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ESTABLISHING A PROTOCOL TO OBSERVE LEADERSHIP BEHAVIORS IN ENGINEERING DESIGN TEAMS

A Thesis
Presented to
the Graduate School of
Clemson University

In Partial Fulfillment
of the Requirements for the Degree
Master of Science
Mechanical Engineering

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by
Douglas James Chickarello
May 2018

Accepted by:
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ABSTRACT

The primary purpose of this work is to establish a protocol capable of identifying functional leadership behaviors in engineering design teams. The protocol is grounded in general leadership theory and research performed on collaborative design teams. A pilot study is used to evaluate the protocol applied to design team meetings. Three different raters applied the leadership protocol to a video recording of a graduate student team performing a collaborative function structure modeling activity. The results of the pilot study highlighted a need to identify the design space and activities that correspond to each leadership function observation to establish a relationship between functional leadership and engineering design. Next, a case study approach is used to observe functional leadership behaviors in three mechanical engineering senior design teams. Weekly team meetings and design reviews were recorded with video and audio equipment. Two raters applied the protocol to thirteen hours and thirty minutes of design team meetings and nine hours of design review meetings. The results of the case study indicate that technical leadership, observed in the problem and solution design spaces, are most frequently observed as Sensemaking and Providing Feedback. The case study also reveals that some team members demonstrated leadership functions in the project space, while others were observed in the problem and solution spaces. Additionally, the results highlight the limited amount of leadership observations in the problem space, thus indicating that teams might be neglecting the problem definition phase of the design process. The case study results serve as foundations for future research focused on the leadership functions observed in the problem and solution design spaces.

DEDICATION

This thesis is dedicated to my parents, Jim and Kathy Chickarello, and my brother Jeff Chickarello. Each of you have inspired me to be a leader in more ways than you know. Without your love and support, this work would not have been possible.

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While completing this work I failed (often) and learned (lots). Research requires a team.

Without this team, I would have accomplished little.

My Thanks to All

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CHAPTER ONE

MOTIVATION

This purpose of this research was to study functional leadership behaviors in engineering design teams. A case study approach was used to observe leadership behaviors performed by design team members in situ. The topic of leadership has been studied at length, but there are few studies that investigate leadership behaviors in an engineering design context. This section will introduce the motivation for performing a case study focus on leadership in engineering design teams.

Typical mechanical engineering undergraduate curriculums offer little to no formal leadership training. However, many engineering classes include team projects which provide opportunities for students to develop team work and leadership skills. Another aspect of most engineering curriculums is that the projects provided in freshman through junior level classes are not representative of projects found in industry. Students are not typically exposed to industry type projects until their senior year. This style of curriculum enables students to develop collaboration and leadership skills without increasing the number of credit hours required to graduate. As a result, student teams are not properly equipped for success. This work was conducted in an effort to understand how students demonstrate leadership behaviors over the course of a fifteen-week Capstone Senior Design class without formal leadership training.

Four distinct leadership experiences served as the motivation for studying functional leadership behaviors in engineering design teams. Two of the leadership

experiences were in academia, while the other two occurred in industry. Each experience contained unique challenges that taught the value of functional leadership in an engineering project team. Overall, the following four experiences established the motivation for research into functional leadership of engineering design teams. Functional leadership theory will be formally introduced in Chapter Two, however, its impact on the motivation of this research will be stressed throughout the explanation of each of the four experiences.

1.1 Engineering Co-Op (Sophomore – Senior)

One year (three individual semesters) as an engineering Co-Op at an automotive supplier located in North Charleston, SC presented an opportunity to observe differences in how engineers in industry lead and manage project teams. It was clear that some engineers emphasized task related behaviors over interpersonal behaviors. While others balanced task and interpersonal behaviors over the course of a project. It is important to note the differences in the behaviors as there is not one correct way to lead.

The first experience of leading an engineering project team occurred during the final rotation of the Co-Op, when the department underwent a quarterly Continuous Improvement Process (CIP) Workshop. Engineers from manufacturing and assembly separated into cross functional teams and studied all the department’s processes (for example: manufacturing, assembly, logistics, safety, and changeover). Over the course of the two-and-a-half-day workshop, the teams identified and prioritized the projects that would make the largest performance increase over the next quarter.

The CIP Workshop resulted in an opportunity to lead a CIP project for a manufacturing line that produced an internal component for the product. CIP projects are

typically one quarter long and led by a fulltime engineer. This project involved many challenges for a Co-Op with less than one-year experience in industry, including leading senior engineers, experienced technicians and operators, and coordinating with different departments of the plant.

The goal of the project was to reduce the changeover time of the manufacturing line by 50%. To accomplish the 50% reduction the team needed to identify opportunities to reduce, the number of steps in the process and the tools required, and improve the accuracy of pieces produced when the line restarted.

While unaware at the time, this project furnished the opportunity to learn and practice functional leadership behaviors in the form of Managing a Team's Boundaries and Training and Development. In this project, the leadership functions were performed by coordinating a changeover time reduction workshop for the team. The workshop was run by the Technical Engineering (TEF) group, which was a separate department in the plant. The workshop was a crucial part of the project because it taught the team methods to reduce the time required to complete a changeover to a manufacturing line. Coordinating the workshop with the TEF group (an organization outside of the team) is an example of Managing the Team's Boundary and Training and Development because it required coordination with a group that was external to the team and it provided the team training that was crucial to successfully completing the project.

As a result of the workshop, the team reduced the number of steps required to complete the changeover. The number of steps in the changeover was reduced by

redesigning the fixturing, moving the tool storage locations lineside, and documenting the proper changeover process which increased the accuracy of the parts produced after restart.

1.2 Introduction to Engineering Design (Senior I Course)

The second experience leading an engineering team occurred during an Introduction to Engineering Design Course. This course was taught in the first semester of a mechanical engineering student's senior year. The course had two components, a lecture series and a team term project, that occurred in parallel. Students were taught the systematic design process in the lecture series, and at the same time, had to apply each of the lessons to their concurrent team projects. The only prompt for the project was for teams to design and fabricate a platform, for fourth grade students, to perform science experiments.

The project team was composed of six mechanical engineering seniors with varying levels of industrial experience. The project's prompt was purposely left ambiguous to stress the importance of working with the project's customer to develop a purpose of the device being designed. The ambiguity of the project's prompt introduced the importance of the functional leadership behavior: Define the Team's Mission. For the first two weeks, the team struggled as it did not define the goal of the device that it was designing. In the first design review, the team received feedback that they should start over and re-think the purpose of their device. It was at that point that the decision was made to focus on developing a platform to demonstrate the effects of automating a process. Defining the Mission enabled the team to actually start the design the project. Furthermore, the team decided to focus on building a coin sorting machine to demonstrate the effects using an automated process to sort coins. Coins could be sorted by hand or by using the coin sorter,

which could be operated by hand or motor. Thus, the coin sorter was designed to support experiments with varying levels of automation, allowing fourth graders to understand the effects of automating a process.

The project's other main challenge was keeping team members involved and motivated to work on the project. As the project progressed, one team member's performance decreased a noticeable amount. Despite multiple confrontations from team members, the individual's performance did not improve. This did not change the total amount of work required to complete the project. This emphasized the importance of the functional leadership behavior to Monitor and Guide Team Tasks. The tasks assigned that were assigned to the team member whose performance dropped had to be re-assigned to other team members. If the tasks were not re-assigned, the team would have failed to finish the project by the due date.

This project was the first team project in academia that lasted more than two or three weeks. Defining the Team Mission enabled the team to focus their work towards the overall outcome early in the semester. Over the course of the project, it became vital to Monitor the Team's Tasks as a team members performance dropped. These functional leadership behaviors enabled the successful completion of the term project.

1.3 Capstone Senior Design Class (Senior II Course)

The third experience with leading an engineering project team occurred in the mechanical engineering Capstone Senior Design Class. The Capstone class is a student's internship in engineering design. In Capstone, students in their final semester are placed on teams that are tasked with completing a project for an industry sponsor. Projects require

students to apply the entire systematic design process they were taught in the Introduction to Engineering Design Course.

The design team consisted of six senior mechanical engineering students. None of the team members had worked with each other prior to this project. The industry sponsor for this project was a major automotive Original Equipment Manufacturer (OEM) located in Greer, SC. The sponsor tasked the design team with producing an Automated Guided Vehicle (AGV) to be used to deliver production parts lineside in their vehicle assembly facility. The project lasted one semester (four months).

The team worked with two representatives from the industry sponsor. The first was the university liaison officer, and the second was an engineer responsible for deploying the AGV in the assembly facility. The two representatives had differences in opinions regarding the performance and cost of the AGV. This provide an opportunity to practice the Sensemaking leadership behavior. The team had to dissect the requirements requested by each representative and then determine the best course of action. Finally, the team had to communicate their plan in manor that would persuade the representatives to come to a consensus on the AGV's goals. Sensemaking allowed the design team to develop a list of requirements that both industry representatives approved. The approval of the requirements reduced the ambiguity surrounding the design of the AGV and enabled the team to advance to the concept development phase of the design process.

The design and fabrication of the AGV was a complex project for a team of six mechanical engineering students. The project required the team members to learn new skills such as electrical fabrication and programming. As the team progressed through the

semester, all team members were encouraged to participate in managing the project. Due to the complexity of integrating each team member's work into the final AGV, Encourage Team Self-Management became important part of the success of the project. Team members were encouraged to debate and make decisions together because of how interconnected each of the subsystems became. Encouraging Team Self-Management kept the design team on the same page and enable teammates to work on multiple subsystems at once.

The team completed the design of the AGV, however, did not complete a functioning prototype. This caused the project to transition from an academic project to an engineering internship at the Automotive OEM.

1.4 Internship at an Automotive OEM

As the AGV project transitioned from academic project to industry project, the project's team shifted. The team size was reduced from six undergraduate seniors in mechanical engineering, to one of the original mechanical engineers and two technical scholars in the process of obtaining Associate's Degrees in mechatronics.

When the project resumed at the automotive OEM, the overarching goal of deploying the AGV into the assembly facility remained, however, there was not a structure or plan to achieve that goal. At the beginning of the internship a detailed plan for the three-month project was created and presented to the industry representative responsible for the project. The plan included fabrication and testing tasks, and their respective owners, that needed to be completed before the AGV could be deployed to an assembly area. This detailed planning is represented as the Structure and Planning functional leadership

behavior. The plan that was produced at the beginning of the internship guided the new design team to a successful completion of the AGV.

Working with two technical scholars who had no prior knowledge of the AGV's design brought on a new challenge. As the scholars learned the function of the design and worked on the AGV there were instances when the scholars made mistakes. Feedback was provided in a constructive way to ensure that the mistake would not be made again, and to encourage the scholars to keep working with enthusiasm. Typically, this feedback was provided in an informal manner (conversations during fabrication). Teaching the scholars, the AGV design and how to fabricate the design, revealed the importance of the functional leadership behavior Providing Feedback. The AGV could not have been completed without effectively providing feedback to the scholars who had no prior experience with the AGV.

Overall, the internship at the automotive OEM experience introduced two new functional leadership behaviors that are crucial to project success. Specifically, finishing the AGV project taught the importance of detailed planning, and being able to work with associates of all skill levels. This project reinforced the idea that complex engineering design projects require teams with strong leadership.

1.5 Concluding Remarks

Table 1 provides a summary of the experiences that motivated this research on functional leadership behaviors in engineering design teams. Each of the leadership experiences introduced different functional leadership behaviors and their impacts on engineering projects.

Table 1 Personal Leadership Expereinces.

Leadership Experience	Design Team	Functional Leadership Behaviors	Project Outcome
Engineering Co-Op	Yes	• Managing Team Boundary • Training and Development	Achieved goal of 50% time reduction
Intro to Engineering Design.	Yes	• Define Mission • Monitor Team Tasks	Project received excellent grade
Capstone Senior Design	Yes	• Sensemaking • Encourage Self-Management	Project received above average grade
Internship at Automotive OEM	Yes	• Structure and Plan • Provide Feedback	Delivered functioning AGV

Students in a typical mechanical engineering curriculum are not formally introduced to leadership theories, including functional leadership. However, these experiences reveal that functional leadership behaviors can occur in engineering projects and are important to project success. Therefore, research is needed to identify how functional leadership behaviors manifest in engineering design projects.

CHAPTER TWO

ENGINEERING DESIGN AND LEADERSHIP

Collaborative design and leadership within engineering design teams are both recognized as critical elements of most engineering design endeavors [1–5]. As the complexity of engineered systems increases, the importance of design teams and the size and degree of distribution of teams have also increased [6–8]. Only the simplest of designs can be accomplished without a coordinated team effort. In reality, the design of a product may require multiple teams designing components and assemblies [8,9]. Leadership is a key contributor to the effectiveness of these teams and the products they design [10–12]. While the importance of leadership and management are well recognized, relatively little education and training is provided to prepare undergraduate students for their potential roles as project leaders [10,13,14].

While collaboration and teamwork are required to tackle large scale design problems, within an engineering context, limited work has been done to understand leadership of design teams. Additional work is needed to understand the various aspects of leading an engineering design team. However, before research on leadership behaviors in engineering design teams can be performed, a protocol must be established to enable researchers to identify occurrences of leadership within an engineering design context.

The purpose of this work is to establish a protocol to be used to identify leadership behaviors within engineering design teams, and initial results of a case study on three engineering design teams. The protocol will allow researchers to more effectively study leadership in an engineering context. The proposed protocol is grounded in a review of

current leadership theories and collaborative design research. The protocol is further evolved through a pilot study involving engineering graduate students working in teams to develop function structures. The case study applies the protocol to three engineering design teams to identify relationships between functional leadership and engineering design. Additionally, the case study highlights potential future research opportunities regarding leadership of design team. This section presents a review of the literature that is focused on collaborative design, general leadership theory, and leadership of engineering design teams.

2.1 Collaborative Design

Leadership cannot occur in situations without collaboration or teamwork. Therefore, engineering leadership should be studied through collaborative design teams. This section presents research on collaborative design teams to highlight the need for additional research focused on leadership of design teams.

2.1.1 Team Distribution

As the economy continues to shift towards a global market place, design teams are no longer working in the same office or even the same country [3,6,15]. There have been numerous studies focused on understanding the challenges that globally distributed design teams face [16,17]. These studies focus on different cultural, communication, and organization challenges that distributed product development and design teams encounter. Additional studies focus on other aspects globally distributed design teams [18,19],

however at this point minimal studies focused on the leadership challenges that globally distributed product development and design teams face.

2.1.2 Collaborative Design Tools

Collaborative design tools have been developed to help designers communicate, identify concepts, and present information in conceptual design [20–22]. Traditional collaboration tools for sharing information have also been evaluated to determine the best methods of communicating technical information during team projects [23–26].

One tool exists to assess leadership in engineering students [27]. The tool is limited because it assesses an individual's self-awareness of their leadership abilities; it cannot be used to identify leadership behaviors within a team. The survey tool was created to define and assess engineering leadership understanding in the context of an undergraduate curriculum [27] and not to identify individual occurrences, or impacts, of leadership within a team setting.

2.1.3 Team Composition

Team composition has been a recent topic of research within the collaborative design field [11,28,29]. There have been different focus areas within the team composition research ranging from diversity (gender and cultural) within design teams [11,30–33]. Additionally, research focused on the personalities of design team members has also been conducted [30,34–36] with the intent of developing better team experiences and better performing design teams.

2.1.4 The Collaborative Design Taxonomy

A collaborative design taxonomy was established to classify instances of collaborative design situations [2,37]. A diagram of the updated taxonomy can be seen in Figure 1 [38]. The purpose of this taxonomy is to be able to compare different design projects and experiences. Additionally, the taxonomy was developed to highlight the need for future collaboration tools to facilitate collaborative design activities [39].

The collaborative design taxonomy has three different levels. The taxonomy's first level is comprised of Team, Communication, Problem Nature, Design Approach, Information, and Distribution. These top-level attributes are each decomposed into two additional levels of granularity. The leaf nodes in the third level contain elements that can be evaluated and applied to a collaborative design scenario. Figure 1 demonstrates the three levels of the collaborative design taxonomy, readers are referred to [2,38] for a detailed discussion of the collaborative design taxonomy.

Leadership, as shaded in Figure 1, is a second level attribute under the top-level attribute, Team. The collaborative design taxonomy only requires users to evaluate the leadership style present in the design team. The leadership style options include options such as autocratic, participative, and leaderless.

In its current state, the collaborative design taxonomy, can only capture a limited understanding of the leadership occurring in a design team, the hierarchical style. The leadership theories presented in section 2.2 identify numerous alternative evaluation methods besides simply evaluating the leadership's hierarchy. The collaborative design

taxonomy should be expanded to include additional techniques, rooted in leadership theory, to evaluate the leadership occurring in design teams.

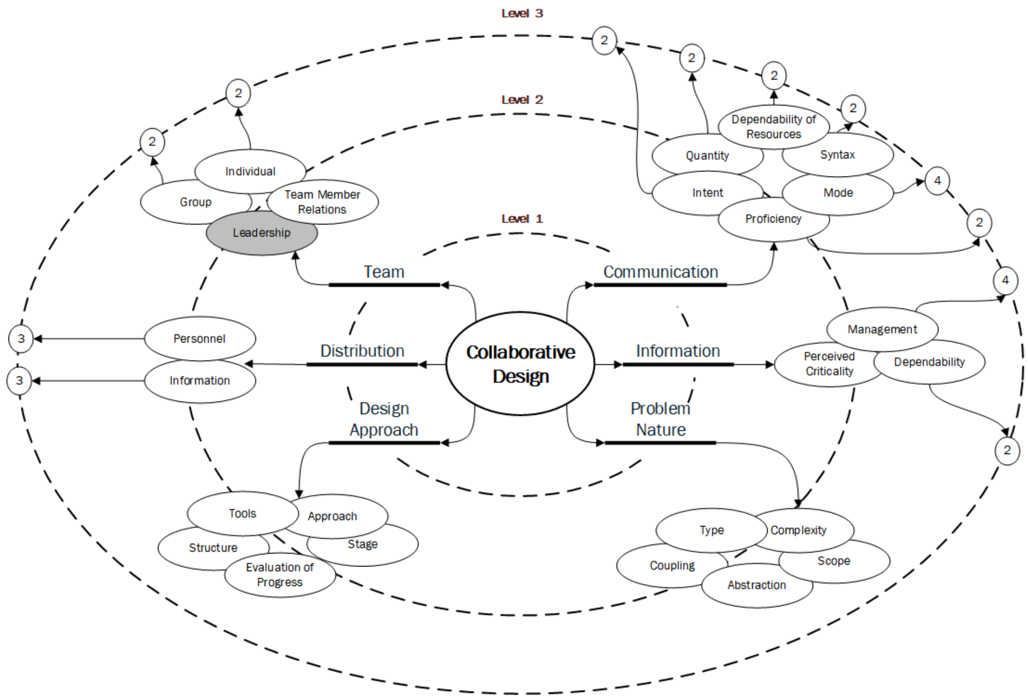


Figure 1 The collaborative design taxonomy [38].

2.2 Leadership Theory

Many claim that the development of modern day leadership theory emerged in the mid nineteenth century [40,41]. Initial theories introduced the idea that leadership was a characteristic individuals obtained at birth [42]. Current theories demonstrate that leadership can be developed, taught, and studied through behaviors and interactions [40].

2.2.1 Trait Theory

The fundamental principle of trait theory is that leadership stems from characteristics or traits that the leader possesses [40,43]. The characteristics vary from physical, such as height and attractiveness, to personality or character traits, such as

integrity and forcefulness [43]. A seminal review analyzed 124 leadership studies focused on traits and characteristics [42]. The results of the analysis contained contradicting results. The results varied in that six studies found leaders were generally younger, while ten claimed that leaders were generally older. Additionally, two studies did not find a correlation, and a single study demonstrated that a leader’s age is situationally dependent [42].

Due to the numerous contradicting results, many researchers question if traits have a relationship with leadership. Further, some claim that traits should be considered as one of many components of leadership, and that their impact is dependent on the situation [40,43]. Factors that have been identified as “associated” with leadership include, but are not limited to, capacity, achievement, responsibility, participation, and status. These factors have been shown to effect the performance of leaders in certain situations [40,42,43]. Recent studies found that characteristics, such as cognitive ability, may be related to leadership, however, are not capable of predicting a leader’s success or failure [44].

2.2.2 Behavior Theory

Unlike trait theory, behavior theory focuses on the behaviors that a leader demonstrates [43,45]. Studies have listed leader behaviors and organized them into two dominant groups, initiating structure and consideration. The initiating structure group contains leader behaviors focused on organizing team roles, tasks, and priorities. Consideration behaviors include behaviors that build trust within the team and develop team member relationships [43,46,47]. Studies have also investigated job centered and employee centered behaviors [48]. Other studies used questionnaires to solicit

subordinates, or occasionally peers, to evaluate leaders according to behaviors and characteristics [43,48–50]. The works presented demonstrate that behaviors are most commonly grouped according to task or relationship oriented. These studies concluded that an individual's traits and behaviors effect leadership [45,49]. This conclusion created the possibility to study leadership through case study and observation.

2.2.3 Contingent Leadership

Contingent and situational leadership theories are based on the concept that the leadership style should vary depending on the situation or context the leader faces [40]. Individual theories segregate situations through factors such as employee maturity, nature of the problem or goal, or degree of team member acceptance. The combination of factors in a situation determines the degree of team member participation in team processes [51]. Contingent leadership theories emphasize that the leadership style should change depending on the team's environment.

2.2.4 Leader-Member Exchange Theory

Leader-member exchange theories are similar to contingent leadership theories, in the claim that leadership differs in each context and team. Specifically, leader-member exchange theories claim that leaders do not treat all team members in the same manner [40,52]. Relationships between leaders and team members are considered to be dyadic (separate from other leader-team member relationships). Team members can be characterized as a stranger, acquaintance, or partner based on the level of task interaction and relational trust [40]. Leader-member exchange theory, for the purpose of this work,

demonstrates that a leader's interactions will vary depending on the team member he/she is interacting with.

