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Managers and Engineers: Impact of Defined Roles on Shared Leadership in Capstone Design

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Abstract

The aim of this study is to learn how the assignment of project roles in engineering capstone design teams influences leadership skills such as accountability, communicating a vision, teamwork, role identity, and management, along with a measure of leader effectiveness, the Competing Values Framework. The research is situated within the capstone design context at a large mountain-region flagship university. In this class, a group of 6-7 senior engineering students work together to complete an industry-sponsored design project. The results show that project managers, financial managers, systems engineers, and manufacturing engineers had a similar progression of leadership effectiveness at the beginning, middle, and end of the year-long course with a dip in the middle. Logistics managers started with low leader effectiveness and rose continually through the semester. Test engineers and CAD engineers did not exhibit a similar pattern to their colleagues, with their leader effectiveness remaining relatively consistent over time. Additionally, students who finished with high leader effectiveness believed that the assignment of roles positively contributed to the team in terms of division of tasks and team effectiveness. These same students also believed that the assignment of roles positively contributed to their sense of purpose and ability to articulate contributions to the project.

Introduction

As engineering education evolves based on societal needs, leadership becomes increasingly important in preparing students to address new challenges. The addition of leadership to the 2019 ABET requirements [1] exemplifies this evolution, leading engineering educators to define intentional ways of integrating leadership development into engineering curriculum. Capstone design provides an opportunity to integrate leadership as a professional skill [2] developed authentically while students are working to address complex, real-world challenges in a team environment.

Background

Over the last 20 years, engineering educators have realized the importance of building leadership skills among engineering students. This movement is evidenced by the creation of dozens of engineering leadership programs that offer classes, certificates, minors, and even a Bachelor of Science in engineering leadership. Despite these initiatives, research shows that professional engineers do not view engineering as a leadership profession [3]. With ABET and industry encouraging the development of leadership skills during college, this study explores the influence of project roles on shared leadership development within capstone engineering teams.

Capstone design courses are often relied upon by engineering programs to teach professional skills, such as teamwork and collaboration, that students need for success in the workforce and that educator's need to meet ABET requirements [4]. Assigning roles contributes to the creation of a team, whose members share leadership responsibilities and a specific goal, rather than the formation of a group, in which individuals work independently toward a broader, organization-wide mission. [5]. Research situated in industry and in education identifies the value of having clearly defined roles in helping teams work collaboratively to meet mission, vision, goals, and objectives [6]. Team role theory identifies the value of organizing team members by functional role, defined by the tasks needing to be fulfilled and the set of abilities needed to complete these tasks successfully [7]. In engineering education, Felder et al., [8] find that assigning students into functional team roles is an effective way to create collaborative learning opportunities. Despite the value of functional role assignment in teams, most capstone design programs assign a project manager or project lead role instead of assigning functional roles to all team members [9].

The benefits of assigning functional roles in teams (helping teams meet mission, vision, goals, and objectives) aligns with definitions of leadership. Various design mindsets align with leadership competencies: bias toward action, radical collaboration, and creating a coherent vision within complexity [10, 11] For the purposes of this study, we define leadership and shared leadership in alignment with Novoselich and Knight [12]:

- *Leadership*: "a process whereby an individual influences a group of individuals to achieve a common goal" [13, p. 5]

- *Shared leadership*: "a dynamic interactive influence process among individuals in groups for which the object is to lead one another to the achievement of group or organizational goals or both" [14, p. 1]

The aim of this study is to explore how the assignment of functional roles in engineering capstone design teams influences students' individual leadership development as well as the emergence of shared leadership among teams. The influence of functional roles on shared leadership was previously explored in a capstone setting by Novoselich et al. [15] and focused on aspects of the team experiences, such as instructor team formation, culture of the course, number of students per team, and individual technical ability. In their effort to define a shared leadership model, Novoselich et al. used a post-hoc qualitative analysis of a panel discussion to validate statements about shared leadership in capstone classes. One relevant proposition includes, "shared leadership affects team member affective, behavioral, and cognitive responses [15, p.1941]." The consensus of the panel discussion in this article was that having assigned roles with specific responsibilities provides an opportunity for shared leadership among team members – it creates a sense of empowerment for students. The study further proposed that shared leadership positively influence "accountability … increased cohesiveness, satisfaction, and increased effort." [15, p. 1949].

