) Comment on whether your contributions to the project were limited or enhanced by your role(s). Table 9 shows the condensed results for these questions from both Spring iterations.

Table 9: Student Engagement with their Team with respect to their Assumed Roles

Spring (107 responses)				
Did my Team Appreciate my Contributions within my Role(s)?				
Yes	I think so	I don't know	No	No answer
60%	21%	8%	1%	9%
Were my Contributions to the Project Enhanced or Limited by my Role(s)?				
Enhanced	Limited	Both	Neither	N/A
48%	4%	3%	34%	12%

An overwhelming majority had a positive knowledge or belief that their contributions within their role(s) were appreciated by their teammates. This majority had a fair mix of students who had and had not rotated roles. In contrast, almost all of those in the non-positive 9% were in teams that did not rotate roles; however, the sample size is too small to define a tendency.

Regarding their contributions within their roles, 48% of the respondents felt that their roles enhanced their contributions, while 34% felt that their designated roles had no impact on their contributions, 4% felt that their contributions were limited by their roles and 3% had a mixed experience based on multiple roles assumed. For those who claimed no impact on their contributions, almost every response was stating how their role assignment had no impact on their technical work towards the project completion, rather than commenting on their team dynamics. Less than 10% of the respondents explicitly stated that the assignment of these roles had a negative impact on their team contributions. No correlation was found between these responses and whether the teams had rotated roles. The overall sentiment of responses indicated a majority of students appreciate the freedom of choosing how to manage roles within the team.

To evaluate if role fulfillment affects student perception of team success, the Spring survey had two questions: (1) Comment on how successful the team was throughout the year, and (2) Comment on how successful team collaboration was throughout the year. Combining again the 107 responses for both Spring iterations, 86% stated that their team was successful and 79% stated that team collaboration was successful. For context, these results are broadly consistent with the evaluations the students obtained from the faculty for those semesters. Most of the respondents who stated in both answers that their teams had struggled, described issues with team communication and role responsibilities. However, this sample size is also too small to define a correlation with role assignments and rotations. Future analysis is needed to provide

further insight on any correlation between student perceived success, their opportunities for role placement and their individual performance.

Conclusion

This work aims to promote strategies that increase student interest in team engagement within a collaborative and inclusive environment. The results support the idea that students in general benefit from rotating roles to maximize their opportunities to fulfil their Experience goals, including the development of leadership and teamwork skills. Most respondents reported satisfaction with role rotation and team success, supporting the idea that teams should be allowed to define, assign, and determine the rotations of their roles. The recommendation from these results is that at the beginning of the course, team members should share their course goals and create a plan to align these desired experiences with the expected team outcomes. Instructor oversight is likely needed to ensure the plan is executed throughout the development challenges and ensure fair opportunities have been allowed.

Role rotation led to broader opportunities for meaningful experiences. Even in cases where respondents acknowledged having to assume roles that they did not want, most of those comments were from the positive perspective of appreciating the rotations and experiences. Further research is needed to determine if there is an optimal balance in role rotation to increase student satisfaction, team performance, and successful collaborations.

All responses were evaluated with respect to the reported demographics. While some concerning cases were identified, these were individual cases, and no course-wide correlations were found with respect to overall demographics.

Future Work

The program faculty will continue collecting data to augment the results here presented. Student interviews or focus groups could also be included for follow up questions. As currently structured, the surveys also allow for multiple deep dives into the data to further investigate the research questions from this study. For example, identifying data will be used to determine how many students were able to experience all the roles they wanted based on their answers throughout the course year, and how many students, either by choice or by need, only experienced roles they did not want to assume. Other pending questions are which factors contributed into students obtaining or not the roles they wanted to assume, and which factors contributed into students redefining the roles they wanted throughout the course year.

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