2.2.5 Transactional and Transformational Leadership

Transactional leadership focuses on establishing team goals and rewarding team members for achieving goals [53]. Intrinsic motivation sources are the focus of transformational leadership models [54]. Specifically, leaders evoke change or team performance through charismatic action, intellectual challenge, and social consideration [40,55]. Transformational theory makes the claim that this form of leadership is a preferred in situations requiring organizational change [41].

2.2.6 Functional Leadership

Functional leadership includes aspects of most of the works and theories previously established. Functional leadership is most closely related to behavioral leadership. Behavioral leadership theory proposed patterns of behaviors that a leader should exhibit such as structure and consideration. However, functional leadership theory expands behavioral theory to the identification of leadership processes or functions leaders fulfill [40,56]. Leadership functions are the roles that a leader performs. Leader functions have been identified and organized as task focused and relational focused (similar to behavioral leadership theory) [40,56].

Functional leadership theory is commonly used as a framework to study teams; as it provides an organized set of leadership functions that can be observed during team activities [56–58]. Leadership functions are first organized into task and relational types.

The task oriented leadership functions are further decomposed into transition and action phase functions [59]. Transition phase functions include establishing goals and providing feedback, while action phase functions include solving problems and performing team tasks [56]. Additional examples of leadership functions in the transition or action phases, are available in Table 2. Functional leadership behaviors were selected for use in this work based off of the applicability to teams and the ability to observe behaviors in team meetings.

Table 2 Examples of leadership functions [56]**.**

Transition Phase	**Action Phase**
• Compose Team • Define Mission • Establish Expectations and Goals • Structure and Plan • Train and Develop • Sensemaking • Provide Feedback	• Monitor Team • Manage Team Boundaries • Challenge Team • Perform Team Task • Solve Problems • Provide Resources • Encourage Team Self-Management • Support Social Climate

2.2.7 General Leadership Summary

It is important to note the theories presented are not the only theories on leadership. Additional theories do exist, however, the theories presented in this work provide a summary of the research that has been conducted. Table 3 below demonstrates a summary of the leadership theories presented in this section.

Table 3 Summary of current leadership theories.

Leadership Theory	Reference	Subject
Trait	[40,43]	Connection of personal characteristics to leadership effectiveness
Behavioral	[43,48]	Primary categories or factors related to leadership behaviors
Contingent	[40,51,60]	Appropriate Leadership behaviors vary based on circumstances
Functional	[56,58,61,62]	Specific activities performed by leaders
Leader-Member Exchange	[40,52,63]	Relationship between a leader and followers or members
Transformational and Transactional	[53,55,64]	Charismatic and contingent-reward leadership

2.3 Leadership in Engineering Design Teams

Table 4 presents studies that discuss leadership of engineering design teams. Engineering design leadership is the primary topic of several of the selected papers, while it is a subheading of other papers regarding collaborative design. The studies presented in Table 3 are categorized by the type of study and by the leadership characteristic that was the focus of the study. Among the studies reviewed, twelve were case studies, one was a case study/simulation study, one was an experimental study, and one was a literature study. Note the number of case studies present is indicative of a predominant type of leadership research method.

Table 4 Summary of leadership research within an engineering design context.

Type of Study				Study Information	Leadership Characteristic Studied									
Case Study	**Experimental Study**	**Literature Study**	**Simulation Study**	**Reference**	**Collaboration**	**Team Distribution**	**Leadership Education**	**Communication**	**Style**	**Boundary Spanners**	**Transformational**	**Leader Positivity**	**Structure**	**Project Length**
X				Hitt, Nixon, Hoskisson, and Kochhar [65]	X	X								
X				Seat et al. [13]			X							
X				Osborn et al. [66]				X						
X			X	Schreiber and Carley [67]					X					
		X		Ostergaard and Summers [2,39]	X									
X				Kumar and Hsiao [68]			X							
X				Kratzer et al. [69]				X						
X				Di Marco et al. [16]						X				
X				Watson and Lyons [14]			X							
X				Palmer and Summers [12]							X			
	X			Avey et al. [50]								X		
X				Taylor and Ahmed-Kristensen[15]		X								
X				Novoselich et al. [70]									X	
X				Knight and Novoselich [71]			X							
X				Righter, Blanton, et al. [72]										X
13	**1**	**1**	**1**	**Total**	**2**	**2**	**4**	**2**	**1**	**1**	**1**	**1**	**1**	**1**

2.3.1 Research Methodology

Table 4 demonstrates that thirteen of the sixteen studies that investigated leadership of engineering teams used a case study methodology. The objective of most case studies is to investigate naturally occurring phenomena by providing detailed descriptions of the events [73–75]. Additionally, a case study offers a qualitative method to observe human

behaviors and processes [18,73,76]. Table 4 demonstrates that numerous studies used a case study methodology to study leadership within engineering teams without impacting the team or artificially inserting leaders. A case study enables allows researchers to capture naturally occurring team behaviors without interrupting the team's work or team member roles.

Other research methods commonly used to study human behavior in a design setting are protocol studies. Protocols studies enable researchers to observe how designers design, work in teams, and think through the use of video recordings and the applying an established protocol [77–80]. The results of protocol studies enable researchers to develop specific research questions and hypotheses that can be tested through experimental studies [81]. Protocol studies can be used to study leadership within engineering design teams as team meetings can be recorded and a protocol can be applied to identify instances of leadership within the team meetings.

A case study using protocol analysis is presented as a preferred method of studying leadership of design teams. In this type of study, engineering teams would be recorded in situ during team meetings. Then a protocol designed to identify functional leadership would be applied to the recorded team meetings. The results of the protocol analysis would identify the instances of functional leadership within engineering design teams.

2.3.2 Leadership in Engineering Education

Literature on engineering education includes analysis of the need for leadership education for undergraduates and for doctoral students [14,68]. It includes an analysis of traits and experiences before and during college and their impact on leadership [71]. The

literature also provides descriptions of engineering leadership initiatives within higher education [13].

One study considered the impact of both college and precollege experiences on the leadership efficacy of undergraduate students. The study analyzed surveys to conclude that precollege experiences and traits did not have a significant impact on their leadership efficacy. The study concluded that students are capable of developing leadership confidence and ability during their undergraduate education. The study also suggested that academic programs emphasizing leadership skills increased the students' perception of their ability to lead. Finally, the study suggested further research was necessary to determine if faculty should explicitly assist students with leadership skill development during team activities [71].

Engineering education literature suggests that leadership is a necessary learning outcome for undergraduate engineers [14,68]. The leadership skills were identified as significant include team building, communicating effectively, and motivating team members. Problem based learning is encouraged as an effective method to develop leadership skills [68].

2.3.3 Engineering Leadership Studies

A survey instrument [82] was developed to investigate leadership and communication within undergraduate design teams based off of the collaborative design taxonomy [2]. The survey tool specifically identifies leadership styles within design teams and was intended primarily to be used with undergraduate design teams. The leadership styles targeted by the survey instrument were based on the contingency model and

participation in decision making [51,66]. While the study did not yield specific results on the development of leadership and communication in design teams, it did establish an instrument for future research [66].

The instrument has been further refined to investigate leadership structure and communication in design teams [72]. The modified survey instrument was used to establish the leadership structures and communication patterns in selected Capstone design teams. The Capstone teams consisted of both one and two-semester projects. The study explored the impact of the project's length on the establishment of formal leadership roles and the differences in frequency and duration of communication. The study identified that the two-semester teams appeared to function as a multiteam system (MTS) or a system of teams [72].

Transformational and transactional leadership have been researched in undergraduate engineering design teams in a case study. The case study used observation to identify the occurrence of transformational and transactional leadership, within a student team, in a design review setting. The study concluded that student leadership was primarily transactional [12].

Another study investigated the centrality of faculty coaches and graduate advisors in undergraduate teams. The coaches and advisors were in formally appointed leadership roles. However, they were not members of the team performing team tasks. The leadership was evaluated using statements from the multi-factor leadership questionnaire. This questionnaire was developed to evaluate leaders from the perspective of transformational and transactional leadership [70].

Other studies also addressed a team's reaction to leader positivity. A study of an aerospace company examined the effect of positivity conveyed by a leader in written communication. Team members were exposed to a written statement by leadership and asked to consider a conceptual design problem. The team's perceptions, specifically efficacy, optimism, and resilience, to the leader's positivity were recorded. The study indicated that leader positivity is related to these factors and also that the complexity of the problem may have a negative impact on the same factors [50]. A limitation of this study is that, although it was performed in an industry setting, the conceptual design problem used did not replicate a problem the team members would normally face. Additionally, the leader's positivity was merely a written statement and there was no physical interaction with the leader [50]. Thus, team members were merely reacting to a positive statement regarding their performance, demonstrating the limitations of an experimental leadership study.

The impact of the position of formally assigned leaders, on the creativity of product development teams, has been explored by social network analysis in a case study of two teams. The study investigated the relationship between the leader's centrality in communication networks and boundary spanning role in addition to other factors. The study determined that boundary spanning by the leader tended to increase creativity, while the highest and lowest centrality to the communications network appeared to have a negative impact as compared to centralities between the extremes [69].

Table 4 summarizes the research that has been performed on leadership within an engineering context. The topics include a wide range from leadership style to leadership

education. Finally, a majority of the leadership research in engineering design has been performed using a case study methodology.

2.4 Opportunities for Additional Research

Existing literature examines transformational and transactional leadership, leadership style, positivity, and formal position in a team's structure. Literature also makes the case for increased leadership education within the undergraduate and graduate engineering curriculums. Industrial and organizational psychology and management studies focus on team leadership from the functional perspective, while design team leadership has not been studied using leadership functions. Overall, there is a limited amount of research regarding leadership within engineering design teams. More research is needed to determine leaderships effect on team experiences and performances to better teach leadership to students and novice engineers. This section will identify two distinct opportunities for additional research focused on leadership in engineering design teams.

Within an engineering design context, little research has been done to understand the impact of functional leadership behaviors on team projects. Functional leadership involves the specific tasks and functions a leader performs over the course of their term as a leader [56,58]. Additional research is required to understand what leadership functions engineers are performing, when the different functions are performed, and how do the different leadership functions impact the progression of a design project. Studying functional leadership within an engineering design context will highlight the different leadership actions and tasks that are required over the progression of a design project.

Despite the vast number of case studies performed, there is a lack of research stemming from the direct observation of engineering design teams. Many of the case studies performed used surveys or interviews to gauge an understanding of the leadership occurring in the design teams studied. Although these indirect methods are useful, directly observing design teams will allow each instance of leadership and its implications on the progression of the project to be identified. Observational studies will also make it possible to understand how functional leadership behaviors emerge in a design project setting since engineers are not formally trained in leadership.

2.5 Research Questions

The following research questions have been established based on the opportunities for additional research.

RQ.1. What are the relationships between functional leadership behaviors and the engineering design space?

Question one aims to identify how functional leadership behaviors emerge in the context of a team design project. This question was proposed because the literature revealed that, often, students are not formally taught leadership. Question one will enable researchers to understand how engineers lead design teams without any formal training in leadership.

RQ.2. What insights into functional leadership behaviors and project progression does observing design team meetings with a leadership protocol reveal?

The purpose of question two is to understand what effects different functional leadership behaviors have on a design project. Answering this question will require

observing more than one design team so that an analysis of the different functional leadership behaviors observed can be performed.

MQ.1. Can a protocol be established to observe functional leadership behaviors in student teams during a 4-6-month design project?

This is a methodological question that must be answered to properly answer research questions one and two. Before relationships between the design space and functional leadership behaviors can be made, a protocol, capable of identifying the two types of information, must be developed.

2.6 A Roadmap to this Thesis

This thesis contains five chapters that establish a protocol to observe leadership behaviors in engineering design teams and present the results of a six-week case study. This chapter established the current state of research focused on leadership of engineering design teams and introduced the research questions that will be addressed throughout the remainder of this thesis.

Chapter Three demonstrates how the initial leadership protocol was established. Chapter Three also presents a pilot study that introduced opportunities to improve the protocol. The case study performed on three engineering design teams is presented in Chapter Four. The results of the case study will highlight relationships between functional leadership behaviors and engineering design teams. Additional results will demonstrate the impact of the functional leadership behaviors on the progression of the design projects. Chapter Five will provide the conclusions and impacts of this research and introduces avenues for future work based off patterns in the results of this research. Finally, the

appendices of this thesis include the coding manual used by raters to evaluate the case study recordings, the complete coding data set, and the IRB consent form signed by all participants.

CHAPTER THREE

ESTABLISHING THE PROTOCOL

The purpose of the pilot study presented in this chapter was to answer MQ.1 by developing a protocol capable of identifying functional leadership behaviors and the design space from observations of design team meetings. Developing the functional leadership protocol occurred in three distinct steps. First, a protocol was established from a review of the literature, as seen above. Second, a pilot study, in the form of a protocol study, was conducted to test the content of the initial protocol. Finally, the protocol was modified based off the results of the pilot study.

3.1 Initial Protocol

The goal of the initial protocol was to establish a method of identifying functional leadership behaviors within a natural team setting. Returning to the literature, it was important to develop a protocol capable of identifying task and relational leadership functions. The task functions correspond to behaviors that the leader exhibits that are related to the project deliverables or the team performance. Relational, or interpersonal, correspond to team member relationships or team function [40].

It is also important to note whether the leadership functions occur in the action or transition phases of team activities. Teams in transition phases are evaluating their progress and setting new goals and targets based off their status. In contrast, action phase team activities consist of team members performing tasks, identified and planned in transition

phases, that contribute to the team's goals [56,62]. Table 5 presents a summary of the leadership function types.

Table 5 Leadership function types [59].

Leadership Function Type	Definition
Transition	In transition phases, teams are establishing goals and plans to achieve the overall team mission. Leaders are also reviewing team performance and providing feedback to ensure team members understand how to better focus their efforts.
Action	Teams are working to achieve the goals established in the transition phases. In action phases leaders are managing the team boundary, solving problems, and monitoring and guiding team tasks.
Interpersonal	Interpersonal leader functions focus on building effective team member relationships that improve the function of the team. The functions include supporting the social climate, consideration, and empowerment.

The initial leadership protocol was established using leadership functions from [56]. Consideration and empowerment [47], two interpersonal leadership functions, were added to the leadership protocol to increase the range of interpersonal behaviors that could be identified using the protocol. The initial leadership functions selected for the leadership protocol, along with their definitions are displayed in Table 6. The leadership functions in Table 6 were also selected because of their acceptance as functions that leaders perform over the course of a project [57,58].

Table 6 Leadership functions used in the initial protocol [47,56]**.**

Leadership Function	Type	Definition
Compose Team	Transition	Selecting individuals that can achieve the goals outlined for the team.
Define Mission	Transition	Determining and communicating the organization's performance expectations for the team.
Establish Expectations and Goals	Transition	Identifying internal performance expectations for team members and setting internal team goals.
Structure and Plan	Transition	Developing an understanding of how best to coordinate team actions and work together to achieve the established goals and expectations.
Train and Develop	Transition	Identifying deficiencies in team capabilities and providing training and opportunities for the team to enhance its skill set.
Sensemaking	Transition	Identifying and interpreting essential environmental events and communicating this interpretation.
Provide Feedback	Transition	Providing feedback on performance against established goals and milestones.
Monitor Team	Action	As team is actively involved in work, the team's progress and performance must be monitored to ensure the team is on target for reaching their goals.
Manage Team Boundaries	Action	Managing the relationships between the team and the external environment (other teams, the larger organization, customers, and other influences on the team).
Challenge Team	Action	Challenging the team with respect to their performance levels, processes, standards (rules & regulations), and attitudes.
Solve Problems	Action	Diagnose and solve any problems that keeps the team from achieving its potential.
Provide Resources	Action	Acquiring financial, informational, material, and personnel resources for the team to use to complete their tasks and achieve the team mission.
Encourage Team Self-Management	Action	Encouraging the team to manage itself and perform its own leadership functions.
Support Social Climate	Interpersonal	Supporting the team's social climate involves dealing with interpersonal issues that may hinder the team's performance.
Empowerment	Interpersonal	Showing concern and respect for individual team members.
Consideration	Interpersonal	The act of strengthening an individual's beliefs in his or her sense of effectiveness.

3.2 Pilot Study

The research method selected to test the initial leadership protocol is a protocol study because it enables direct observation of designers and engineers performing an activity. The actions of the participants are then coded using a pre-defined protocol similar to that described in [79,83]. Coding the activity that the participants performed reveals *how* the participants completed the activity [84,85]. Thus, a protocol study is ideal for answering MQ.1; because the initial leadership protocol could be used to code functional leadership behaviors observed during a team design activity.

The activity in this protocol study consisted of graduate students creating a function model for a given problem statement. The modeling activity required participants to read and understand a problem statement, then work as a team to create a function structure model addressing the problem statement. This study was conducted under Clemson IRB2016-343 and was deemed exempt.

3.2.1 Function Modeling

Function modeling as a design tool is typically introduced in conceptual design and revisited throughout the entire design process [8,86–88]. Function models take on many forms [89], however the overall purpose of function modeling is to represent the functions of the product/device being designed [8,9]. Examples of different forms of function modeling include Function Behavior Structures [90], black box function models [9,91], and Function Trees [92].

The black box modeling method was selected for use in the pilot study as an extension of previous function modeling studies [79,93–95]. Black box function models

consist of an overarching function, known as the "black box model," which represents the overall function of the product/device. The "black box model" is then decomposed into a detailed "function structure." The "function structure" maps the flows of materials, signals, and energies through the various functions the product/device must complete to achieve its overall "black box model" [91].

A hand mixer is a common product that can be used to demonstrate an example of a function structure. One representation of a "black box model" for a hand mixer is to: Mix Food. Then, the "black box model" is decomposed into a detailed function structure, some of the functions it must complete could include (in the form of a function flow pair), converting electrical energy into mechanical energy, regulate electrical energy, and import human signals. Figure 2 represents an example of a black box model and a partial function structure for a hand mixer.

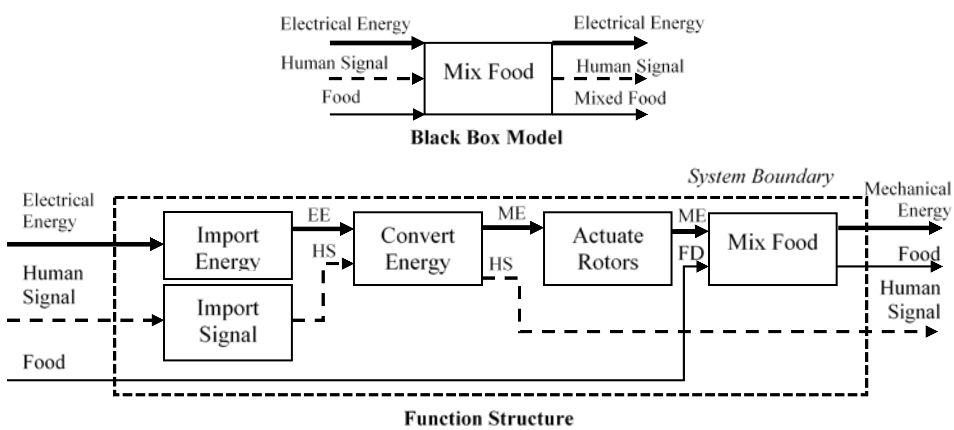


Figure 2 Example of a "black box model" and "function structure" for a hand mixer.

3.2.2 Protocol Activity

A graduate student team of four was tasked with creating a function structure for an automatic recycling sorter [96]. The specific prompt is provided below in Table 7.

Table 7 Protocol activity prompt (from [95,96]**)**

"Design an automatic recycling machine for household use. The device should sort plastic bottles, glass containers, aluminum cans, and tin cans. The sorted materials should be compressed and stored in separate containers. The amount of resources consumed by the device and the amount of space occupied are not limited. However, an estimated 15 seconds of recycling time per item is desirable."

The team was told that they could take as much time as needed to complete the activity, but that the activity typically lasted about an hour. The team used a white board equipped with a data capture system to record their responses that was laid on a table. The data capture system recorded each marker stroke and edit so that researchers could capture the team's completion of the function structure.

Two cameras recorded the team completing the protocol activity. The cameras were set up on opposite corners of the room to capture as much of the room as possible. The cameras also recorded the audio from the activity. Figure 3 demonstrates the experimental setting from the point of view of the two cameras in the room.

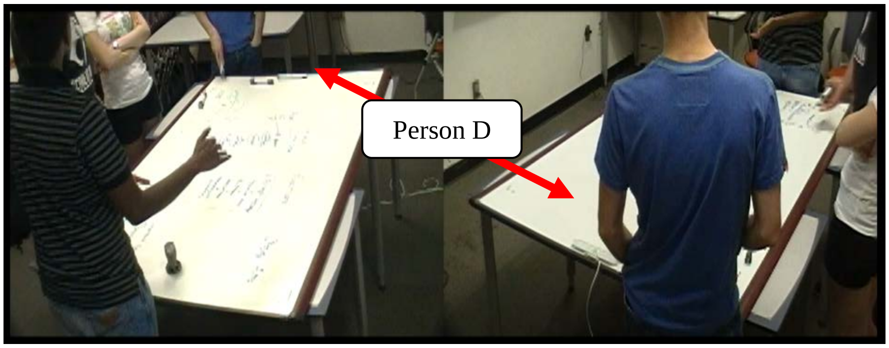


Figure 3 Protocol experimental setup, from the view of each camera.

3.2.3 Participants

The participants for this study were enrolled in an engineering and systems design summer course during May 2017 at Clemson University. The four participants were graduate students from Purdue University, Georgia Institute of Technology, University of Alabama – Huntsville, and Arizona State University. Two of the team members were PhD students and the other two members were pursuing an MS. The participants were studying engineering design in mechanical and systems engineering programs. The team members had limited experience with functions structures and black box models. The team members were from India, China, Italy, and Greece. The team was composed of one female and three male members. The age range of the team spanned from 22-26.

3.2.4 Applying the Initial Leadership Protocol

The team was recorded as it competed the function structure activity. The activity took 53 minutes from when the team first received the prompt, until it completed the function structure.