Shared leadership is a leadership theory that is often layered over another theory or framework to measure leadership skills. The Competing Values Framework (CVF) serves that purpose in this study. The CVF is a method of assessing leadership effectiveness. The framework consists of four quadrants that each align with a leadership orientation: collaborate, control, create, and compete. The crux of the CVF is that the most effective leaders can exhibit leadership behaviors that align with any of the four leadership orientations depending upon a given situation. This ability is called behavioral complexity and correlates with leadership effectiveness [16].

The researchers chose to focus this research on leadership in design teams rather than on teamwork more generally. While a small amount of previous research has explored project roles in capstone design teams [15, 17], there is potential for this study to provide a set of best practices for engineering educators to intentionally foster the culture of shared leadership in their classes and add to the body of knowledge around team roles and leadership on project teams. This practice aligns with team effectiveness [15] and meets goals of integrating leadership development into the engineering education curriculum [1].

Research Questions

1. Does the development of behavioral complexity/leadership effectiveness differ for students in different roles?
2. To what extent do students' beliefs in the benefits of having a role relate with their level of behavioral complexity/leadership effectiveness?
    a. For the team
    b. For the individual

Methods

Study context

The research is situated within the mechanical engineering capstone design course at a large, mountain-region, flagship university. In this two-semester required class, a group of 6-7 senior engineering students work together to complete an industry-sponsored or entrepreneurially focused student-created design project. The course is organized as a transitional experience from education to industry. Each student design team has a designated faculty advisor who serves as their "director" and students lead regular meetings with their industry client through the course of the project. Class sessions are termed "morning meetings" and the course has an employee handbook rather than a syllabus. The students are guided through the engineering design process, teams typically brainstorm and select a design in the first semester and manufacture and test their design in the spring semester. The first semester concludes with teams presenting their design to their client and holding a manufacturing review, a test plan review, and a proposed budget review to the course instructors, fabrication engineers, and administrative staff. The course culminates in each design team completing their final project at the end of the spring semester. Industry sponsored projects deliver their final project hardware to their clients.

In their teams, every student takes on explicit managerial roles, and every student is responsible for technical contributions, regardless of their role. The team collectively determines who among them will fulfill each role. Typical roles include project manager, logistics manager, CAD engineer, test engineer, systems engineer, financial manager, and manufacturing engineer (see Table 1 for definitions of project roles). As an example, logistics managers will fulfill their role by leading meeting scheduling and communication with client and director while maintaining responsibility to contribute to the design ideas, drawings, manufacturing, and testing aspects of the project. CAD engineers will lead the team's CAD development efforts and CAD workload distribution and structure but are expected to contribute to design ideas and are not responsible for drawing every project component.

Table 1. Description of Project Roles

Project Manager	Responsible for leading the team, overall project scheduling, and deliverables. Organizes and runs team meetings, reviews, and evaluates progress on action items, and ensures that all team members' opinions are expressed and evaluated.
Logistics Manager	Responsible for providing coordination for all internal and external team interactions. Works with project manager to plan team meetings, creates meeting agendas, records meeting minutes, and documents action items. Is primary point of contact with client and director.
CAD Engineer	For CAD-heavy projects, responsible for managing the team's CAD files and revisions for parts and assemblies. Explores the capabilities of SolidWorks and takes the lead to produce professional renderings, FEA results, CFD results, and animations.
Test Engineer	For test-oriented projects, responsible for leading experimental design, test plan, procedures, and data analysis. Acquires and sets up data acquisition systems, establishes testing schedules, and presents experimental findings. Leads the December Test Plan Review.
Systems Engineer	For projects that have complex engineering systems, responsible for coordinating and integrating all project sub-assemblies as well as required technical documentation (instruction manuals, capability reports, life cycle analysis) and presentations. Develops complete understanding of the project's technical components and works with the team to ensure that all components work together.
Financial Manager	Responsible for providing financial advice and support to team members, clients, and directors. Researches/benchmarks technical purchases and acquisitions. Purchases all materials, monitors team budget, and follows state fiscal rules. Is primary point of contact with staff financial person. Leads the December Budget Proposals.
Manufacturing Engineer	Responsible for overseeing manufacturing delegation and review of designs to ensure best practice in design for manufacturing. Is primary point of contact with the machine shop manager. Leads the December Manufacturing Review.