Three raters (A, B, & C) independently watched ten-minute segments of the video and applied the initial leadership protocol. The application of the leadership protocol is

referred to as a coding session, because the raters recorded each observation of functional leadership while watching the video segments. The average duration of a coding segment was fifty-minutes, and the time between coding sessions was roughly one week. For example, Rater A coded the 00:00-10:00 minute segment on a Monday and then coded the 10:00-20:00 minute segment on the following Monday. This was done to ensure that the raters were not biasing their coding based on the previous sessions' results. The breakdown of the sections reviewed by the three raters is shown in Table 8. Multiple raters were used to test the inter-rater reliability of the protocol.

Table 8 Breakdown of video sections reviewed.

Elapsed Time	Rater 1	Rater 2	Rater 3	Rater 4
00:00 - 10:00	A	B	C	A'
10:00 - 20:00	A	C	A'	
20:00 - 30:00	A	B	A'	
30:00 - 40:00	A	A'		

Rater A coded forty-minutes of the video over the course of four-weeks and, after a month of no coding, re-coded the entire video. The results from Rater A's second coding sessions are shown as Rater A' in Table 8. This was done to examine intra-rater reliability of the leadership protocol.

The raters were instructed to watch the segment in its entirety before coding any leadership behaviors. This was done so that the raters could become familiar with how the team members interacted before applying the leadership protocol.

The raters then watched the video segment, again, from the beginning. Over the course of the video segment, the raters recorded each instance a leadership function occurred. In addition to recording the leadership function that occurred, the raters also

identified the team member(s) performing the behavior (the leader(s)) and any team members influenced by the behavior (the followers). Finally, the raters recorded the time stamp at the beginning and end of the instance. The complete protocol, with instructions, is available in Appendix A. An example of a leadership coding table is available in Table 9.

Table 9 Example of functional leadership coding.

Number	Function (Acronym)	Per. A	Per. B	Per. C	Per. D	Start Time	End Time	Duration
1	DM	L	F	F		0:00:30	0:00:36	0:00:06
2	COMP	F		L	F	0:00:40	0:00:42	0:00:02
3	SP	F	L		F	0:02:46	0:02:50	0:00:04

Key: **COMP –** Compose Team, **DM –** Define Mission,
EG – Establish Goals, **L** – Leader, **F –** Follower.

The first leadership behavior coded in the example shown in in Table 9 is Define Mission. Person A was stated that the team's overall goal was to create a function structure. Thus, person A performed the behavior and was coded as the Leader. Person B and Person C were influenced by the behavior (acknowledged what Person A did through verbal agreement) and therefore were recorded as Followers. Finally, the start and end times were recorded and the duration was calculated. Note that there are periods, between each leadership function observed, where no leadership function was recorded. This is expected as the protocol only instructs raters to code for leadership behaviors and not the overall team behavior. Therefore, it is not uncommon to have periods of time with no leadership observations.

3.3 Results and Protocol Improvements

After applying the leadership protocol to the video segments, additional steps are required to prepare the raters' raw codes for analysis. Figure 4 is a graphic representation of the code generated by Rater A'. It is clear from Figure 4 that each team member exhibits leadership functions over the course of the activity, and that the predominate function that Rater A observed was Sensemaking. Note that the entire code is available in Appendix B.

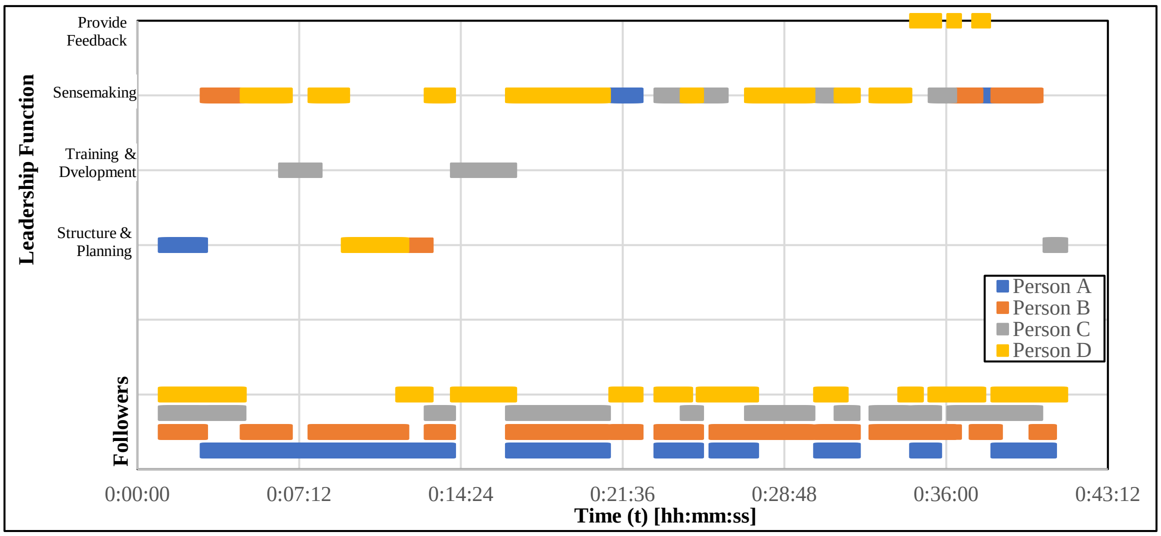


Figure 4 Graphic representation of the meeting coded by Rater A'.

3.3.1 Analysis Method

The leadership functions that each rater observed were organized according to the start and end times. the sorted observations were compared to the other raters' observations. Since there were four raters, six-pairs of codes were evaluated (each code was compared to the other three independently).

3.3.2 Rater Agreement Results

Each pair was then analyzed at four different levels to understand the rater agreements at varying levels of granularity. At each level, the six pairs of codes were analyzed for the percent agreement and the Cohen's Kappa statistic [97]. Cohen's Kappa evaluates the agreement between the raters in relation to the pure statistical chance of agreement. Therefore, a Kappa value of zero indicates that agreement between two raters is no higher than the pure statistical chance of agreement. A Kappa value of one indicates perfect agreement between raters [98]. Table 10 presents the levels of agreement for different Kappa values.

Table 10 Levels of agreement for Cohen's Kappa [98]**.**

Kappa Value	Agreement Level
< 0	Less than chance agreement
0.0 – 0.2	Slight agreement
0.2 – 0.4	Fair agreement
0.4 – 0.6	Moderate agreement
0.6 – 0.8	Substantial agreement
0.8 – 1.0	Almost perfect agreement

The first evaluation performed was to determine if raters identified a leadership event or not. If the two raters each identify a leadership behavior for the same timestamp, regardless of if the functions matched, then their codes agree. If one rater identifies a leadership behavior while the other does not, then their codes are not in agreement. Finally, if both raters identify common timestamps without leadership behaviors, then the codes are also considered to agree. The results of the event analysis are shown in Table 11.

Table 11 Event identification agreement.

A. Percent Agreement

		Rater 1		
		B	**C**	**A'**
Rater 2	**A**	0.68	0.56	0.71
	B		0.73	0.75
	C			0.46

B. Cohen's Kappa Statistic

		Rater 1		
		B	**C**	**A'**
Rater 2	**A**	0.34	0.13	0.28
	B		0.45	0.34
	C			0.10

The largest Kappa value shown in Table 11 is for the Rater C and Rater B's pair. The Kappa value of 0.45 demonstrates that the intra-rater agreement for the protocol has a fair to moderate level agreement. Additionally, the Kappa values for the other rater pairs reveal that, at minimum, there is slight level of agreement between the raters. These results indicate that there is agreement between raters when identifying leadership events.

The second level of granularity evaluated whether there is agreement in the type of leadership function identified. The types of leadership functions are transition, action, and interpersonal (summarized in Table 5). Each leadership function's type is shown in Table 6. If the two raters each identify the same type of leadership function for a common timestamp, then their codes agree. If one rater identifies a certain type while the other identify a different type (or did not identify one), then their codes are not in agreement. Finally, if both raters identified common timestamps without leadership behaviors, then the codes were also considered to agree. Table 12 presents the results for the leadership function type analysis.

Table 12 Leadership function type agreement.

A. Percent Agreement

		Rater 1		
		B	**C**	**A'**
Rater 2	**A**	0.56	0.51	0.69
	B		0.65	0.62
	C			0.40

B. Cohen's Kappa Statistic

		Rater 1		
		B	**C**	**A'**
Rater 2	**A**	0.27	0.09	0.35
	B		0.37	0.35
	C			0.09

The Kappa values presented in Table 12 demonstrate that the inter-rater agreement for the leadership function type is fair. The lowest Kappa value of 0.09 is still in a "slight agreement" range. The raters did have an overall slight decrease in agreement compared to the event analysis presented in Table 11. This is expected as it is more difficult to identify the type of leadership behavior compared to whether leadership occurred or not.

The third level of analysis was selected to determine the level of agreement between raters when identifying the specific leadership function. If the two raters each identify the same leadership function for a common timestamp, then their codes agree. If one rater identifies a leadership behavior while the other identifies a different leadership (or did not identify one), then their codes are not in agreement. Finally, if both raters identify common timestamps without leadership behaviors, then the codes are also considered to agree. The results for the leadership function agreement are available in Table 13.

Table 13 Leadership function agreement.

A. Percent Agreement

		Rater 1		
		B	**C**	**A'**
Rater 2	**A**	0.31	0.48	0.54
	B		0.41	0.45
	C			0.30

B. Cohen's Kappa Statistic

		Rater 1		
		B	**C**	**A'**
Rater 2	**A**	0.09	0.20	0.36
	B		0.24	0.29
	C			0.16

Table 13 reveals that the overall level of agreement when identifying the specific leadership function is lower than when identifying leadership types. The inter-rater values range from slight to fair agreement. This is expected because the number of leadership functions, seventeen, that the raters must distinguish between. Overall, the results suggest that the protocol can be further improved by clarifying the definitions of each leadership function.

The pilot study identified a clear limitation of the protocol. The inter-rater agreement analysis revealed that there is only fair to moderate agreement at best. Two key factors contributing to the fair rater agreement are the number of leadership functions that must be considered while coding, and the process of coding each leadership behavior to a specific time stamp. While antidotally, raters agree on the general substance of the video recorded in the protocol activity, the second by second rater agreement reveals only a fair amount of agreement. Overall, the results demonstrate a level of agreement that is fair to moderate. Methods of improving the rater agreement will be presented in 5.4, the future work section of this thesis.

3.3.3 Leadership Requires Influence

Table 14 presents the results of the leader follower analysis, the final level of granularity. Agreement is achieved when the raters correctly identify the leaders or followers of an activity. Note that this is the only level where a Kappa value is observed in the slight agreement range. These results are still acceptable as the remaining Kappa values demonstrate fair agreement.

Table 14 Leader and Follower Agreement

A. Percent Agreement

		Rater 1		
		B	**C**	**A'**
Rater 2	**A**	0.48	0.51	0.52
	B		0.37	0.55
	C			0.38

B. Cohen's Kappa Statistic

		Rater 1		
		B	**C**	**A'**
Rater 2	**A**	0.26	0.24	0.36
	B		0.10	0.39
	C			0.24

For someone's behavior to be coded as leadership, their actions must achieve influence over their teammates. Identifying the team members influenced can be difficult due to the range of potential follower behaviors. This is clear from the lower Kappa values present in Table 14.

3.3.4 Performing Team Tasks

One leadership function that was observed, but not coded for was Performing Team Tasks. This leadership function was omitted from the initial protocol to ensure it was not over used as the study was designed to test the applicability of all the leadership functions. To elaborate, an individual completing the entire function model with minimal teamwork would not be considered leadership due to the lack of follower behaviors. However, the

protocol study revealed that performing team tasks occurred and should be captured in a larger case study due to the increased time frame and possibility that leaders will perform tasks collaboratively (with input from followers during task completion) in the meetings.

3.3.5 Relating Leadership to Engineering Design

The protocol established for the pilot study focused on identifying leadership behaviors within a collaborative design scenario. Therefore, the protocol was modified to answer RQ.1and RQ.2.

Fields were added to code the design space (project, problem, or solution) and design activity (synthesis, analysis, decision making, transformation, and communication) [8,9,99,100]. Table 15 provides definitions for the design spaces used in the coding manual, and Table 16 provides definitions of the design activities. Coding these design fields allows relationships between leadership and design space to be observed. The design space and design activities fields make it possible to identify what leadership behaviors occur in different design spaces, and while the team is performing what type of design activity.

Table 15 Definitions of engineering design spaces, adapted from [8,9,100].

Design Space	Definition
Problem	Working on understanding the problem, the users, or the use cases.
Solution	Work revolving around the design of potential solutions (concept generation, prototyping, detailed design, etc.).
Project	Coordinating team activities. (Planning team meeting/work sessions, identifying team goals, assigning responsibilities to team members, etc.)

The design spaces were adapted from commonly accepted systematic design processes [8,9,100]. The problem, solution, and project spaces are higher level adaptations of the specific design processes. This decision was made because these designs spaces provide an opportunity to first identify higher level relationships between functional leadership behaviors and engineering design. Additional levels of granularity, such as using specific design process phases, could be implemented in future studies investigating more specific situations.

The design activities, presented in Table 16, were also established with the intent of identifying higher level relationships between functional leadership and engineering design. The design activities presented encompass the basic activities required to progress through the design process and produce a device or product [8,9,100]. Before relationships with specific design activities such as FMEA or concept brainstorming can be made, initial relationships between leadership and engineering design must be identified. The higher-level relationships identified can then provide direction and context for future research directed towards specific design activities.

Table 16 Definitions of engineering desgin activities, adpated from [99].

Design Activity	Definition
Synthesis	The creation of new material that is relevant to the problem, solution, or project.
Analysis	Studying, testing, or predicting the current design information that the team has available.
Decision Making	Review of the current design information and analyses to change the make a choice or decision influencing the project.
Communication	Any communication of design information or material internal or external to the design team.
Transformation	Process of taking design information in one representational state and transforming it into another.

It is important to note that the design space and design activity were coded after each leadership observations. Functional leadership behaviors were coded first, then the design space in which the leadership behavior occurred was coded. Finally, the design activity that was occurring while the leadership was observed was coded. Following this process, raters record observations of functional leadership behaviors, the design space the team was in, and the design activity the team was performing.

3.3.6 Pilot Study Conclusions

The leadership protocol was established through an extensive literature review and tested through a pilot, protocol study. The results of the protocol study demonstrated that the inter-rater and intra-rater agreement levels were not ideal, however, opportunities for future studies to improve the rater agreement will be introduced later in the thesis. The results also demonstrated that improvements were required to include a way to relate functional leadership behaviors to engineering design activities. Thus, the protocol was

modified to also code for the design space (problem, solution, or project) and design activity (synthesis, analysis, decision making, transformation, or communication) that occurred when the instance of functional leadership occurred. The modified protocol, presented in full in Appendix A, satisfies MQ.1 by establishing a method to observe functional leadership behaviors in design teams.

The modified functional leadership protocol was applied through a case study to engineering design teams to answer RQ.1 and RQ.2. The case study included recordings and observations from team meetings and design review meetings. This study is presented in detail in Chapter Four. The following case study will provide a descriptive basis that will allow further development of leadership interventions for use in academic and industry teams.

CHAPTER FOUR

CASE STUDY: LEADERSHIP BEHAVIORS IN DESIGN TEAMS

As previously introduced in the literature, a case study creates the opportunity to apply the leadership protocol to recorded observations of engineering design teams over the course of a project. Therefore, a case study methodology enables relationships between leadership and engineering design to be identified, thus providing a method to answer RQ.1 and RQ.2. This chapter will introduce how the case study was designed to observe three independent student design teams, demonstrate how the protocol was applied to recordings of design teams, and present the results of coding team meetings and design review meetings.

4.1 Case Study Design Using Capstone Senior Design Teams

The focus of this case study was three senior mechanical engineering Capstone design teams at Clemson University. The literature demonstrates that studying engineering senior design teams serve as a substitute for novice engineering teams [71,101]. Students at Clemson are required to take ME 4020, Capstone senior design, in the second semester of their senior year. Literature has shown how Clemson's Capstone design course is similar to senior design courses taught at other universities [72,74,102,103]. Mechanical engineering senior design teams at Clemson University are tasked with solving problems provided by local industry partners. The problems range from, designing equipment to be used in a manufacturing process, to generating prototypes for future product development [72,74,102,103]. The team size ranges from four to six members depending on course

enrollment and the number of projects available each semester. The typical project duration extends over the course of one fifteen-week semester. The students teams are advised by a mechanical engineering faculty member and a graduate student coach [104,105]. The teams also interact with the industry sponsor a minimum of three times during the project.

Each project supplied by an industry sponsor has three to four student teams assigned to solving the problem. Although the teams are tasked with solving the same problem, there is limited interaction across teams as they are tasked with independently providing a solution to the industry sponsor's problem.

The faculty adviser and graduate coach hold weekly design review meetings with each student team. In a predefined order, each team presents slides of their progress to the faculty adviser and graduate coach. The graduate coach and adviser then provide comments and feedback on topics ranging from technical details and decision making to professional communication standards to each team. The duration of a design review is typically thirty minutes for each team.

Typically, the student teams interact with the sponsor three times during the semester. The first interaction is at the beginning of the project. The sponsor will either visit Clemson's campus or invite the student teams, faculty adviser, and graduate coach to their facility. The purpose of the first meeting is to introduce the teams to the sponsor's representatives and the problem the teams are tasks with solving. During the introduction meeting, the teams work with the sponsor representatives to develop goals and milestones for the project. If the student team was invited to the sponsor facility, there is typically a tour and an introduction to the physical problem space. While on site, the students have

the opportunity to question additional associates to help establish design requirements. After the initial meeting, each team works on defining requirements, developing concepts, and selecting leading concepts capable of solving the sponsor's problem.

The second interaction with the project sponsor is for a midterm presentation of the project's progress. The midterm presentation occurs in the middle of the semester on week seven or eight. During the midterm meeting, the student teams present their design requirements, refined concepts, and concept analyses to the sponsor. The sponsor provides feedback in the form of eliminating or selecting design concepts, providing additional requirements, and answering each teams' questions. Each team has the second half of the semester (seven or eight weeks) to finalize their concept's function, fabricate a functioning prototype (with necessary assembly/operation documentation), and deliver a design report detailing how their device solves the sponsor's problem.

The final meeting with the sponsor representatives is at the end of the semester for the final presentation and delivery of the design artifacts. In this meeting, the students present and demonstrate how the final design solution solves the sponsor's problem. Each team delivers the final design report. Depending on the project's scope, each team delivers additional design artifacts ranging from final concepts with engineering drawings and a bill of materials, to functioning prototypes with supporting manufacturing documentation.

Capstone senior design provides an ideal medium to study engineering design teams. A case study can be performed on one industry project that has three to four teams working independently on solving the same problem. This establishes a case study with a

sample size of three or four (depending on the specific project). Therefore, a case study was established to study leadership behaviors in Capstone design teams.

The remaining sections of Chapter Four will present how the leadership protocol was used to identify each team's leadership behaviors in recorded design team meetings and design review meetings. Additionally, the behaviors will analyzed for their relationships to the engineering design space. Finally, comparisons of design teams tasked with the same project will demonstrate functional leadership's impact on project progression, thus answering research questions RQ.1 and RQ.2. Details concerning the specific Capstone project for this case study will be presented in section 4.1.1.

4.1.1 Fall 2017 Capstone Project

The Capstone project selected for this case study occurred in the Fall of 2017 in the Clemson University Department of Mechanical Engineering. Three teams, composed of four mechanical engineering seniors, were assigned to solve a problem for an industry sponsor located in Augusta, Georgia. The teams were tasked with designing a material handling unit capable of lifting, lowering, and translating up to 6,000-lbs of material from a laser cutting machine to a nearby unloading location. Additional requirements were supplied by the sponsor. Two of the requirements were that the collapsed height of the device must be no higher than six inches and the device must fit inside the dimensions of the laser cutting material machine that supplies the material to the handling device. The sponsor also supplied criteria such as the device should navigate a course to the unloading location while translating the material. Studying this Capstone project provided a sample size of three senior design teams.

4.1.1.1 Participants

The three design teams were composed of four senior mechanical engineering students. The students ranged from twenty-one to twenty-three years old. Out of the twelve total students, only two were female. All twelve of the students have lived in the United States for over fifteen years. Approximately eight of the twelve students had experience in industry through Co-Ops and internships. Two of the students had experience with fabrication of mechanical devices through work experience at fabrication shops.

The demographic information is provided to establish an understanding of the participants in the case study. The demographic information is not broken down by team members because leadership trait leadership theory is not the focus of the research. The purpose of this study is to identity relationships between functional leadership, what roles leaders are fulfilling, and the engineering design space. A further breakdown of demographic information is withheld to reduce the biasing the results based on traits and demographics of the participants.

4.1.1.2 Participation in the Case Study

Participation in the case study was completely voluntary. During the first meeting of the semester, a ten-minute presentation was given to the students, faculty adviser, and graduate coach outlining the commitments, benefits, and possible negative impacts of volunteering to participate in the study. The students were informed that the purpose of the study was to observe teamwork skills in engineering design teams. To reduce possible bias in the results, the students were not informed that the study focused on leadership behaviors. Introducing the true purpose of the study may have artificially prompted

students to perform leadership functions, and the purpose of the case study was to observe leadership in a natural design team setting.

The study required each team to meet once a week, for one hour, in a prototyping and light fabrication lab space in the mechanical engineering building. This meeting was required to collect weekly one-hour observation of team meetings. The students were informed that this weekly meeting would be recorded using two video cameras and one microphone. Additionally, the students, faculty adviser, and graduate coach were informed that the weekly design review meetings would be recorded.

In return for participating in the study, students were given access to the lab space for the entirety of their project. This provided students the opportunity to use the meeting space, materials, hand tools, and light fabrication equipment found in the lab space at any time (including weekends and night hours). Access to the lab space was not limited to the weekly recorded team meeting. The lab space and the resources it contained were not available to other senior design teams not involved in the study. The participants in the study were given access to the lab after the appropriate safety training was completed.