Data collection and analysis

As part of the course, students took three surveys – at the beginning of the fall semester, at the middle of the academic year in late January/early February, and at the end of the spring semester in late April. This survey, the entirety of which takes around 40 minutes to complete, asks questions related to various parts of the course such as learning outcomes, learning spaces, student beliefs and confidence in skill development, course content, and course structure. For the academic years in this study, the survey included a set of questions that align with the CVF called the Managerial Behavioral Instrument (MBI). The MBI was created as the instrument to measure leadership orientations as defined by the CVF and was validated with data from over 2000 management professionals [18]. This survey was adapted to fit into an engineering education context and validated in previous research [19]. Student responses were categorized into two groups: students who rated themselves as 4 or 5 in three or four of the CVF categories are considered "effective" leaders while students who do not are considered "non-effective" leaders.

Data in this study are from students who took the capstone design course in 2017-18 and 2018-19 academic years. Data are included for students who completed all or almost all of each of the three surveys for their given year. The two years were combined for a total n=308 students. Student responses which indicated a dual role (for example, some students served as both test and systems engineer) and students who responded "other" were excluded. These students may have a role specific to their project or are students whose home department was something other than mechanical engineering (e.g., electrical engineering students who opted into the mechanical engineering senior design course).

This research is categorized as exempt by the Institutional Review Board 14-0488. Data was analyzed using IBM SPSS Statistics version 29.0.0.0. Outcomes were compared by role using a one-way ANOVA and Least Significant Difference (LSD) post-hoc analyses. Comparisons across time were done using paired t-tests and groups were further compared using independent t-tests.

Results

These results are organized below by research question.

Research Question 1: Does the development of behavioral complexity/leadership effectiveness differ for students in different roles?

Differences in leadership effectiveness by role were analyzed via a one-way ANOVA, comparing each role against the others. No significant differences ($p<.05$) were found on the pre, mid-, or post-surveys, as seen in Table 2.

Table 2. Comparison of percentage of effective leaders by role at each of the three timepoints

Timepoint	Significance
Pre-survey	.151
Mid-survey	.231
Post-survey	.335

While the results did not show significance overall at the pre-, mid-, and post-survey, the researchers decided to pursue post-hoc analysis because of the exploratory nature of this study. The post-hoc comparisons revealed some differences that were significant ($p<.05$) and some that were approaching significance ($p<.10$) for different roles as seen in Tables 3-5 below. At the pre-survey (Table 3), the number of project managers shown to be effective leaders was significantly different ($p<.05$) from the number of logistics managers shown to be effective leaders. The number of project managers shown to be effective leaders also showed interesting results for differences from the CAD engineer, the finance manager, and the manufacturing engineer ($p<.10$). Similarly, at the mid-test, the number of test engineers shown to be effective leaders was significantly different from the project managers ($p<.05$) and had interesting differences ($<.10$) when compared to the number of logistics managers who were effective leaders. On the post-survey, there are only interesting differences (no significant differences) among the roles such as the test engineer and the project, logistics, and financial managers, as well as the manufacturing engineer ($p<.10$). These significant differences and differences that proved to be interesting will guide future research.

Table 3. Post-hoc comparison of number of respondents with high leadership effectiveness by role on the pre-survey

	PM	LM	CE	TE	SE	FM	ME
Project Manager		.003**	.058*	.176	.471	.054*	.076*
Logistics Manager	.003**		.539	.273	.071	.276	.565
CAD Engineer	.058*	.539		.658	.294	.761	1.00
Test Engineer	.176	.273	.658		.559	.836	.674
Systems Engineer	.471	.071	.294	.559		.369	.320
Financial Manager	.054*	.276	.761	.836	.369		.776
Manufacturing Engineer	.076*	.565	1.00	.674	.320	.776	

**statistically significant at $p<.05$
*statistically interesting at $p<0.1$

Table 4. Post-hoc comparison of number of respondents with high leadership effectiveness by role on the mid-survey

	PM	LM	CE	TE	SE	FM	ME
Project Manager		.740	.101	.040**	.332	.146	.046**
Logistics Manager	.740		.187	.083*	.508	.286	.092*
CAD Engineer	.101	.187		.693	.544	.662	.683
Test Engineer	.040**	.083*	.693		.319	.380	.977
Systems Engineer	.332	.508	.544	.319		.800	.323
Financial Manager	.146	.286	.662	.380	.800		.384
Manufacturing Engineer	.046**	.092*	.683	.977	.323	.384	

**statistically significant at $p<.05$
*statistically interesting at $p<0.1$

Table 5. Post-hoc comparison of number of respondents with high leadership effectiveness by role on the post-survey

	PM	LM	CE	TE	SE	FM	ME
Project Manager		.938	.065*	.060*	.865	.812	.780
Logistics Manager	.938		.084*	.077*	.921	.880	.739
CAD Engineer	.065*	.084*		.944	.140	.102	.078*
Test Engineer	.060*	.077*	.944		.128	.093*	.072*
Systems Engineer	.865	.921	.140	.128		.976	.689
Financial Manager	.812	.880	.102	.093*	.976		.646
Manufacturing Engineer	.780	.739	.078*	.072*	.689	.646	

**statistically significant at p<.05
*statistically interesting at p<0.1

The change in leadership effectiveness over time by role was also investigated with comparisons across the pre-, mid-, and post-surveys using paired t-tests with results displayed in Table 6. The Percentage of students who were shown to be effective leadership was graphed in Figure 1. The largest number of significant differences were obtained for the mid- to post-surveys, suggesting that gains in leadership skills occurred in the second semester of the two-semester course. Large gains mid to post were observed for the project manager, systems engineer, financial manager, and the manufacturing engineer roles while the CAD engineer and test engineer did not show significant development in leadership effectiveness across the academic year. Figure 1 also showcases that the leadership development of the logistics manager increased consistently across the timepoints, differing from the pattern exhibited by all of the other roles.

Table 6. Comparison of leadership effectiveness over time for students in each role

Role	Pre- to Mid-Survey	Mid- to Post-Survey	Pre- to Post-Survey
Project Manager	.260	.031**	.709
Logistics Manager	.031**	.073*	.001**
CAD Engineer	.535	.325	.768
Test Engineer	.096	.211	.768
Systems Engineer	.254	.017**	.324
Financial Manager	.517	.002**	.007**
Manufacturing Engineer	.327	.002**	.050*