The students were informed that their identities would not be revealed by participating in the case study. No potential negative impacts were identified; however, the students were given the opportunity to ask questions and not participate in the study if they were uncomfortable. Finally, two copies of the IRB consent form found in Appendix C, were provided to the students, faculty adviser, and graduate coach. All of the students, the faculty adviser, and the graduate coach signed and returned one copy of the consent

form. The second copy remained with each participant for reference over the course of the study.

The industry sponsor’s representatives were informed of the case study. The sponsor had no objections and allowed the study to take place. The three sponsor representatives that visited Clemson for the midterm presentation were each provided two copies of the IRB consent form. Each representative signed and returned one copy and kept the second for reference.

After the study concluded, the students were informed that the specific focus of the study was on leadership behaviors within engineering design teams. The students were also informed that the videos would be coded for leadership behaviors, and that the purpose of coding the videos was to identify relationships between leadership behaviors and the engineering design space. Finally, the students were given the opportunity to ask questions regarding the study, however, no participants had further questions.

This study was conducted under Clemson IRB2016-343. The study was deemed exempt and the consent form provided to the participants is available in Appendix C.

4.1.2 Data Collection Methods

Design team meetings and design review meetings were the two primary sources of team observations for this study. Additionally, each team’s weekly progress reports and design review presentations were captured via email. The progress reports and presentations were collected to verify any questions that arose while coding design team meetings and design review meetings.

4.1.3 Weekly Design Team Meetings

Each team was required to schedule a recurring weekly meeting in the prototyping and light fabrication lab space located in the mechanical engineering building. This weekly meeting was recorded using two video cameras and one microphone. The cameras were placed near the ceiling in the corners of the room, away from where the people typically worked. This was done to minimize interference in team processes and to reduce the Hawthorne effect [106]. The two cameras focused on different spaces inside the lab. Camera one was set in the back corner and it focused on the meeting table, white board, and TV (used for presentations). Camera two was positioned on top of a shelf to capture when team members used the light prototyping equipment (ban saw, table saw, grinder, and belt sander). The microphone was placed on the meeting table to record any conversations that the video cameras could not. A diagram of the lab spaced used for team meeting is available in Figure 5.

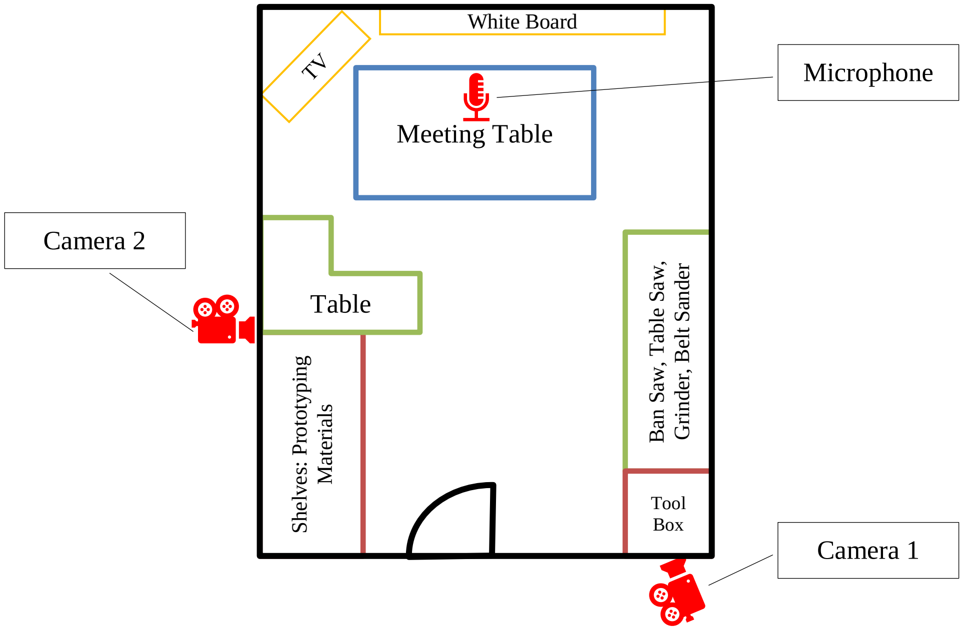


Figure 5 Diagram of the lab space used for team meetings.

While placing the cameras, the assumption was made that the teams will be spending most of their time either at the meeting table or working on the bench with the light fabrication tools. Figure 6 demonstrates a sample of the views from cameras one and two.

a. Camera One **b. Camera Two**

Figure 6 Example of team meeting views.

4.1.4 Weekly Design Reviews

The weekly design reviews occurred in a typical lecture hall setting. Two cameras and one microphone were used to record the design review meetings. Camera one was placed in the middle of the seating area and captured the students presenting their design update in the front of the lecture hall. The second camera was placed near the students and pointed back towards the seating area to capture the faculty adviser and graduate coach. The faculty adviser and graduate coach were not the focus of the study, however, the student interactions with the advisers needed to be captured and coded for potential leadership behaviors. Figure 7 is an example of a design review recording from cameras one and two.

a. Camera One **b. Camera Two**

Figure 7 Example of design review meeting views.

4.2 <u>Case Study Reality: Capstone Project Outcome</u>

During the course of the case study, three events occurred that interrupted data collection. The first interruption was caused by Hurricane Irma, which caused widespread power outages across the southeastern United States. Parts of Clemson did not have power and as a result the University was closed on Monday 9/11/2017 and Tuesday 9/12/2017.

The University closure caused Team A and Team B to cancel their team meetings for the first working week of the project. Attempts were made to reschedule for later in the week, however, the students had not yet visited the sponsor's facility and therefore the team decided not to meet.

The second interruption was caused by Clemson University's fall break. Classes were canceled for the two days of fall break, Monday 10/16/2017 and Tuesday 10/17/2018. Fall break caused Team A and Team B to cancel their regularly occurring meetings for week six of the project. Additional attempts were made to schedule a make-up meeting later in the week, however, the students travel and class schedules prevented rescheduling either meeting.

The midterm presentation occurred in the sixth week of the project, on Thursday, 10/19/2017. Three representatives of the sponsor company visited Clemson and conducted individual design review meetings with the student teams. After the final design review, the sponsor's representatives met with the faculty adviser and graduate coach and discussed the results of the first half of the project. The representatives were pleased with the design Team A presented for the overall lifting mechanism, but concerned that having the three teams work independently was a waste of resources and man power. The sponsor's representatives introduced the idea of combining the three teams into one team focused on not only delivering a refined concept, but fabricating a functioning prototype for the December 7th end of semester deadline. After minimal discussion, the faculty adviser and graduate coach agreed to the change in the project's scope and organization.

On the following Monday, 10/23/2017, a sponsor representative sent an email to the faculty adviser outlining the changes to the project scope that both parties agreed upon during the midterm meeting. The faculty adviser forwarded the email, along with additional comments, to all the students involved with the project. This initiated the official change in the project scope and organization of the student teams. The email sent to the students, and the forwarded message from the sponsor, is included in Appendix D (note all identification information has been removed or generalized to REPRESENTATIVE, FACULTY ADVISER, or GRADUATE COACH).

The change in project scope and organization negatively affected the ongoing case study. The teams did not operate independently past 10/23/2017, however, the recordings of the weekly team meetings and design review meetings continued. The teams worked together for the second half of the semester and did deliver a functioning prototype to the sponsor.

After the project was completed the decision was made to only apply the leadership protocol to the first six weeks of design team observations. The case study was designed to identify and compare leadership behaviors between three independent design teams. When the teams were redirected on 10/23/2017 this violated the purpose of the case study and therefore the leadership protocol was not applied to the team meeting recordings in the second half of the semester.

The organization of the design teams during the second half of the semester represented that of a multi-team system [107]. The team meetings and design review

meetings from the second half of the semester can be analyzed with a protocol geared towards leadership in multiteam systems. This will be revisited in section 5.4 Future Work.

The recorded team meetings and design review meetings for the first six weeks of the project totaled 22.5 hours. Table 17 provides a breakdown of the design team meetings that were recorded over the first six weeks of the project.

Table 17 Break down of team meeting observations captured.

Week	Date	Team A	Team B	Team C	
1	9/14/2017	**Hurricane**		60 min	
2	9/21/2017	60 min	60 min	60 min	
3	9/28/2017	60 min	60 min	30 min	
4	10/5/2017	60 min	60 min	60 min	
5	10/12/2017	60 min	60 min	60 min	
6	10/19/2017	**Fall Break**		60 min	
Totals		**240 min**	**240 min**	**330 min**	**810 min (13.5 hr)**

Table 18 provides a summary of the design review meetings that were recorded during the first six weeks of the project.

Table 18 Breakdown of design review meeting observations recorded.

Week	Date	Team A	Team B	Team C	
1	9/14/2017	30 min	30 min	30 min	
2	9/21/2017	30 min	30 min	30 min	
3	9/28/2017	30 min	30 min	30 min	
4	10/5/2017	30 min	30 min	30 min	
5	10/12/2017	30 min	30 min	30 min	
6	10/19/2017	30 min	30 min	30 min	
Totals		**180 min**	**180min**	**180 min**	**540 min (9 hr)**

The first six weeks of the project yielded a total of 1,350 minutes (22.5 hours) of design team recordings. These recordings were then coded using the leadership protocol to identify functional leadership behaviors and the engineering design spaces they occurred in.

4.2.1 Video Analysis Process

Two raters applied the leadership protocol to the recorded design team meetings and design review meetings. The complete protocol with the set of coding instructions is available in Appendix A. Rater A coded all the team meeting videos while Rater B recorded all the design review meetings. The raters coded the meeting types separately to eliminate any bias from the different meeting contexts. To elaborate, if Rater A observed an individual performing numerous leadership functions in the team meetings, then it is possible that while coding the design reviews, Rater A would over analyze the individual from the team meetings. Separating the meeting types allowed each rater to focus on coding only one meeting context, and thus reduced the rater bias in the coding results.

4.2.2 Example Coding

Each rater used the leadership coding spreadsheet (presented in the complete protocol in Appendix A) to record observations of functional leadership in design team meetings and design review meetings. The raters also captured, what design space the team was in and what design activity the team was performing when the leadership behavior was observed. An example of a completed coding spreadsheet for the team meeting of Team A, Week 2, is available in Table 19.

Table 19 Rater A’s code for Team A, Week 2, deisgn team meeting.

TIME RECORDING			LEADERSHIP	DESIGN ACTIVITY CODING		INDIVIDUAL BEHAVIOR CODING				ATTENDANCE			
START TIME	**END TIME**	**DURATION**	**LEADERSHIP FUNCTION**	**DESIGN SPACE**	**DESIGN ACTIVITY**	**PER. A**	**PER. B**	**PER. C**	**PER. D**	**PER. A**	**PER. B**	**PER. C**	**PER. D**
0:03:33	0:03:47	0:00:14	SP	SOLUTION	COM.	F		L			A		A
0:03:50	0:04:34	0:00:44	SM	PROJECT	COM.	L		F			A		A
0:04:38	0:05:00	0:00:22	EG	PROJECT	SYNTHESIS	F		L			A		A
0:13:25	0:13:50	0:00:25	SP	SOLUTION	COM.	F	L	F					A
0:14:25	0:15:37	0:01:12	PR	PROJECT	SYNTHESIS	L		F					A
0:16:17	0:16:25	0:00:08	SP	PROBLEM	COM.	F	F	L					A
0:16:25	0:16:31	0:00:06	SP	PROBLEM	COM.	F	L	F					A
0:16:31	0:18:19	0:01:48	TD	PROBLEM	COM.	F	L	F					A
0:25:48	0:26:00	0:00:12	SP	PROJECT	SYNTHESIS	L	F						
0:31:16	0:33:00	0:01:44	SM	PROBLEM	SYNTHESIS	L	F						
0:32:37	0:33:42	0:01:05	SM	PROBLEM	SYNTHESIS		L	F	F				
0:49:17	0:49:45	0:00:28	PT	SOLUTION	SYNTHESIS	L	F	F					
0:50:20	0:51:17	0:00:57	PT	PROBLEM	SYNTHESIS	F	L						
0:51:20	0:52:20	0:01:00	PT	SOLUTION	SYNTHESIS	F	L	F	F				
0:53:20	0:53:26	0:00:06	C	SOLUTION	SYNTHESIS	F	L						
0:00:45	0:01:30	0:00:45	MG	SOLUTION	SYNTHESIS	F	L						
0:04:19	0:06:22	0:02:03	PF	SOLUTION	DECISION MAKING	F	F		L				
0:06:54	0:07:31	0:00:37	PR	SOLUTION	COM.	F	F		L				
0:09:12	0:10:00	0:00:48	PR	SOLUTION	COM.	F			L				

The coding results shown in Table 19 are difficult to interpret due to the number of fields being coded for. Figure 8 provides an example of Rater A’s code for Team A’s Week 2 design team meeting. Note that Week 2 was the first team meeting recorded for Team A and Team C due to Hurricane Irma. Note that the leadership functions and design spaces displayed do not represent a hierarchy or order of importance. Figure 8 represents what leadership behaviors were recorded, and in which design space they occurred, over the course of the meeting.

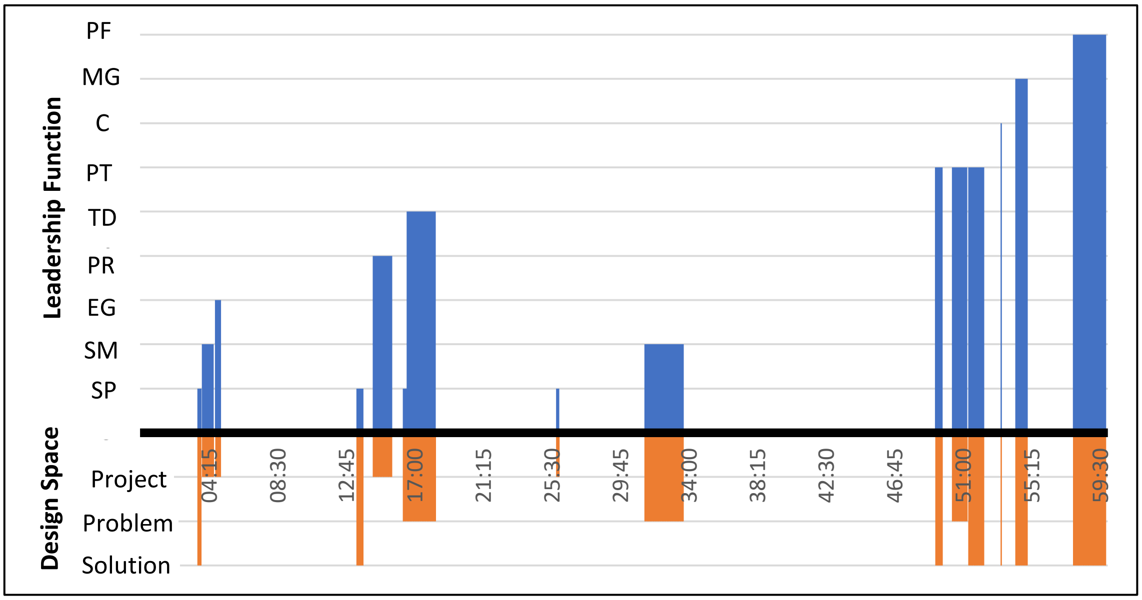


Figure 8 Graphic representation of coding leadership and engineering design space over the course of Team A's design team meeting in week two.

Figure 8 demonstrates that Team A performed nine different leadership functions during the team meeting. Additionally, leadership functions were observed in the problem, solution, and project design spaces. Each leadership observation duration varies. Finally, there are periods when no leadership functions were observed. This was discussed in the pilot study explanation, and is expected because as teams progress through different stages of a meeting, leadership is not always occurring [59,108].

Section 4.3 will present the results of the application of the leadership protocol on the design team meetings and design review meetings. The analysis performed focused on answering the primary research questions: RQ.1 What are the relationships between functional leadership behaviors and the engineering design space? and RQ.2 What insights into functional leadership behaviors and project progression does observing design team meetings with a leadership protocol reveal?

4.3 Protocol Analysis Results

The protocol analysis revealed 378 observations of functional leadership behaviors in the design team meetings over the course of the project. The cumulative duration of the 378 observations was 4 hours, 55 minutes, and 58 seconds. Recall, a total of 13.5 hours of design team meetings were recorded. Therefore, leadership was observed in approximately 36.5 % of the total recorded observations of design team meetings. The recordings of the design team meetings contained observations of students performing limited problem definition, concept development, and creating morphological charts for concept selection, among other team processes. The complete design team meeting coding performed by Rater A is in Appendix B.

The results of the protocol analysis of the design review meetings only cultivated one observation of functional leadership. The observation occurred in Week 5 of the project. Person D on Team A set up a meeting with a faculty member experienced with function structure modeling to solicit feedback on the team's current function model. The behavior was observed for 34 seconds.

The purpose of a design review is to communicate a design status update and solicit feedback from the faculty adviser and graduate student coach [108,109]. It was observed that while the faculty adviser and graduate coach provided technical feedback and advice to the student teams, they did not have discussions that prompted the students to perform functional leadership behaviors. The second half of the case study may contain different insights as the goal to deliver a functioning prototype was established with a short timeline.

Coding the second half of the design review meetings for functional leadership will be emphasized in the Future Work.

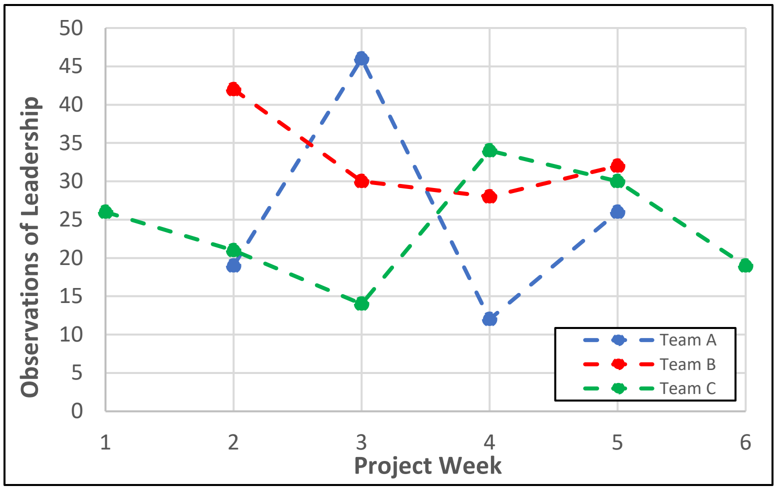
The remaining sections of Chapter Four will present the observations of functional leadership from the 13.5 hours of recorded design team meetings. The purpose of the analysis was to highlight relationships and impacts of functional leadership on the progression of a design project.

4.3.1 General Leadership Analysis

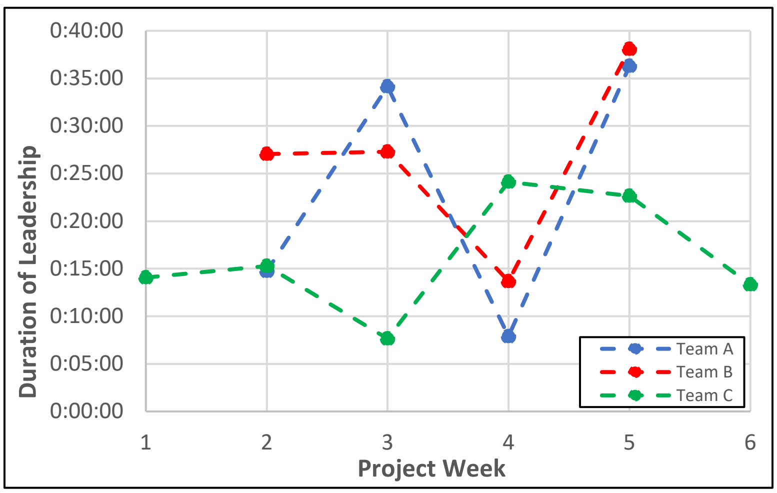
A general understanding of the leadership observations is introduced before relationships between functional leadership and the engineering design spaces are established. First, the functional leadership behaviors observed in each design team were plotted over the course of the project. Figure 9 (below) depicts the number of leadership behaviors each team was observed performing, and the duration of the observed leadership behaviors each week. Note, that Teams A and B did not meet on Week 1 or Week 6 (due to Hurricane Irma and fall break respectively). Figure 9 reveals that each team performed different amounts of leadership behaviors over the course of the project. Additionally, there are no major differences in the trends between the number of each team's leadership observations and the duration of leadership observed each week. This indicates that there are minimal instances of leadership behaviors with significantly longer durations that would misrepresent the number of leadership behaviors observed in the team meetings.

Additional analysis will be presented comparing the number of observations to the duration of the observations. This analysis was done to ensure that individual observations

of leadership behaviors did not over influence the relationships to the engineering design space.



a. Number of observations

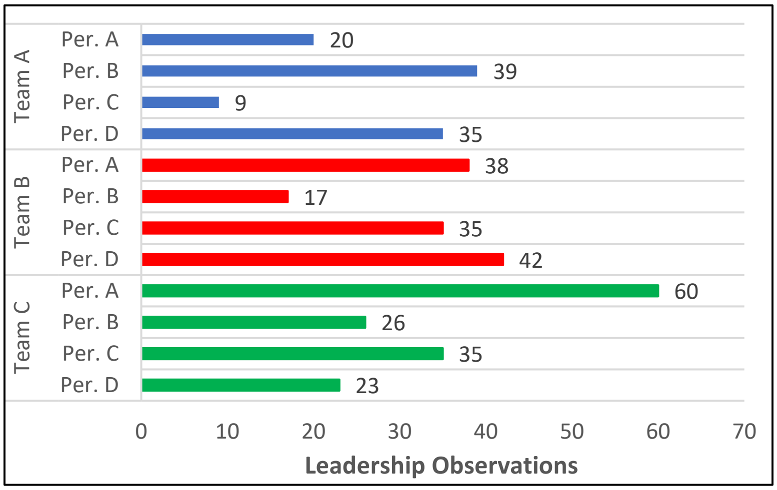


b.Duration of observations

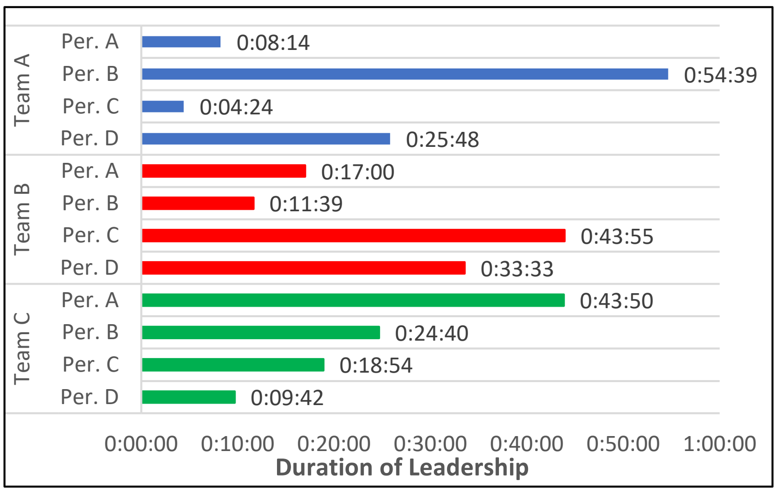
Figure 9 Leadership observations over the course of the project.