**statistically significant at p<.05
*statistically interesting at p<0.1

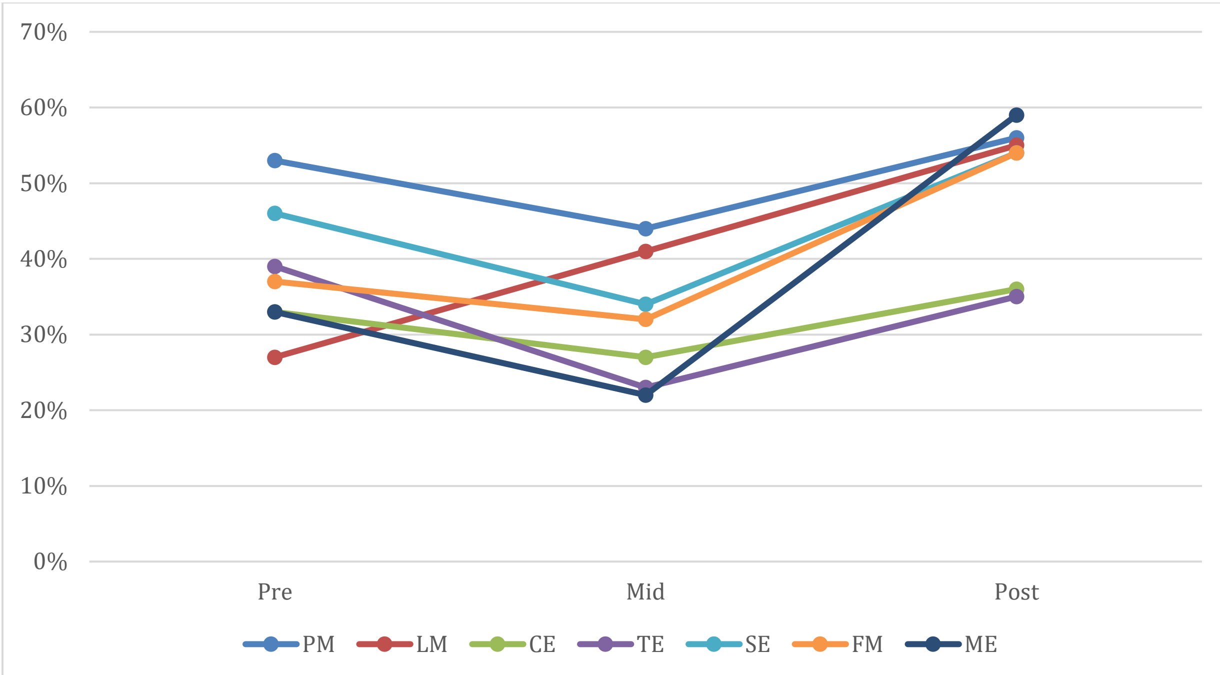

Figure 1. Percentage of students in each role who demonstrated leader effectiveness at pre, mid, post surveys.

Research Question 2: To what extent do students' beliefs in the benefits of having a role relate with their level of behavioral complexity/leadership effectiveness?

a. For the team

b. For the individual

Leader effectiveness was investigated with respect to beliefs about the benefits of roles in the design teams for both individuals and design teams. Student responses that align with high leader effectiveness were compared to student responses that align with low leader effectiveness using a one-way ANOVA. Significant results for the ANOVA (p<.05) were found across all rated benefits as shown in Table 7 with post-hoc comparisons displayed in Table 8 and 9. All significant results by role (p<.05) were found to have higher scores for the effective leaders.

Table 7. Comparison of effective leaders to non-effective leaders' responses to the question "To what degree do you feel that having assigned roles has benefited your **team/you** in terms of:"

Question	Significance Value
Individual Responsibility	<.001
Accountability	<.001
Division of Tasks	<.001
Team Dynamics	<.001
Sense of Belonging	<.001
Sense of Purpose	<.001
Ability to Articulate Contribution	<.001

For team level items (Table 8), significant differences were found showing the perceived benefit of roles in clarifying individual responsibility and team dynamics for the project managers, logistics managers, and financial managers. Project managers and financial managers also had significant differences in their perception of the benefit of roles in dividing tasks. The manufacturing engineers showed no significant difference at the team-level but reported significant differences across all three individual-level items of sense of belonging, sense of purpose, and ability to articulate contributions. On the individual-level, among the roles, 4 out of 7 roles thought having roles improved their sense of belonging, 3 out of 7 thought having roles improved their sense of purpose, and 5 out of 7 of them believed having roles improved their ability to articulate their contributions to the project.

Within the role, logistics managers displayed significance across all categories indicating effective leaders in this role were most appreciative of the benefits of roles. Like research question 1, there were not significant results for the CAD engineer and test engineer across categories.

Table 8. Comparison of effective leaders to non-effective leaders' responses by role to the question below.

Question: To what degree do you feel that having assigned roles has benefited **<u>your team</u>** in terms of:				
	Your Team			
Role	Individual Responsibility	Accountability	Division of Tasks	Team Dynamics
Project Manager	.029**	.276	.017**	.022**
Logistics Manager	.023**	.035**	.016**	<.001**
CAD Engineer	.115	.182	.401	.161
Test Engineer	.152	.544	.077*	.213
Systems Engineer	.101	.026**	.097*	.020**
Financial Manager	.021**	.152	.113	<.001**
Manufacturing Engineer	.962	.565	.560	.088*

**statistically significant at p<.05
*statistically interesting at p<0.1

Table 9. Comparison of effective leaders to non-effective leaders' responses by role to the question below.