Note the lines connecting the observations in Figure 9 are dotted because they do not represent a linear relationship between the weeks of the meeting. The lines are present to highlight the changes in the observations of leadership behavior from week to week. This format will be used in subsequent figures.

Figure 10 demonstrates the leadership structure of each team. It is clear from Figure 10a that each team had a slightly different leadership structure. Team A appears to have two distinct leaders with Person B and Person D performing most of the leadership behaviors. The leadership structure in Team B demonstrates that Person A, C, and D were observed performing many of the leadership behaviors. Person A in team C was observed performing 60 leadership behaviors, almost twice as many as the next teammate Person C who was observed as a leader 35 times.



a. Number of observations



b. Duration of observations

Figure 10 Breakdown of total leadership observations by team.

Figure 10 b. provides additional insight regarding each team's leadership structure. Team C's leadership breakdown is like Figure 10a, with Person A observed as a leader almost 20 more minutes than the next teammate. Team B's structure is similar to the number of leadership functions observed, however, Person A who was observed performing the second largest number of leadership functions was only observed as a leader for 17 minutes. Finally, Team A's structure is also slightly different when compared to the

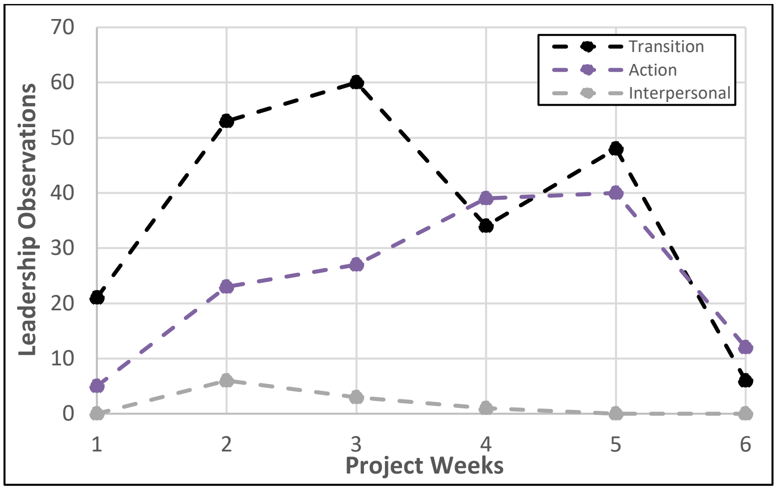
number of observations. While Person B only performed 4 more leadership functions than Person D, it is clear from Figure 10b that Person A was observed as a leader for nearly 28 more minutes than Person D.

The general leadership analysis was not performed to answer the research questions. However, it introduced the leadership observations over the course of the project and the leadership structure of each team.

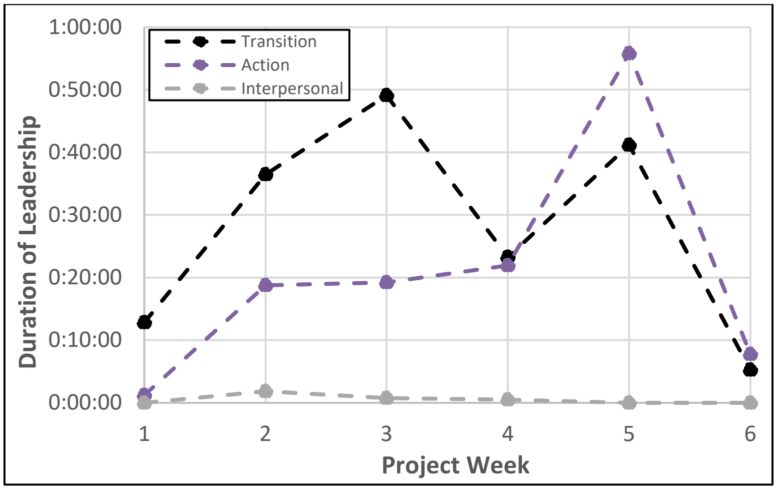
4.3.2 Leadership Function Type Analysis

Before investigating specific leadership functions, an analysis was performed on the leadership function types observed over the project's duration. This analysis was performed to provide insight into when teams were performing transition, action, and interpersonal leadership function. This analysis will be followed with a more detailed investigation into the specific leadership functions in section 4.3.3.

Figure 11 reveals that a limited number of interpersonal leadership behaviors were performed. This aligns with the literature, because engineering student are not required to attend formal leadership training, where they may have been introduced to interpersonal leadership [13,68]. Figure 11 does reveal that transition and action functions occurred during the project. This was expected because the students, while not formally introduced to leadership, have completed various team projects throughout their curriculum that require behaviors from the transition and action behavior types.



a. Number of observations



b. Duration of observations

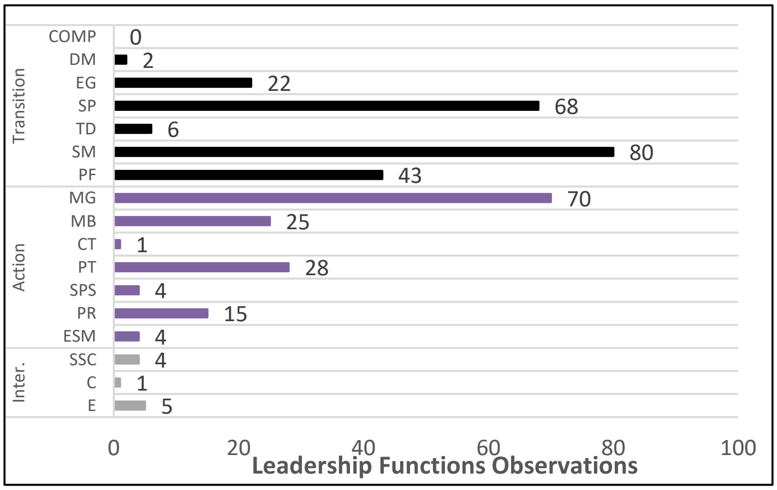
Figure 11 Leadership function types observed over the course of the project.

Figure 11 does reveal that teams were spending more time in the transition phase in the early weeks of the project. In the later weeks, teams spent more time in the action phase. This aligns with the project milestones. Early in the semester, teams should be setting goals, creating structure for the team's roles. Then, as the project progresses towards deadlines, team leaders should be performing tasks and guiding team progress. This trend is present in Figure 11.

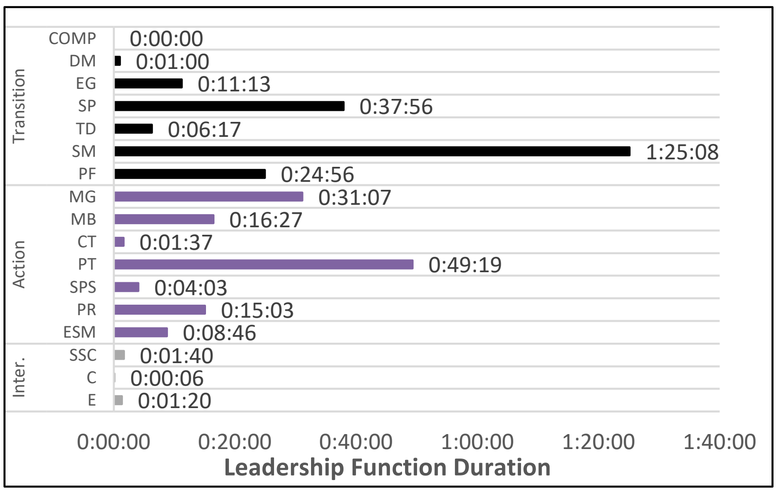
4.3.3 Leadership Function Analysis

This analysis was conducted to highlight the leadership functions that were observed the most and for the longest duration. Figure 12 reveals that Sensemaking was observed 80 times and for a total of 1 hour and 25 minutes. Performing Team Task was observed with the second highest duration of 49 minutes and 19 seconds, although it was only observed 28 times. This indicates that when leaders perform team tasks, the behavior lasts significant longer than other functional leadership behaviors.

Leadership functions such as Establish Goals, Structure and Plan, and Monitor and Guide Team tasks were observed more than Performing Team Tasks, however, with much shorter durations. An observation from Figure 12 is that the nature of performing team tasks in an engineering project requires significant time comparted to other functional leadership behaviors. Analysis performed on the engineering design activities, presented in section 4.3.5, will help explain what activity is occurring while performing team tasks.



a. Number of observations

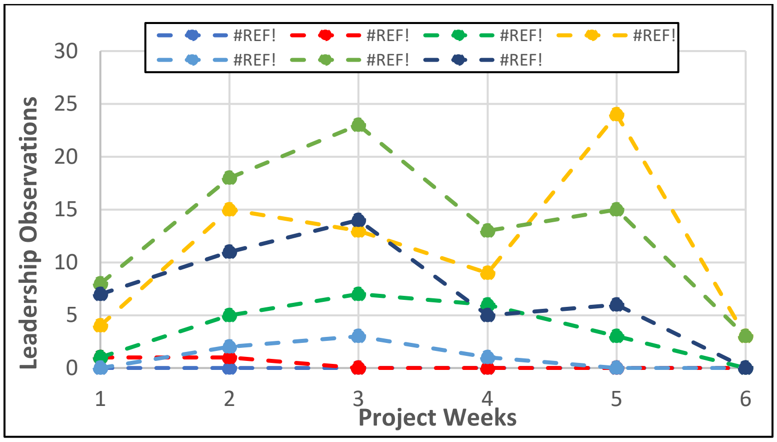


b. Duration of observations

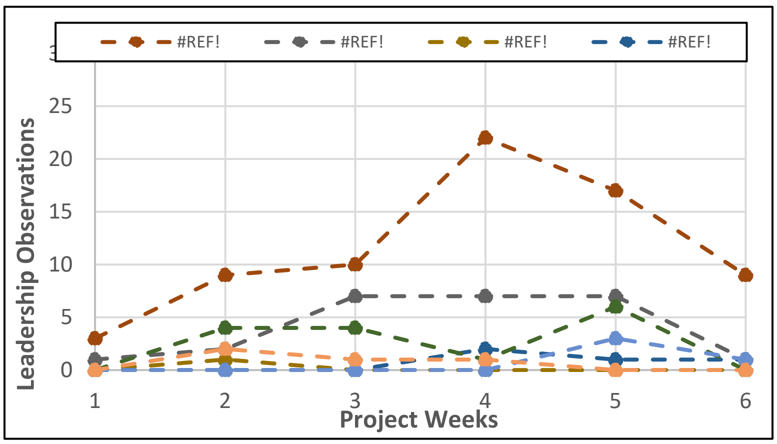
Figure 12 Breakdown of leadership fucntions, by type, observed over the course of the project.

Figure 13 presents the leadership functions, separated by function type, over the course of the design project. It is clear in Figure 13 that Sensemaking was the most observed transition function in each week except Week 5. Additionally, Monitor and Guide Team Tasks was the most observed action leadership function (second longest duration).

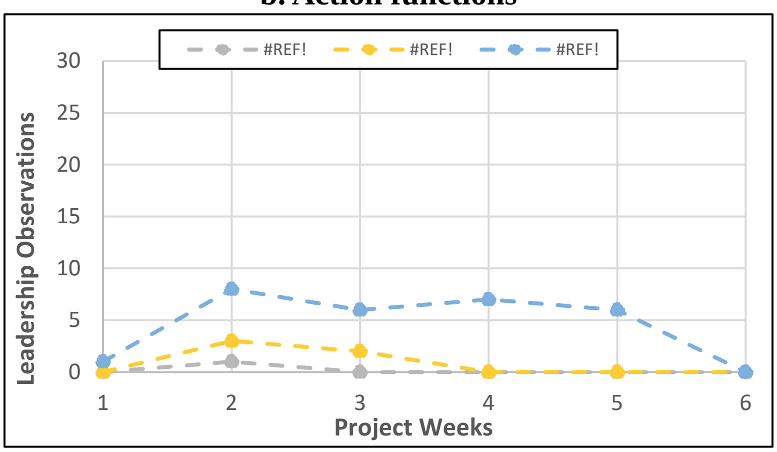
Figure 12 and Figure 13 reveal that the only leadership function not observed over the course of the entire project was Compose Team. The design teams were established prior to the beginning of the project and case study. The teams are composed by a faculty coordinator who is responsible for forming all the Capstone project teams each semester. It is also quite rare that a team member drops out of the class and must be replaced. Therefore, it was expected that the Compose Team leadership function would not be observed. This study does not dismiss the importance of the Compose Team function. However, this specific case study did not provide an opportunity to observe its relationship to engineering design, or its impact on project progression.



a. Transition functions



b. Action functions



c. Interpersonal functions

Figure 13 Breakdown of leadership functions, by type, over time.

4.3.4 Design Space Analysis

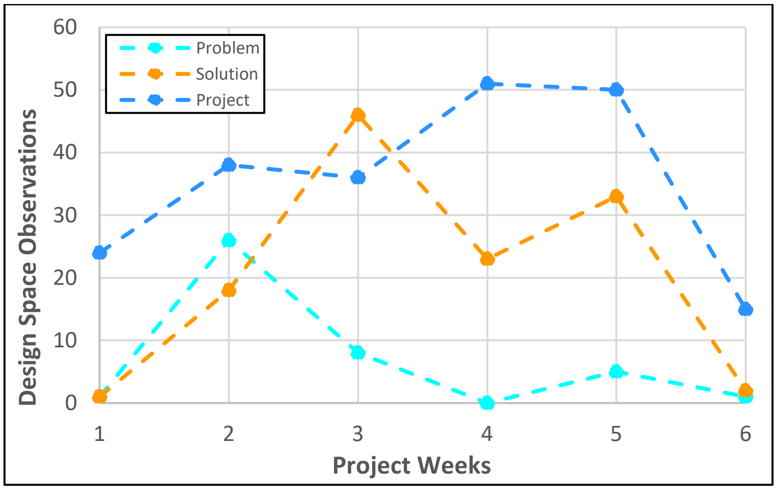
This section introduces the design space in which the leadership observations occurred. The analysis was conducted to understand how the design teams transitioned through the design spaces over the course of the six-week design study. It is important to emphasize that the design space was coded after the observation of functional leadership. A rater would first record an observation of functional leadership, then code the design space in which the leadership occurred.

Figure 14 presents the observations of the design spaces over the course of the project. Figure 14a demonstrates that the leadership observations occurred most frequently in the project space (five of the six team meetings). However, Figure 15 reveals that the teams were observed in the solution space for a similar duration as the project space. The teams spent a total of 2 hours and 9 minutes in the project space and 2 hours, 11 minutes, and 40 seconds in the solution space. This indicates that despite the higher number of project space observations, the team's leadership behaviors in the solution space occurred for longer periods of time. It is important to note that Figure 15 reveals Team A spent much more time in the solution space than Teams B and C. This significantly increased the amount of time that the three teams spent in the solution space.

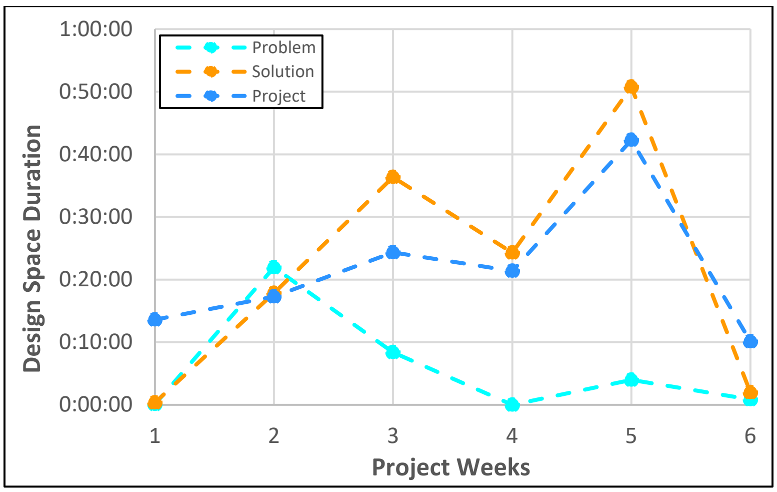
Figure 14 also reveals that the teams were observed in the problem space for the least number of times and the shortest duration. For purpose of this case study, the problem space involved any discussion that the student team members had regarding requirements (provided by the sponsor or defined by the teams), the manufacturing environment or use cases at the sponsor's facility, or other concerns regarding the problem the team was tasked

with solving. It is concerning that the fewest leadership observations occurred in the problem space because numerous systematic design processes demonstrate that the problem space, or problem definition, is a critically important part of engineering design [8,9,100]. Figure 14 demonstrates that the largest number (and duration) of leadership behaviors within the problem space occurred in Week 2. This is not unexpected as students had visited the facility for the introductory meeting in the weekend prior to Week 2. In Week 2, 26 leadership behaviors were observed in the problem space and they lasted for a total of 21 minutes and 57 seconds. After Week 2 leadership behaviors in the problem space were scarce.

The leadership behaviors observed in the solution space spike in Week 3 (Figure 14a.) and then again in Week 5 (Figure 14). This also converges with the timeline of the design project. Teams visited the facility between Weeks 1 and 2, and thus by Week 3, many of the teams were underway generating concepts to address the problem.



a. Number of observations



b. Duration of observations

Figure 14 Design space observations over the course of the project.

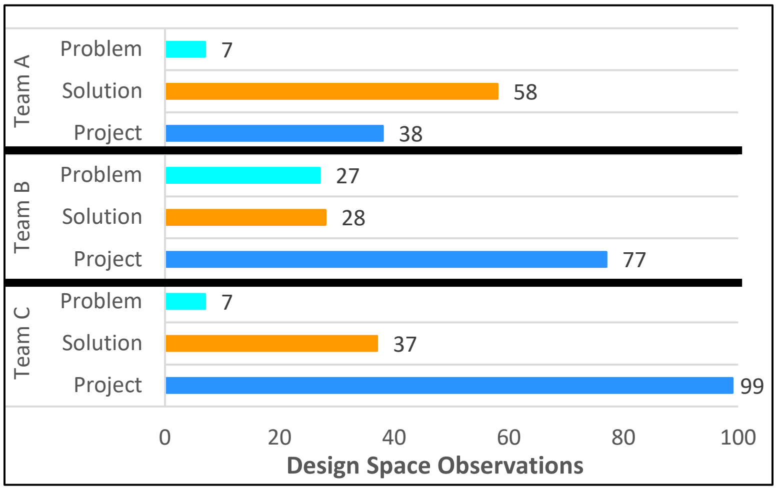
The complete code for the design team meetings, including comments for each specific behavior that was performed, is available in Appendix B. A few examples of the leadership behaviors that were observed in the solution space are available in Table 20.

Table 20 Specific observations of leadership observed in the solution space.

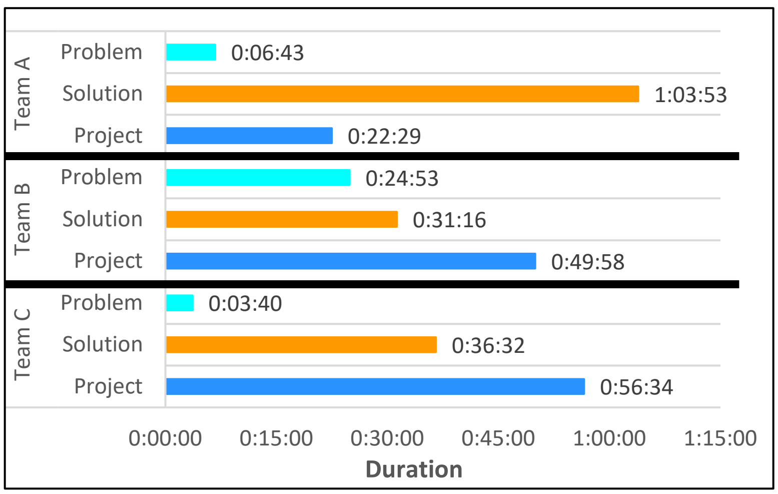
In Team A, while the team was developing a function structure, Person C interpreted feedback that was received in the design review meeting regarding how the advisers did not want to see the energy type in the function structure. (SM, week 3, 15:09)
In Team B, while the team attempted to evaluate concepts, Person D established a method for weighting the solution types based off the criteria weights established in the PDS. (EG, week 3, 43:23)
In Team B, while the team was discussing the function of their concept's safety system, Person C clarified how the team's proposed light curtain would have to be positioned to effectively detect intrusions into the safety zone. (SM, week 5, 13:47)

Table 20 provides three examples of leadership behaviors observed in the solution space. The first and last rows were Sensemaking behaviors that clarified confusion within the team and lead to an enhanced understanding of the solution's function structure (Team A) and the safety system (Team B). The second example in Table 20 demonstrates how Person D established work expectations for the team. The method Person D introduced to the team was implement for the final weighted analysis. Each of the examples demonstrates how the leadership behaviors influenced the team and ultimately the design outcome.

Figure 15 presents a breakdown of the total amount of time each team was observed in the problem, solution, and project design spaces for the entire project. It is clear that the majority of leadership behaviors for Teams B and C were observed in the project space. This was not a surprising result since the leadership functions are geared towards behaviors found in the project space (establishing goals, monitoring tasks, managing the team boundary, etc.).



a. Number of observations



b. Duration of observations

Figure 15 Total observations of design spaces for each team.

The largest number (and duration) of Team A's leadership behaviors were observed in the solution space. This result is contrary to Teams B and C. When the sponsor's representatives, faculty adviser, and graduate coach discussed the project's status after the teams' midterm presentations, it was observed that the sponsors praised Team A's concept while they questioned the analysis put forth by Teams B and C. As a result, Team A's concept was selected for the lift mechanism. Team A was tasked with completing the

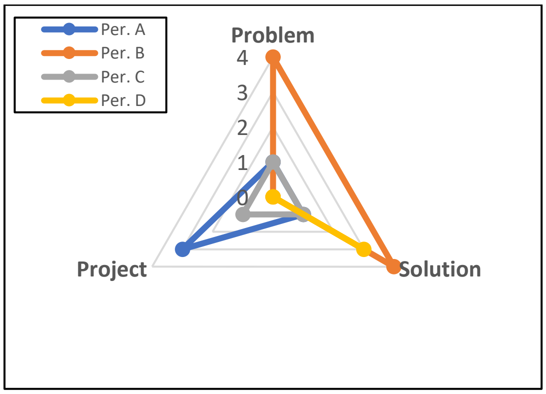
detailed design and fabrication of the lift (see email from sponsor in Appendix D). The other teams were tasked with developing a controls system, and integrating translational movement into the lift device. To ensure each team remained motivated on delivering a functioning prototype, it was not formally announced that Team A's solution was selected as the best (Appendix D).

The analysis was not conducted to identify relationships between leadership and performance. However, it is important to highlight that Team A had significantly more observations of leadership behavior in the solution space than Teams B and C whose concepts were not selected by the sponsor for implementation. This is a point of interest for future studies. Specifically, how does more leadership in the problem and solution spaces, or the technical areas of the design space, impact the design outcome? Future studies addressing this potential research question will be presented in section 5.4.

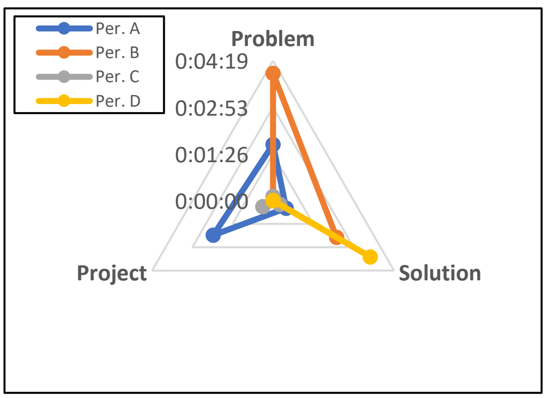
Further analysis was conducted to show the relationships between leadership functions and the technical design spaces (problem and project). The results of this analysis will be highlighted in section 4.3.6.

The next analysis was performed to determine if team members were observed performing leadership behaviors in each of the design spaces equally, or if team members were only performing leadership behaviors in specific design spaces. Figure 16 through Figure 18 depict the distribution of the design space leadership in each team. The figures selected for this analysis provide a clear representation of how individual team members were observed leading in different design spaces.

Team A's design space distribution is available in Figure 16. Person B focused primarily on the problem and solution space during Week 2. Person A however, was observed primarily in the project space. Person D was only observed leading in the solution space (3) and Person C was observed performing 1 leadership behavior in the problem, solution, and project spaces. Figure 16b demonstrates that the number of observations and the duration of leadership behaviors does not have much difference in distribution.



a. Week 2 number of observations

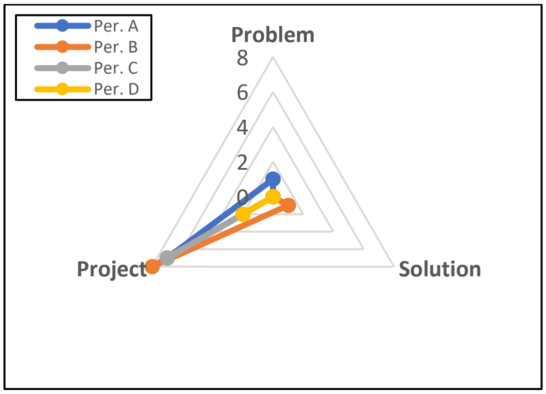


b. Week 2 duration of observations

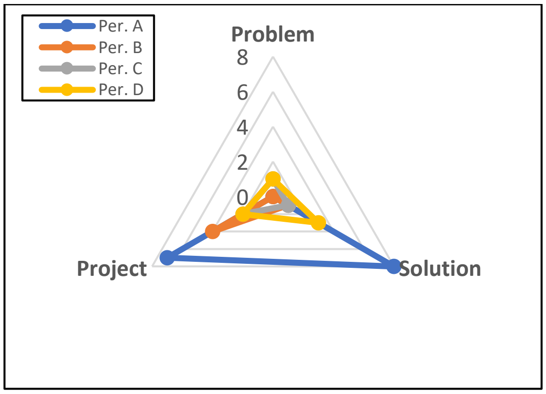
Figure 16 Team A, Week 2, leadership observations brokendown by member and design space.

Figure 17 demonstrates that Team C focused primarily in the project space during Week 1 of the project. While in Week 5, the team performed leadership functions observed in the project and solution spaces. This tracks with the project timeline as the team was

preparing concepts and coordinating for the midterm presentation in the following week. Note, there is a limited number of leadership observations in the problem space.



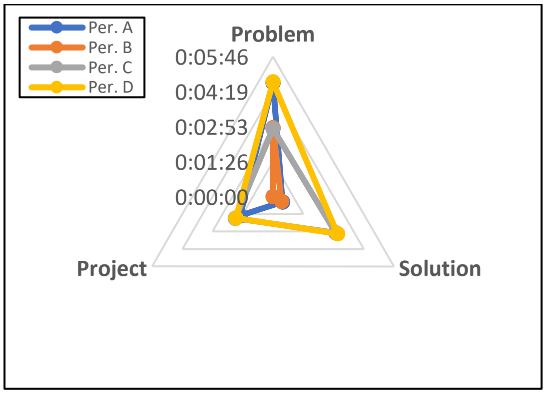
a. Week 1



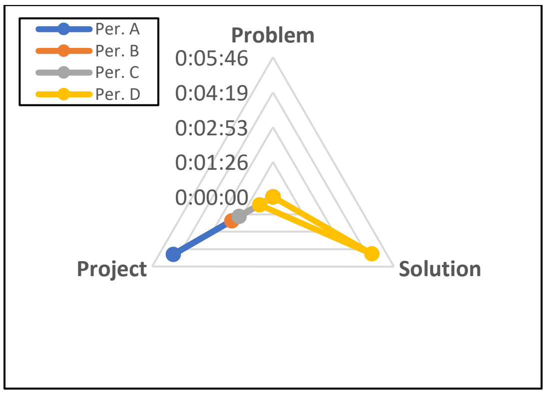
b. Week 5

Figure 17 Team C's leadership observations brokendown by member and design space.

Team B's leadership observations shifted drastically from Week 2 to Week 4. In Week 2, the team spent most of its time in the problem space. However, there were also significant observations in the solution and project spaces. In Week 4 this distribution shifted to only the project and solution spaces. Additionally, Person D was the only member of Team B that was observed performing leadership in the solution space. The other members of Team B were only observed leading in the project space.



a. Week 2



b. Week 4

Figure 18 Team B's leadership observations brokendown by member and design space.

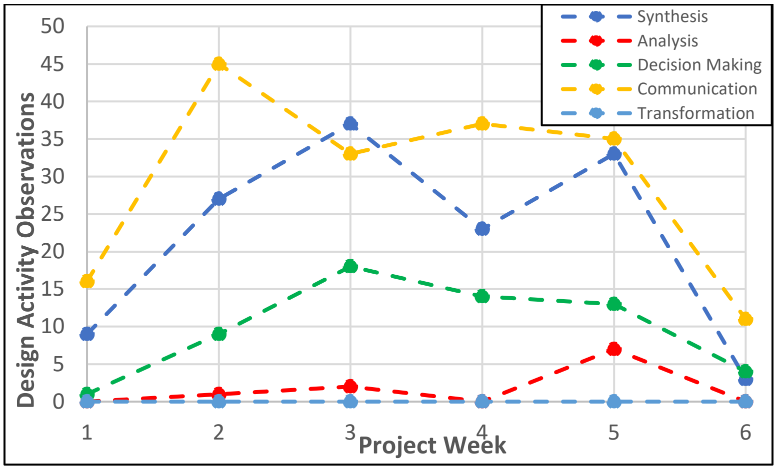
This analysis was not conducted to determine a correct distribution of leadership in the design spaces. Rather, it was done to establish that each of these teams had a different leadership distribution in the design spaces. It is important to note that there are limited observations in the problem space. The low number and duration of leadership observations found in the problem space will be the focus of future studies introduced in section 5.4 future work.

4.3.5 Design Activities Analysis

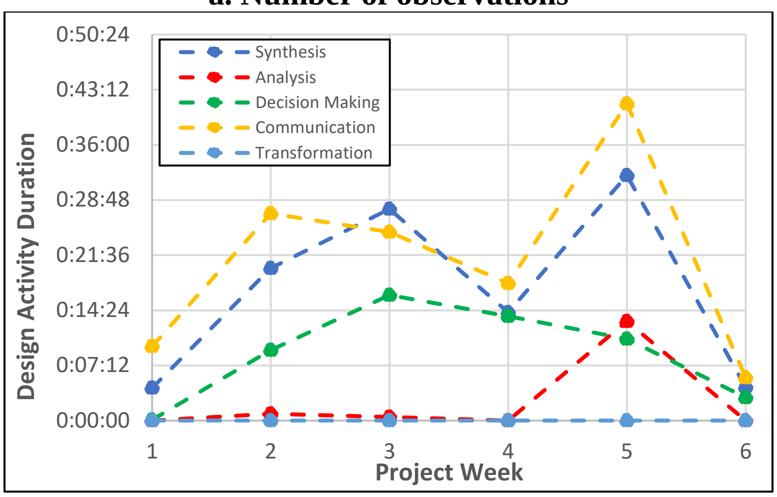
This section will introduce an analysis on the design activities that were being performed while the leadership observations were made. Figure 19 introduces the design

activities observed over the course of the semester. There is a clear hierarchy to the design activities performed. Communication is observed the most. While synthesis was observed the second most and decision making was observed the third most. Finally, analysis was only observed 3 times before Week 5. This observation is consistent with the project timeline. The teams were in the process of concept generation prior to Week 5 and did not begin analysis until the week before the midterm presentation. However, this does reveal that the teams are not spending time analyzing their project timelines and responsibilities. The teams were synthesizing new goals and plans, but there were no detailed team planning sessions observed.

Applying the leadership protocol to the second half of the Capstone project has already been established as future work. One additional factor to consider when analyzing the data from this case study is the frequency and duration of the analysis design activity. The teams in the second half of the semester finished the embodiment and detailed design, which typically contain more analysis steps than the concept generation phase [8,9,100]. Additionally, the teams only had eight weeks to finalize the design and deliver a working material handling unit. This condensed timeline would require detailed planning and analysis meetings that may be observed in the case study focused on the second half of the project.



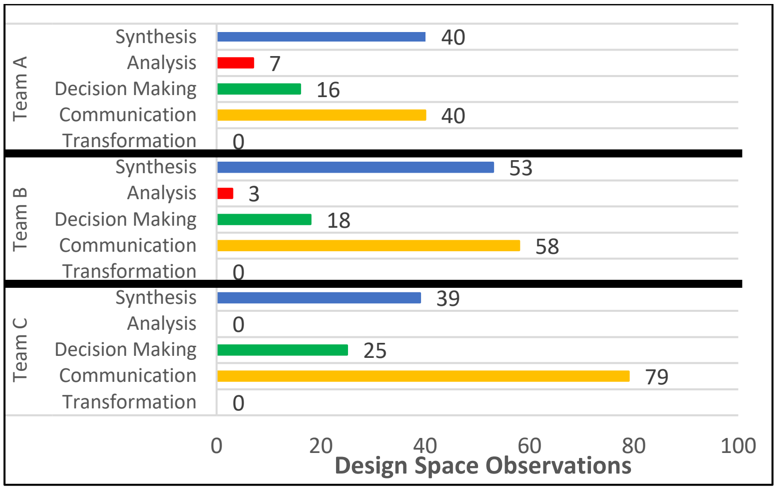
a. Number of observations



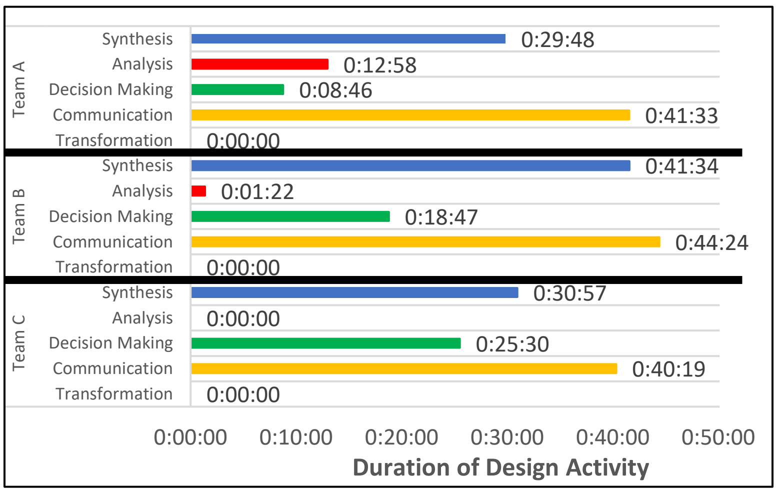
b. Duration of observations

Figure 19 Weekly design activity observations.

Figure 20 presents the breakdown of the design activities by each team evaluated for the length of the complete six-week case study. The hierarchy of the observed design activities that was presented in Figure 19 is visible for each team in Figure 20.



a. Number of observations



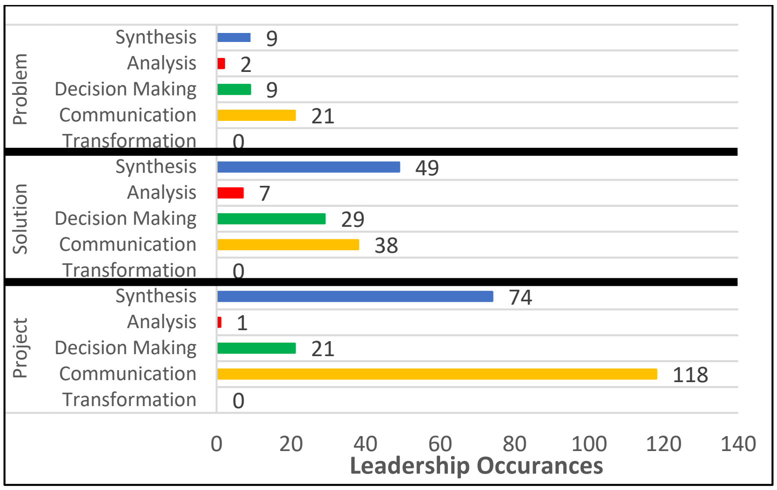
b.Duration of observations

Figure 20 Design activity observations broken down by team.

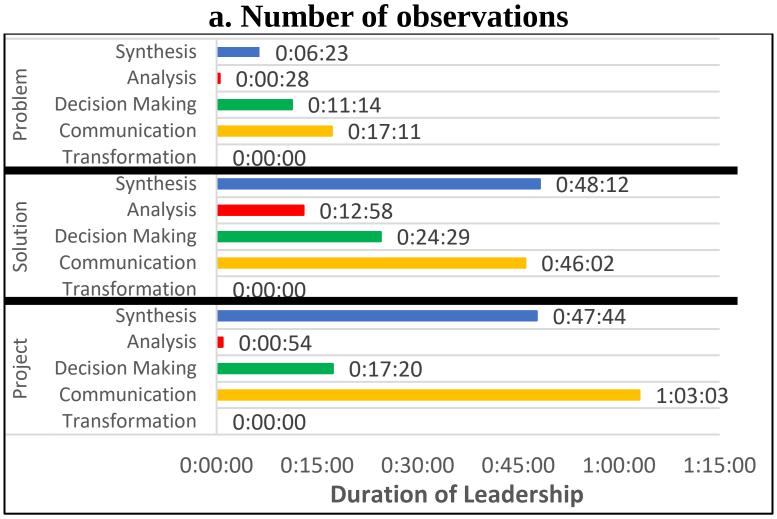
The design activity analysis reveals that functional leadership was observed most frequently as communication, followed by synthesis, then decision making, and finally analysis. Note there were no observations of the design activity transformation. This was unexpected, but it is not unusual. The transformation activity involves transforming a design artifact from one form to another. An example of transformation is creating a 3-D model from a sketch. This activity is typically done on the individual level and therefore leadership while performing a transformation activity is unlikely.

4.3.6 Design Space and Design Activities

Further analysis was performed to understand what design activities were being observed within each design space. Figure 21 demonstrates the breakdown of the of the design activities that occurred in each design space.



a. Number of observations



b. Duration of observations

Figure 21 Design activities in each design space.

The analysis presented in section 4.3.5 demonstrated that communication was the most observed design activity, followed by synthesis, then decision making, and finally analysis. This trend is also present within each design space. Only in the solution space

does synthesis occur for longer than communication, despite being observed less. However, the total difference in observation time between communication and synthesis in the solution space is 2 minutes and 10 seconds, thus the difference is not considered to be significant.

4.3.7 Relationships Between Leadership Functions and the Engineering Design Space

This analysis will identify the relationships between functional leadership behaviors and the engineering design spaces. This will be done in two parts. First, the leadership function types will be analyzed, followed by the individual leadership functions.

4.3.7.1 Leadership Function Type and the Engineering Design Space

Table 21 presents the leadership function type observations broken down by the design spaces in which they were observed in. Most of the observations occurred in the transition and action functional leadership types. The project and solution spaces contained the most observations of leadership behaviors.

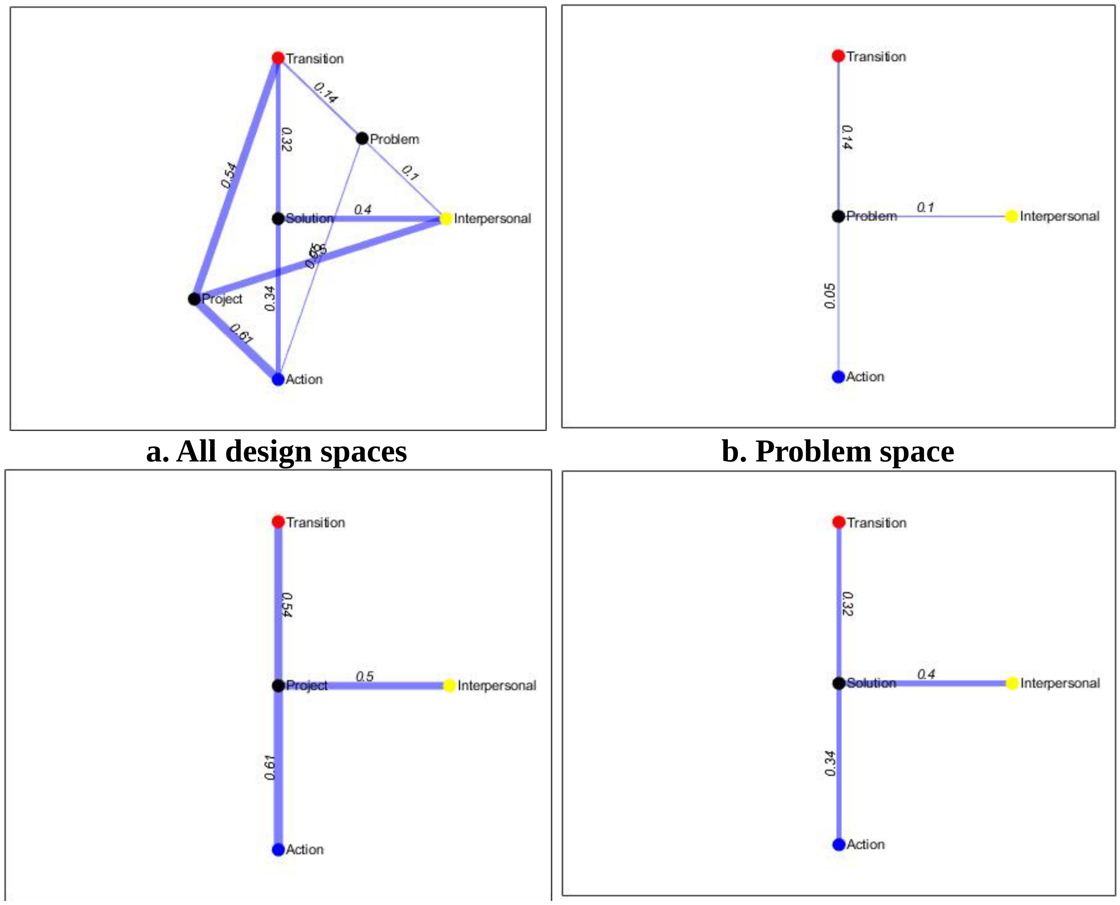
Table 21 Leadership function type – design space matrix.

	All Teams			Total
	Leadership Function Type			
Design Space	**Transition**	**Action**	**Interpersonal**	
Problem	32	8	1	**41**
Solution	70	49	4	**123**
Project	120	89	5	**214**
Total	**222**	**146**	**10**	**378**

Table 21 was used to establish relationships between the type of functional leadership behavior and the engineering design spaces. The functional leadership types were broken down by design space by calculating the proportion of functional leadership

types that were recorded in a specific design space. A simple example is provided for clarification: Calculate the proportion of the transition functions that were observed in the problem space. The number of transition functions observed in the problem space, 32, was divided by the total number of transition type observations, 222. The result demonstrates that 0.14 of the transition type functions observed, occurred in the problem space.