Question: To what degree do you feel that having assigned roles has benefited **<u>you</u>** in terms of:			
Role	Sense of Belonging	Sense of Purpose	Ability to Articulate Contributions
Project Manager	.154	.073*	.018**
Logistics Manager	.006**	.071*	.002**
CAD Engineer	.593	.695	.545
Test Engineer	.639	.441	.574
System Engineer	.007**	.022**	.005**
Financial Manager	.021**	.006**	.013**

Manufacturing Engineer	.017**	.033**	.025**

**statistically significant at p<.05
*statistically interesting at p<0.1

Discussion and Conclusions

The following two subsections discuss the results and subsequent conclusions in the context of each research question. It should be noted that our research team recognizes the limitations of these conclusions when attempting to generalize this work across engineering education contexts. The industry preparation orientation of the capstone course studied in this paper forms the structure for the roles and leadership studied. Though the Competing Values Framework (CVF) is well-validated with reliable aggregated subscales, its implementation in engineering education and capstone courses is fairly limited. Lastly, these scales are self-rated, and bias can be introduced into the data with students potentially overestimating their capabilities.

Research Question 1: Does the development of behavioral complexity/leadership effectiveness differ for students in different roles?

Reviewing Tables 3, 4, 5, and Figure 1 we conclude that the development of leadership effectiveness does differ by role. As was discussed in Tables 3, 4, and 5, there are statistically significant and statistically interesting differences between roles at the pre-, mid-, and post-surveys.

One of our most interesting findings is the leadership effectiveness trend lines shown in Figure 1. Looking at Figure 1, we can assess leadership effectiveness over time. Looking at the pre-survey, project managers self-assess higher than all the roles when it comes to leadership effectiveness. Project managers are statistically higher than the logistics managers at this point. It is not unexpected that project managers were higher at this juncture of the course. When we review the Team Role Proposals assignment that is submitted by each team to their faculty advisor (aka: director) concurrent with team role selection, many of these proposals highlight previous leadership experience, or interest in leadership, for the proposed project manager.

It is also expected that students would decrease in leadership effectiveness confidence by the mid-survey. The downward trend in confidence from pre- to mid-survey, followed by an upward trend mid- to post-survey is similar to what we have seen in past course assessment surveys [20], where students are overconfident in their skills in the beginning of the project and rate themselves lower at the mid-survey once they encounter the true complexity of the project and approach the fabrication and testing phase of the project.

What is unexpected in the data is that logistic managers, who start significantly lower than project managers at the pre-survey, grow in confidence throughout the course. Unlike other roles that show a decrease in the leadership effectiveness at the mid-point of the course, logistics managers continue to increase, matching project managers by the post-survey. Additionally, financial managers, manufacturing engineers, and systems engineers cluster closely to project managers who shift into higher leadership effectiveness by the post-survey. Table 6 displays the statistically significant gains for logistics managers, financial managers, and manufacturing engineers from pre- to post-survey. Figure 1 and Tables 8 and 9 lend evidence that the shared leadership model established in this capstone course may be effective at building students' leadership abilities when it comes to the project manager, logistics manager, financial manager, systems engineer, and manufacturing engineer roles. But these results also beg the questions – why do so few logistic managers start with self-perceived leadership effectiveness at the beginning of the course? Their confidence grows throughout the capstone project, but are those with lower self-perceived leadership effectiveness drawn to this role, which is sometimes perceived as less technical by peers? Alternatively, do the students' perceptions of the role as a leadership role increase over time?

Furthermore, as we turn our attention to the CAD and test engineers, we see in Figure 1 that there is minimal gain in the percentage of people with leadership effectiveness for CAD engineers. For test engineers, there are fewer people with leadership effectiveness from the pre- to post-survey. These two roles stand out when reviewing the development of leadership effectiveness. The data lead to various subsequent questions for future research. Which students are attracted to the CAD and test engineer positions and why? Do they see these roles as providing leadership on the team? Does the current structure of these roles in the class not provide the opportunity for leadership development? Previous research [3] has demonstrated that engineers do not always view leadership as a part of engineering but also highlights that engineering leadership includes technical mastery. Do students who hold these technically focused roles undervalue the leadership that they provide to the team?