Figure 22 maps out the relationships between leadership function type and engineering design space. The lines connecting the leadership function types and the design spaces are weighted based on the proportion of the leadership function type that was observed in the specific design space. Figure 22a demonstrates the complete breakdown of leadership function type by all three design spaces. While parts b through c simplify the network to display the proportion of the leadership function types that occurred in the problem, solution, and project spaces.



a. All design spaces **b. Problem space**

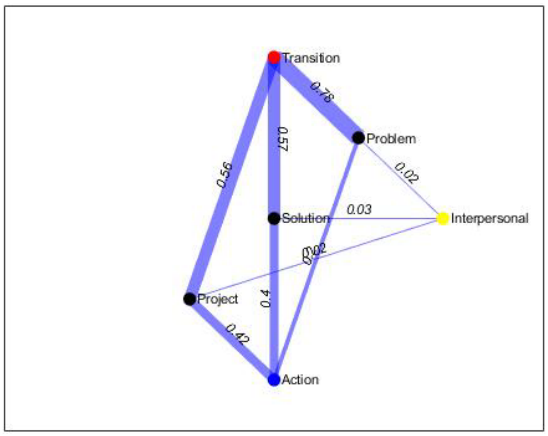
c. Project space **d. Solution space**

Figure 22 Leadership function types broken down by the proportion in each design space.

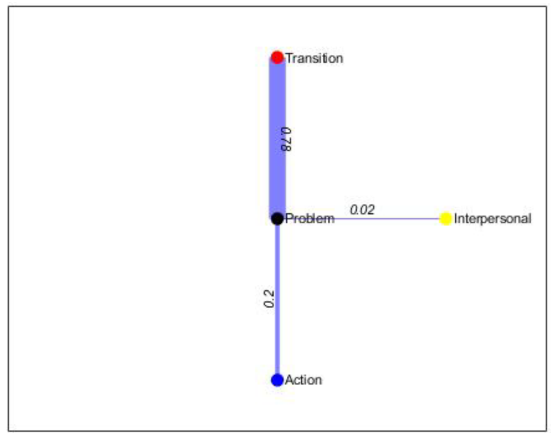
Figure 22 demonstrates that the largest proportion of each leadership function type is in the project space. Again, this is expected as the leadership functions primarily focus on project space objectives. Figure 22 further reveals that each function type's second largest relationship is in the solution space. The problem space accounted for the smallest proportion of each leadership function types.

Table 21 was also used to breakdown each design space by its composition of leadership function types. This was done by determining the proportion of the design space composed by each of the leadership function types. To determine the proportion of the

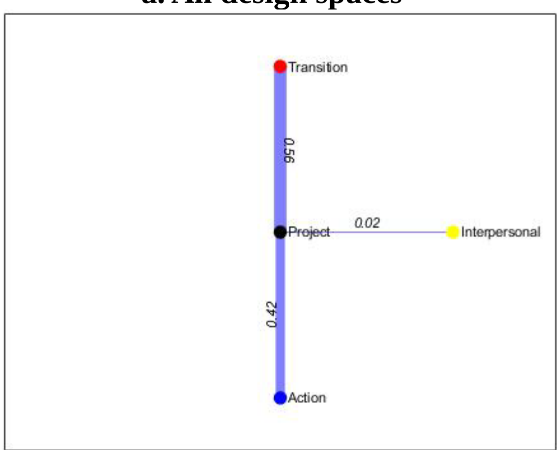
problem space composed of transition type functions, divide the number of transition functions observed in problem space, 32, by the total number of problem space observations, 41. The result is that 0.78 of the problem state is composed of the transition type functions. Figure 23 provides the results of the analysis for each design space.



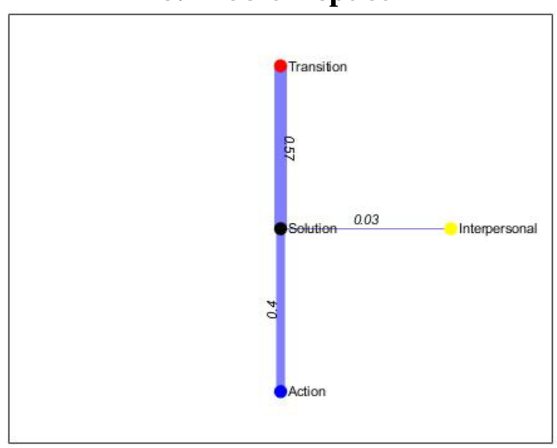
a. All design spaces



b. Problem space



c. Project space



d. Solution space

Figure 23 Composition of each design space by the proportion of each leadership function type.

Figure 23 reveals that the largest proposition of each design space is made up of transition type functions. Each design space's second largest proportion is action type behaviors. Note, the project and solution spaces share similar proportions of transition and action proportions, but the problem space demonstrates a smaller proportion of action

leadership function types. This is partly due to the low number of observations in the problem space. However, it highlights that teams, when in the problem space, are performing transition behaviors and not action behaviors. This result was expected because when teams are in the problem space, they generate requirements and define the problem. Thus, teams set the goals for the design team in the problem space.

4.3.7.2 Leadership Functions and the Engineering Design Space

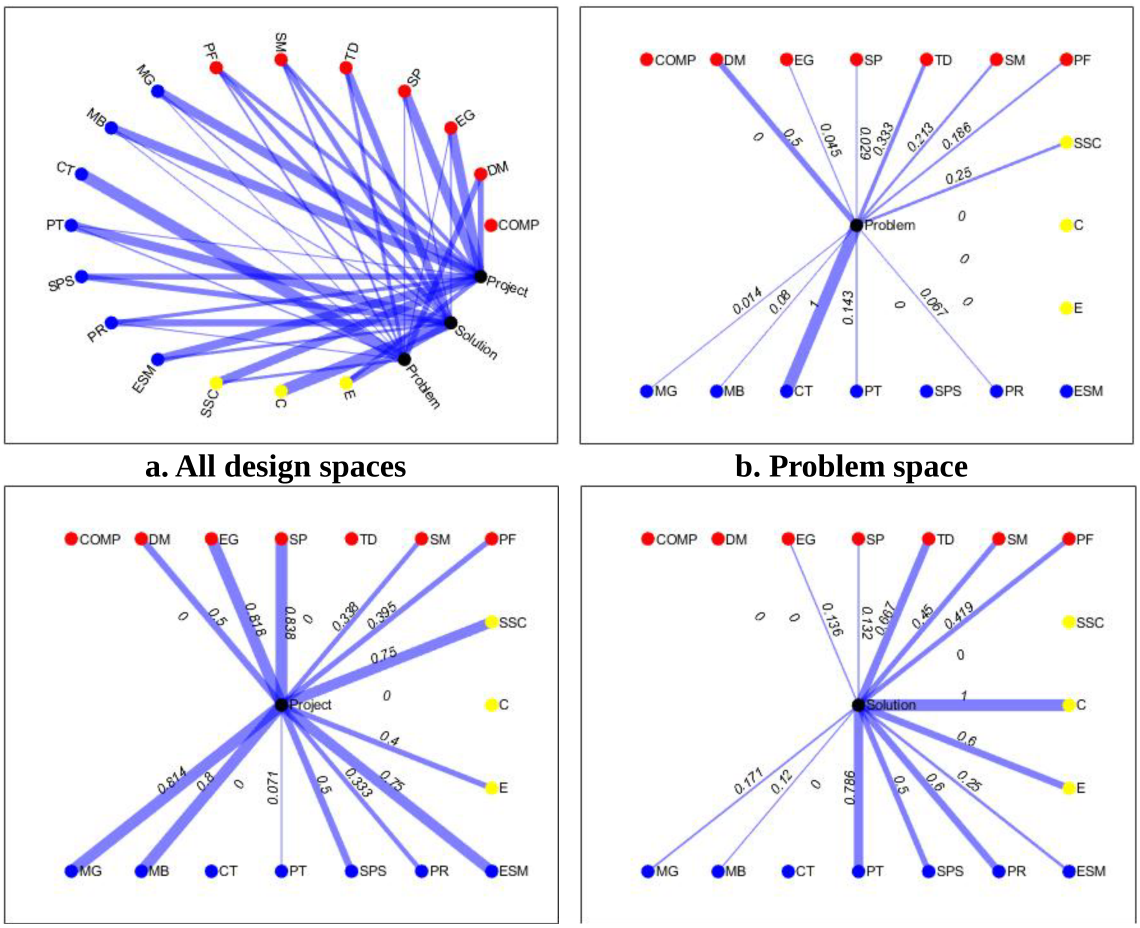
The analysis performed to identify relationships between leadership function types and the engineering design spaces was also performed to identify relationships between specific leadership functions and the engineering design spaces. Table 22 presents the specific leadership observations by design space. This table was used to visually highlight the relationships between functional leadership and engineering design.

Table 22 Leadership functions – design space matrix.

	All Teams																	Total
	Leadership Functions																	
Design Space	**COMP**	**DM**	**EG**	**SP**	**TD**	**SM**	**PF**	**MG**	**MB**	**CT**	**PT**	**SPS**	**PR**	**ESM**	**SSC**	**C**	**E**	
Problem	0	1	1	2	2	17	8	1	2	1	4	0	1	0	1	0	0	**41**
Solution	0	0	3	9	4	36	18	12	3	0	22	2	9	1	0	1	3	**123**
Project	0	1	18	57	0	27	17	57	20	0	2	2	5	3	3	0	2	**214**
Total	**0**	**2**	**22**	**68**	**6**	**80**	**43**	**70**	**25**	**1**	**28**	**4**	**15**	**4**	**4**	**1**	**5**	**378**

The analysis was performed in the same order as section 4.3.7.1. First, the leadership functions were broken down by the design spaces. This was done by dividing the number of observations for a specific leadership function in a specific design space (for example Sensemaking in the problem space – 17) by the total number of the specific

leadership function (Sensemaking total – 80). This resulted in the proportion of the specific leadership function that was observed in the design space (0.21 of Sensemaking was in the problem space). The results of the network analysis are presented in Figure 24.



a. All design spaces **b. Problem space**

c. Project space **d. Solution space**

Figure 24 Leadership functions broken down by the proportion in each design space.

This analysis demonstrates that most of the leadership functions had the highest proportions of observations occur in the project space (Figure 23c). However, define mission and challenge team have the highest proportions of their observations occur in the

problem space. This is due to low amount of observations for define mission and challenge team.

The solution space network (Figure 24d) demonstrates that the transition type behaviors, Sensemaking, Provide Feedback, and Training and Development have the highest proportion of their behaviors occur in the solution space. This indicates that leaders were observed clarifying and communicating the effect of an event to the team, providing feedback to teammates, and training (or teaching) their teammates new skills most frequently in the solution space. The feedback observed in the solution space was technical feedback given to teammates regarding work on the project. This is included in the definition for Providing Feedback in the coding manual available in Appendix A. A note should be made regarding Training and Developing. This function was only observed a total of 6 times and therefore the low number of observations inflates this relationship.

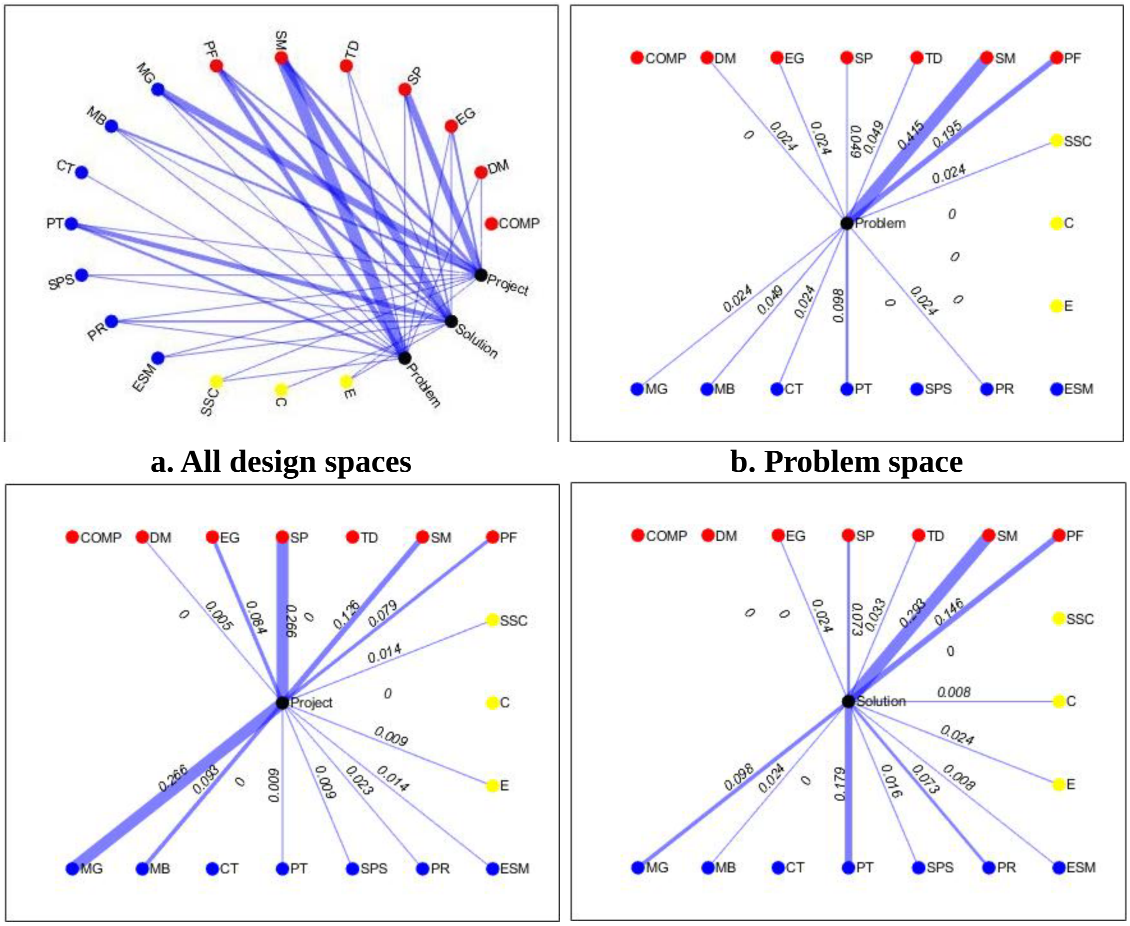
Additionally, the analysis revealed strong relationships between Performing Tasks, Solve Problems, and Provide Resources and the solution space. Performing Team Tasks was observed in the solution space 22 of its total 28 observations. Providing resources occurred in the solution space 9 of its 15 total observations. Solving problems only was observed 4 times and therefore the low number of total observations inflates this relationship.

The interpersonal functions Consideration and Empowerment also had strong relationships to the solution phase (1.00 and 0.600 respectively). These observations included teammates supporting each other’s design concepts and acknowledging good

ideas to implement. However, the relationships are inflated due to the overall low number of observations for each.

This analysis revealed that the transition functions with strong relationships to the solution space (with supporting high numbers of observations) were Sensemaking (0.450) and Providing Feedback (0.419). Further, the action functions that demonstrate strong relationships with the solution space are Performing Tasks (0.786), and Providing Resources (0.600).

The next analysis decomposed the design space by its leadership function composition. The analysis was conducted by dividing the number of observations for a specific leadership in a specific design space (for example Sensemaking in the problem space – 17) by the total number of the specific design space observations (problem space total – 41). This resulted in the proportion of the design space composed of a specific leadership function (0.415 of the problem space was Sensemaking). The results of the network analysis are presented in Figure 25.



a. All design spaces **b. Problem space**

c. Project space **d. Solution space**

Figure 25 Composition of each design space by the proportions of leadership functions.

Despite the low overall observations observed in the problem space, Figure 25b shows that the problem space is composed of largely of Sensemaking (0.415) and Provide Feedback (0.195). This result aligns with the purpose of the problem space, generating requirements and making sense of the problem, to identify what functions and features are important to the solution.

Next, the solution space analysis in Figure 25c reveals that Sensemaking (0.293), Providing Feedback, (0.146), and Performing Team Tasks (0.179) make up the largest

proportions of the solution space. Figure 24 showed that large proportions of these leadership functions occurred in the solution space. The large proportions of Sensemaking, Providing Feedback, and Performing Team Tasks observed in the solution space highlight a relationship between leadership functions and the engineering solution and problem spaces.

The largest proportions of the project space were Monitor and Guide Team Tasks (0.266), Structure and Plan (0.266), and Sensemaking (0.126). This result was expected as teams are required to set goals and monitor their progress to achieve success. Since these functions were observed in the project space, it demonstrates that the protocol is accurately capturing these leadership functions as they typically center on project leadership.

The most import result shown thus far is the solution space being largely composed of Sensemaking, Providing Feedback, and Performing Team Tasks. This result is stressed because the solution space deals with the design being generated to satisfy the project requirements. Thus leadership, observed in the solution space presents as technical leadership regarding the solution content. This analysis revealed that the strongest relationship between functional leadership and the engineering design spaces is observed though Sensemaking, Providing Feedback, and Performing Team Tasks. This results answers research question RQ.1.

4.3.8 Design Activities and Leadership Functions

The goal of the final analysis performed was to identify relationships between functional leadership behaviors and the engineering design activities. Table 23 presents a

breakdown of the leadership functions observed and the design activities that were occurring while the observation was made.

Table 23 Leadership function – design activity matrix.

	All Teams																	Total
	Leadership Functions																	
	Transition							Action							Interp.			
Design Activities	**COMP**	**DM**	**EG**	**SP**	**TD**	**SM**	**PF**	**MG**	**MB**	**CT**	**PT**	**SPS**	**PR**	**ESM**	**SSC**	**C**	**E**	
Synthesis	0	1	18	**43**	1	13	13	10	2	0	**21**	3	2	3	0	1	1	**132**
Analysis	0	0	0	2	0	1	1	1	1	0	3	0	1	0	0	0	0	**10**
Decision Making	0	1	3	9	0	**21**	13	6	0	1	1	1	1	1	0	0	1	**59**
Communication	0	0	1	14	5	**45**	16	**53**	**22**	0	3	0	11	0	4	0	3	**177**
Transformation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Total	**0**	**2**	**22**	**68**	**6**	**80**	**43**	**70**	**25**	**1**	**28**	**4**	**15**	**4**	**4**	**1**	**5**	**378**

Table 23 shows that most transition functions were observed while a synthesis or communication activity was occurring. Upon further review of the comments for each coded behavior (available in Appendix B) and a review of Table 23, synthesis typically focused on planning team tasks and work (Structure and Planning). Communication activities corresponded with Sensemaking activities. This was expected as Sensemaking involves interpreting events and communicating the event's impact on the design team. The analysis performed in section 4.3.7.2 highlighted the strong relationship between Sensemaking and the solution space. Thus, many of the Sensemaking observations that were recorded with a communication activity dealt with the solution and were technical in nature. This table further demonstrates the impact of the Sensemaking leadership function on project progression.

Further review of Table 23 reveals that most action leadership functions were observed while communication and synthesis design activities occurred. This was also

expected as communication and synthesis were the most observed design activities. Within the action functions, Monitor and Guide Team Tasks (53) and Manage Team Boundary (22) were observed most frequently as a communication activity. Additionally, Performing Team Tasks was observed as a synthesis activity 21 times.

The results in Table 23 were expected since Monitor and Guiding Team Tasks and Manage Team Boundaries are primarily communication behaviors performed by leaders. Performing Team Tasks means a leader is performing a task that directly stems from a team goal. Performing design team activities typically results in the synthesis of new design artifacts, such as new concepts, for the team.

4.3.9 Summary of Results

This section explored each team's leadership behaviors, not to select a team that performed the best functional leadership behaviors, but to present how functional leadership occurs in design teams. The network in Figure 25 presents relationships between the leadership functions Sensemaking and Provide Feedback and the solution design space. The impact of the functional leadership behaviors on each Capstone design team's project has been discussed throughout the results section. The results also established relationships between functional leadership behaviors and engineering design activities.

CHAPTER FIVE

CONCLUSIONS

5.1 Conclusions

The purpose of this work was to identify relationships between functional leadership behaviors and engineering design spaces. Chapter Three presented the initial leadership protocol and a pilot study that highlighted the need to observe the engineering design spaces and design activities that occurred while a leadership behavior was observed. The protocol was modified to reflect the pilot study findings and the final protocol is available in Appendix A. The rater agreement of the protocol was tested by calculating the Cohen's Kappa metric for each rater pair. The results demonstrate a fair amount of agreement. This is not ideal, but the results were deemed acceptable due to the high number of fields, and options for each field, being coded for. Methods of improving the protocol are presented in section 5.4, a discussion on future work.

Chapter Four presented a case study of three Capstone senior design teams. The results of the case study reveal relationships between individual leadership functions and the technical design spaces. Additionally, the leadership observations were decomposed by function, design space, and design activity to display the distribution of functional leadership throughout the progression of the project.

The case study results demonstrate that the protocol revealed observations of leadership functions occurring in the problem and solution design spaces. These leadership observations were deemed to be technical leadership since the context of the solution and design spaces focused on the engineering problem being solved and the solution being

developed. The problem space had significantly fewer observations of functional leadership, highlighting the fact that student teams do not spend much time in the problem definition phase.

An analysis of the composition of the problem space by leadership functions was performed to identify relationships between leadership behaviors and the problem space. The results revealed that the problem space was composed primarily of sensemaking (0.415) and providing feedback (0.195). Further, analysis of the solution space showed that sensemaking (0.293), providing feedback (0.146), and performing team tasks (0.179) composed the largest proportions of the solution space. This network analysis concluded that sensemaking and providing feedback have the strongest relationships to the technical design spaces.

Additional results presented the emergence of leadership behaviors through the project's progression. Analyses showed that each team's leadership functions were observed in different parts of the design space over the course of the project. Team A's leadership observations occurred most frequently in the solution space. While Team B's and Team C's observations occurred most frequently in the project space. It is important to note that Team A's solution was selected for development in the second half of the project. Future studies are proposed in section 5.4 to investigate the impact of functional leadership on design outcomes. Further results revealed that each team was observed performing leadership behaviors in communication design activates the most, followed by synthesis, then decision making, and finally analysis.