Research Question 2: To what extent do students' beliefs in the benefits of having a role relate with their level of behavioral complexity/leadership effectiveness?

a. ***For the team***
b. ***For the individual***

In Tables 7, 8, and 9 we compare "effective leaders" and "non-effective leaders" responses to the question "to what degree do you feel that having assigned roles has benefited your team/you in terms of individual responsibility, accountability, division of tasks, team dynamics, sense of belonging, sense of purpose, and ability to articulate contribution." Overall, we find that effective leaders rate team and personal benefits of the team roles framework higher than non-effective leaders (with significant differences shown in Table 7). Therefore, developing leadership effectiveness in a design course can also impact student perceptions of constructs such as teamwork, belonging, and identity.

However, as we divide the question by role, the results are mixed and there are differences in student beliefs when comparing effective and non-effective leaders.

Project Managers - Those who are project managers with higher leadership effectiveness feel that roles benefited the team when it came to individual responsibility, division of tasks, and team dynamics compared to their non-effective counterparts. The PMs with higher leadership also believe that roles provide the ability to articulate their own contribution to the team.

Logistics Managers – Logistics managers with higher leadership effectiveness believe that the roles were beneficial when it came to individual responsibility, accountability, division of tasks, and team dynamics when rating the benefit to the team. Individually, logistics managers with higher leadership effectiveness perceived the roles as benefiting them when it came to sense of belonging, sense of purpose, and ability to articulate contribution, compared to non-effective logistics managers.

Systems Engineers – Systems engineers with higher leadership effectiveness rate accountability and team dynamics higher when evaluating the benefit of roles to the team. Like logistics managers, the students with higher leadership effectiveness perceived their roles as an individual benefit when it came to sense of belonging, sense of purpose, and ability to articulate contribution, compared to non-effective systems engineers.

Financial Managers – Financial managers with a higher self-rated leadership effectiveness saw that having roles was beneficial to the team in terms of individual responsibility. Following the trend of logistics managers and systems engineers with higher leadership effectiveness, financial managers with higher leadership effectiveness believed that an advantage to having team roles included a sense of belonging, sense of purpose, and ability to articulate contribution, compared to non-effective financial managers.

Manufacturing Engineers - The largest benefit that manufacturing engineers perceived was when it came to personal elements. The manufacturing engineers with higher leadership effectiveness rated sense of belonging, sense of purpose, and ability to articulate contribution higher than non-effective manufacturing engineer leaders.

CAD and Test Engineers - For CAD and test engineers, there is no statistically significant difference between those who score higher and lower on the leadership effectiveness scale when it comes to the benefits the roles had for the team, or for them individually.

Team roles were implemented in these capstone projects in hopes of capturing the benefits proposed by Novoselich et al. [15, p. 49] such as "accountability … increased cohesiveness, satisfaction, and increased effort". We expected that having assigned roles with specific responsibilities would provide an opportunity for shared leadership among team members and a sense of empowerment for the students. These data demonstrate that there is a link between leadership characteristics described by the CVF and assigned roles, but that the impact is not evenly felt by all roles, with some roles showing fewer gains that others. In addition, we found that effective leaders found the roles helpful for the team and individuals on the team, suggesting those in leadership roles have an appreciation for this structure in capstone design. We can use this knowledge to reframe how we talk about leadership on an engineering team, in an engineering environment, for effective leaders, and in particular around the roles where students do not currently perceive or experience a growth in their leadership effectiveness. There may be something to be learned about why and how the benefits of roles are most clearly demonstrated for particular roles over others.

Future Work

Through this exploratory study, we have garnered evidence that the assignment and structuring of roles in an industry-oriented capstone course can impact leadership effectiveness. The quantitative nature of this study has allowed us to understand initial facts regarding the relationship between roles and leadership. However, to better understand the human behavior related to this self-rated leadership phenomena, we look forward to moving to a mixed methods approach in future work. Our next step is to initiate interviews with the project managers, logistics managers, manufacturing engineers, CAD engineers, and test engineers within this capstone program to explore student beliefs about engineering, engineering roles, engineering identity and their convergence with leadership. Our hope is to also expand our CVF data set to better determine significant differences between the roles and to reconsider alternative frameworks for studying the intersection of team roles and leadership. Through our next steps we also hope to provide actionable recommendations for practitioners to review for their classrooms.

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