5.2 Answering the Research Questions

This section will present specific answers to the two research questions established in section 2.5. Recall a methodological question was presented that required a protocol capable of observing functional leadership behaviors in team meetings to be created. The methodological question had to be addressed before answering the two primary research questions.

MQ.1 Can a protocol be established to observe functional leadership behaviors in student teams during a 4-6-month design project?

Yes, a protocol was established to identify functional leadership behaviors and the engineering design spaces in design team meetings. The protocol content was tested and improved to capture the engineering design spaces and activities based a pilot study presented in Chapter Three. The rater agreement was determined to be fair through a Cohen's Kappa analysis, and future work will be introduced to improve agreement between raters.

RQ.1 What are the relationships between functional leadership behaviors and the engineering design space?

Chapter Four presented a case study which identified that the leadership behaviors, sensemaking and providing feedback, had the strongest relationship to the technical engineering design spaces. Additional relationships were observed, however, the problem space and solution space each demonstrated high proportions of sensemaking and providing feedback.

RQ.2 What insights into functional leadership behaviors and project progression does observing design team meetings with a leadership protocol reveal?

Additional analyses revealed that each team transitioned through the design space differently. Further, only Team A's leadership observations occurred most frequently in the solution space. Note that Team A's solution was also selected for development. Future studies will be introduced in section 5.4 to investigate the impact of technical leadership on a project's design outcome.

5.3 Limitations of Case Study

This section summarizes the limitations of the studies presented in this thesis. The first limitation of the study is that only three design teams were recorded. Unfortunately, this is the nature of case study research involving teams [76,80]. The case study methodology provided an opportunity to observe leadership behaviors in a natural setting. However, did not provide a sample size large enough to test the statistical significance of the observations.

Another limitation is that only one hour of each team's weekly meetings were recorded. The teams met more than once per week, and unfortunately due to logistical reasons, this data was not captured. It is impossible to know how the leadership functions emerged outside of the recorded design team meetings. met more than once a week Leadership occurred outside the recordings.

Additionally, the act of recording participants influences their behavior [106]. The cameras were placed near the ceiling and away from frequented work space to ensure the work environment appeared as natural as possible. Further, at the beginning of the project

participants were not informed that leadership was the focus of the study. This was done to prevent participants from artificially performing leadership behaviors. The participants were informed of the study's true purpose after the project ended.

Another limitation is that the case study only explored the first six weeks of the project, much of which occurred in the concept design phase. Future work will be introduced to analyze the second half of the project, which involved a multi-team design approach and the embodiment through detailed design phases of the project.

Another limitation of the case study was that the participants had limited diversity and practical engineering experience. This was identified before the case study was conducted. However, Capstone design teams were chosen because they presented an opportunity to observe more than one design team tasked with the same project.

Finally, only one instance of functional leadership was observed in the design review meetings. This was due to the nature of the team's interactions with the faculty adviser and graduate coach. The feedback provided did not prompt the students to respond with functional leadership behaviors.

5.4 Future Work

This section formally presents opportunities for future research that have been identified through the establishing and applying the leadership protocol.

5.4.1 Case Study – Multi-Team Systems in Engineering Design

The first proposed future study is a separate case study for the final six weeks of the design project. This study should be performed using a similar methodology as the

case study presented in Chapter Four. The focus of this case study should be to investigate the leadership behaviors that occur in a multi-team design system. Hypotheses could be tested to compare the leadership behaviors observed in the first half of the project to the second half. Literature suggests that leadership behaviors such as managing team boundaries, structure and planning, and monitoring and guiding team tasks may be more frequent in the multi-team system proposed case study [107]. This would be due to the nature of a multi-team system and having to coordinate with the other sub-teams to accomplish the overall goal of the multi-team system.

The protocol used in the first study could be directly applied to the proposed second case study. The results of the design review meetings may provide more observations of leadership functions as all the teams attended all the design reviews. The proposed case study could be used to answer FRQ.1.

FRQ.1. What are the differences in functional leadership behaviors in multi-team systems compared to traditional design teams?

5.4.2 Technical Leadership

Future case studies and protocol studies should be conducted to evaluate the impact of functional leadership in the technical design spaces, the problem and solution spaces. This study revealed that sensemaking and providing feedback composed most of the leadership behaviors observed in the problem and solution spaces. However, future studies need to be conducted to explore the impact of these functions on design outcome.

This study also demonstrated that Team A's design concept was selected after the midterm meeting for development in the second half of the semester. Further, Team A's

leadership observations occurred most frequently in the solution space. While Team B's and C's most frequently observed design space was the project space. This work does not make the claim that more leadership in the solution space results in better design outcomes. However, this was observed in the case study. Future experimental and protocol studies can be designed to test whether more leadership in the solution or problem paces results in improved design outcomes. FRQ.2, below, presents a specific research question to investigate how increased technical leadership behaviors impact design outcome.

FRQ.2. How does an increased amount of leadership in the problem and solution spaces effect the design outcome?

Additional future studies are proposed to investigate the emergence and impact of functional leadership behaviors in more specific design spaces, such as the concept design, embodiment design, and detailed design phases. More case studies and protocols studies can be performed to identify what specific actions occur when designers are providing feedback and sensemaking in the solution and problem spaces. This study will be aimed to answer FRQ.3 and will allow for more specific engineering leadership functions to be developed.

FRQ.3. What specific actions make up sensemaking and providing feedback in an engineering design space?

Finally, the protocol should be applied to design teams found in industry to compare the observations found in student design teams with those in industry. The study would have to be framed to consider the leadership structure in the industry design team. Further, industry studies could focus on different types of design teams such as product

development teams or early concept generation teams. Studying industry design teams will allow for a diverse range of teams and project types to be studied.

5.4.3 Protocol Improvements

This section will introduce methods to improve the leadership protocol. These methods include simplifying the protocol, coding the leadership fields and design fields independently, targeted studies to further highlight relationships between leadership and the engineering design, and improving the protocol's ease of use.

5.4.3.1 Simplifying the Leadership Protocol

When observing Capstone student design teams, it is not necessary to code for the Compose Team function, as the student teams are composed by the faculty coordinator, and the team composition does not change over the course of the project.

Clustering highly related leadership functions is also recommended to improve the protocol's rater agreement. Specifically, the Supporting Social Climate, Empowerment, and Consideration functions could be clustered and only coded according to the leadership function type, interpersonal. These functions were only observed a total of ten times and are highly related. Therefore, future studies should only record that an interpersonal behavior is observed and not the specific function. This should improve the rater agreement by reducing the number of behaviors to distinguish between while coding. Further, this should not diminish the quality of the coding as the interpersonal behaviors are still recorded and can be analyzed for their impact on the design project.

Defining the Mission, Establishing Goals and Expectations, and Structure and Planning could also be combined into one Planning leadership function for observation purposes. Clustering these transition type behaviors will reduce the number of leadership functions that raters need to distinguish between and should lead to an increase in rater agreement.

Future researchers could also remove the transformation design activity. Transformation was not observed as a collaborative design activity in the case study presented in Chapter Four and therefore, it may not be vital to record.

The proposed simplifications reduce the number of leadership functions from seventeen to twelve. An experimental study should be performed, with multiple raters, to identify a rater agreement metric for the simplified protocol. Further, a formal training workshop should be established to provide raters with examples of commonly observed behaviors (as a supplement to the complete protocol in Appendix A). The experimental study could be repeated after the training workshop is established to determine the effect of the workshop on rater agreement.

5.4.3.2 Independently Coding Leadership and Engineering Design

In future studies, raters should independently code for the design spaces, design activities, and leadership functions. This will decouple the protocol's fields and allow raters to independently code each field. Raters should still watch the recording in its entirety to become familiar with the context of the meeting. Next, raters should watch the video a second time and code for the design spaces the team transitions through. The raters should watch the video a third time, pausing to code for the design activities the team

performs. Finally, the raters should watch the video a fourth time, pausing to code functional leadership behaviors. The protocol could be decoupled further by independently coding for transition, action, and interpersonal functional leadership behaviors. Decoupling the protocol will enable raters to make independent assessments of the design spaces, design activities, and leadership functions and should lead to an increase in rater agreement.

5.4.3.3 Targeted Studies

Targeted studies are proposed to further investigate the relationships between leadership functions and the engineering design spaces. Two specific cases worth investigating would be the problem space paired with the transition leadership functions and the solution space paired with the action leadership functions. These studies could be conducted using a controlled protocol activity or through an observational case study. The results should highlight what behaviors engineers focus on while in the problem space and also provide insight into how to increase the amount of time students spend in the problem space. The solution space and action functions pair allows for a detailed analysis of the behaviors engineers perform in the solution space.

5.4.3.4 Ease of Use

The protocol's ease of use also requires improvement. Currently, raters watch the recorded meetings and frequently pause the video to fill in the coding spreadsheet. The protocol could be incorporated into a video play back software to more efficiently mark timestamps and record leadership observations. This would reduce the number of steps

required to code a video, thus reducing the amount of time required to perform the video coding. Studies could then be performed to determine if improving the protocol's ease of use, also improves the rater agreement.

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APPENDICES

APPENDIX A

LEADERSHIP CODING PROTOCOL

LEADERSHIP IN ENGINEERING DESIGN TEAMS: CODING MANUAL

Clemson Engineering Design Applications Research (CEDAR)

Clemson University Department of Mechanical Engineering

Spring 2018

Version 4

Updated: Wednesday, March 7, 2018

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Coding Instructions

1. **Choose a recorded session to code.**
   a. Use the coding tracking form to identify what sessions need to be coded.
2. **Open the video you are going to be coding.**
3. **Open a new copy of the excel coding template.**
   a. Fill in the header with the information pertaining to the video.
   b. Your name as observer.
   c. The date you are analyzing the video.
   d. The team you are observing.
   e. The date the team was observed.
   f. The source video file name.
4. **Save the Excel coding file.**
   a. IF the video is a team meeting save as **YYYY.MM.DD – Team X Week X.**
   b. IF the video is a design review save as **YYYY.MM.DD – Team X DR X.**
   c. Save a copy of the coding file to the Google Drive and save a personal copy.
5. **Review all the leadership behaviors in this manual prior to coding a session.**
6. **Watch the recorded session all the way through to become familiar with the activities in the session.**
7. **Watch the recorded session a second time, and code all occurrences of functional leadership in the coding tool (see example of coding tool section).**
   a. Record the observed leadership function (Acronym; see list in the **Coding Acronyms and Shortcuts** and definitions in **Definitions of Leadership Functions**).
   b. Record the design space the team was exploring when the leadership behavior occurred (see list in **Coding Acronyms and Shortcuts** and definitions in **Engineering Design Space Definitions**).
   c. Record the design activity that was occurring when the leadership behavior occurred (see list in **Coding Acronyms and Shortcuts** and definitions in **Engineering Design Activities Definitions**).
   d. Record the person performing the behavior with an L.
   e. Record the team members who were influenced with an F.
   f. Record the team members who are absent from the room with an A.
   g. Record the start time of the behavior.
   h. Record the end time of the behavior.
   i. Type out the activity/behavior you coded in the comments section.

j. Note that the grey columns of the coding tool spreadsheet auto-populate.

8. **Refer to the definitions and examples in this manual for assistance determining how to code leadership behaviors.**
   - **a.** Note that no leadership behavior can occur without a paired follower behavior, this is because in order for leadership to take place, there must be influence on the team. This influence is observed as follower behavior.
   - b. Identify each instance of leadership behavior independently of other team members, teams, recordings, or other observations of leadership (do not compare to any other recording).
   - c. Do not consider the quality of the behavior being performed. For example, if Person A creates a strategy and plan for the semester, however, it does not align with the teams' goals, you still record this as a leadership behavior if team members begin to carry out the plan.
   - d. Understand the examples listed in this coding manual are not a complete set. Behaviors will occur that are not listed as examples. Use the examples and the definitions of the leadership functions to identify what leadership function occurred.
9. **Be sure to record any comments or questions with a timestamp so that they can be identified later.**
10. **Save the coding file at least once every 10 minutes.**
11. **Record an entire session at once.**
    - a. Update the tracking sheet upon completion of coding a recording.
    - b. If you cannot code a recording to completion, update the tracking sheet and make a note of the time you left off at so that you do not have to search for it when you return to code the rest of the recording.
12. **If possible, ask questions as often as possible. If possible see CEDAR students in EIB 134/136. If it's not possible to meet with CEDAR students, please get in contact through email.**

List of Leadership Functions

Task Oriented

Compose Team

Define Mission

Establish Expectations and Goals

Structure and Plan

Train and Develop

Sensemaking

Provide Feedback

Monitor and Guide Team Tasks

Manage Team Boundaries

Challenging the Team

Perform Team Task

Solve Problems

Provide Resources

Encourage Team Self-Management

Support Social Climate

Relational Oriented

Consideration

Empowerment

Task vs. Relational Oriented Defined

Identifying whether a behavior is relational or task oriented will help determine what leadership function occurred.

Task Oriented

Task oriented leadership functions primarily deal with the project, work, and tasks the team does throughout its lifetime. These functions include, composing the team, defining the mission, establishing goals and expectations, structure and planning, and providing feedback to name some (the complete list is available on page 125). Task oriented behavior also focusing on setting and monitoring standards for performance and monitoring the team's performance throughout the project [1].

Relational Oriented

Relational oriented behaviors focus on the interpersonal skills and relationships amongst the team. These include consideration and empowerment. Consideration deals with always being friendly and approachable and making sure that all the team members are being treated equally and well. Empowerment includes improving the confidence and moral of the team members by providing positive reinforcement and offering opportunities for team members to improve their skills and gain confidence [1].

Coding Acronyms and Shortcuts

Table 1 Acronyms for leadership functions.

Function	Acronym
Compose Team	COMP
Define Mission	DM
Establish Expectations and Goals	EG
Structure and Plan	SP
Train and Develop	TD
Sensemaking	SM
Provide Feedback	PF
Monitor and Guide Team Tasks	MG
Manage Team Boundaries	MB
Challenging the Team	CT
Perform Team Task	PT
Solve Problems	SPS
Provide Resources	PR
Encourage Team Self-Management	ESM
Support Social Climate	SSC
Consideration	C
Empowerment	E

Table 2 Acronyms for individuals performing the behaviors.

Person Performing Behavior	Acronym
Leader	L
Follower	F

Table 3 Engineering Design Spaces.

Engineering Design Spaces
Problem Space
Solution Space
Project Space

Table 4 Engineering Design Activities.

Engineering Design Activities
Synthesis
Analysis
Decision Making
Transformation
Communication

Coding Cheat Sheet / Team Member Identification

Table 5 Functions and abbreviations.

Function	Abrv.
Compose Team	COMP
Define Mission	DM
Establish Expectations and Goals	EG
Structure and Plan	SP
Train and Develop	TD
Sensemaking	SM
Provide Feedback	PF
Monitor and Guide Team Tasks	MG
Manage Team Boundaries	MB
Challenging the Team	CT
Perform Team Task	PT
Solve Problems	SPS
Provide Resources	PR
Encourage Team Self-Management	ESM
Support Social Climate	SSC
Consideration	C
Empowerment	E

Table 6 Team A identification key.

Team A		
Person A		
Person B		
Person C		
Person D		

Table 7 Team B identification key.

Team B		
Person A		
Person B		
Person C		
Person D		

Table 8 Team C identification key.

Team C		
Person A		
Person B		
Person C		
Person D		

Coding Tool Example

Leadership in Engineering Design Observation Form

Observer:

Analysis Date:

Team Observed:

Observation Date:

Source Video File:

Leadership Behavior Coding		Design Activity Coding		Individual Behavior Coding						Attendance						Time Recordin	
Number	Leadership Function	Design Space	Design Activity	Per. A	Per. B	Per. C	Per. D	Per. E	Per. F	Per. A	Per. B	Per. C	Per. D	Per. E	Per. F	Start Time	End Time

Time Required: ________

Page 1 | 2

Template Updated: 1/24/2018

Definitions of Leadership Functions

The following section will present the leadership functions that coders are looking for. The leadership functions are presented with definitions and examples. It is important to note that the examples listed are not the only forms of the leadership functions that appear in the recordings.

Compose Team

Definition: Selecting individuals that are capable of achieving the goals outlined for the team. This includes selecting team members for their skills, prior experiences, and subject matter knowledge as well as their values, interpersonal skills, and motivations. This function is performed throughout the course of the project, team composition is monitored and adjusted as the team's goals and focus is changed.

If the team is already composed, then the team composition function involves assessing the individuals' skills, knowledge levels, and interpersonal skills and distributing the team members in a manner that will enable the team to achieve its goals and objectives [2].

Examples

Selecting Team Members

- Selecting team members from the pool of individuals qualified to join the team. Things to consider include the individuals' prior experiences, skill level, abilities, and interpersonal skills such as their motivations, values, and their personality.

Establishing Team Roles

- Assigning each team member responsibilities and tasks that the he/she is capable of completing. Ensuring that team members understand how their role fits into the team's structure as a whole.

Monitoring the Team Environment

- Adjusting the composition of the team as the project progresses. Changing the team composition due to outside factors such as being pushed new goals, or internal factors such as poor individual performance or poor group cohesion.

Define Mission

Definition: Determining and communicating the organization's performance expectations for the team in such a way that they are broken down into tangible, comprehensible pieces. Once the organization's expectations are understood, the team's mission (main goal) can be set.

The "organization" in this definition refers to the group that constructed the team, either the company, faculty members, or customer. The organizations will set a performance expectation and the team then defines its own mission from the organizations larger expectations [2].

Examples

Setting a Team Mission/Goal

- Setting an achievable target for the team to achieve in the available time frame. This mission can be creating physical product being due, a solving a problem, or performing a task. This mission can be assigned from the larger organization or defined by the team itself.

Establishing a Mission Statement

- Creating a mission statement defines the main goal or function of the team. This documents the goal or mission of the team.

Establish Expectations and Goals

Definition: Establishing internal performance expectations for team members and setting internal team goals. These goals are more refined and focused for the team functions and individuals on the team, thus making them different from the "Defining Mission" function that focuses on the overarching team goal.

The leader usually works individually or in small groups with team members to establish performance expectations, individual goals, and team operating procedures. These goals and expectations include what each team member is responsible for completing during the project's duration [2].

Examples

Establishing Team Members' Goals

- Each team member's tasks and goals will be identified and documented so that there is a performance target for each member of the team to achieve.

Establishing Team Work Expectations

- Developing expectations for team performance, working expectations, work load expectations, and other performance expectations.

Establishing Meeting Goals

- Setting goals of specific meeting. This sets the team's performance or social goals for the meeting.

Structure and Plan

Definition: Developing a team understanding of how best to coordinate their actions and work together to achieve the goals and expectations that have been established. The leadership function of structure and planning includes determining or assisting in determining how the work will be accomplished (method), who will do which aspects of the work (role clarification), and when the work will be done (time, scheduling, work flow). These behaviors result in an integrated work plan that directs the team's performance, coordinates team efforts, develops task performance strategies, and standardizes team processes [2].

Examples

Establishing Team Roles

- Determining what team members are capable of carrying out the specific tasks laid out in the structure and planning behaviors.

Creating a Plan of Activities

- Laying out the schedule and timeline of the team's work so that the tasks and due dates are clearly documented and understood (examples of charts include gnat charts.

Train and Develop

Definition: Identifying deficiencies in team capabilities, either in the form of individuals not being able to perform their tasks, or the team not being able to work together to perform their tasks. After the deficiencies are identified, the capabilities need to be further developed so that the team is capable of performing the task at hand.

The capabilities can be enhanced through targeted direct training courses with instruction or demonstration to individual team members or the team as a whole. Alternatively, the training may be on going coaching designed to develop the team over the course of the project. These trainings can be for both task oriented deficiencies or relational oriented efficiencies [2].

Examples

Providing Technical Training

- Identifying that a team member is not proficient in a technical area such as, welding, programming, fabricating, or using productivity tools such as Microsoft office or email. Sending the team member to training courses to improve the technical area that was identified.

Prolonged Coaching

- After identifying a proficiency in the team's, or a team member's, performance, having the team (or team member) work with coaches to develop their skills over time. This type of training could be for technical issues or it could be for relational team issues.

Reference to Educational Tools

- To suggest referencing material on areas an individual could improve it. This is less formal than providing training or coaching, but referring the team (or team member) to educational materials on areas that require improvement is another way of training and developing the team.

Peer Coaching

- Having a team member work with another team member to learn a new skill. Having teammates train each other informally develops the overall skill set of the team.

Sensemaking

Definition: Identifying essential environmental factors/events (internal and external to the team), interpreting these events given the team's performance situation, and communicating this interpretation to the team. This behavior facilitates team understanding of the meaning of external, or inside events, their meaning, and how they impact the performance of the team. Through making sense of specific events for team members, this aspect of team leadership helps the team understand the significance of specific events and enables the team to effectively respond to their impact [2].

Examples

Managing Team Response to Events

- Interprets internal and external events and communicates the impact to the team. This could be as simple as communicating new organizational strategy to the team, or as complex as interpreting conflicting customer needs.

Facilitate Team Understanding of External Events

- Helps fill the gaps and understand how an external event affects the performance of the team.

Facilitate Team Understanding of Internal Events

- Help the team communicate the progress effectively so that all understand the status of the team and where the team is moving towards.

Provide Feedback

Definition: Providing feedback on performance against established goals and milestones, metrics, and expectations, and to the extent the team's performance is not meeting those expectations, adapt and determine more effective ways of functioning.

The feedback can be to the team as a whole or individual team members. Also, encouraging team members to give each other feedback during the progression of the project [2].

Note that feedback can also be technical in nature. If a teammate is performing a task and another teammate provides technical feedback that alters the teammates task, then this is also coded as providing feedback.

Examples

Formal Performance Review

- A discussion regarding a team member's performance and task completion over a period of time of the project. Performance reviews can occur on a routine basis or by the request of the team, team member, or the external organization.

Peer Evaluations

- Peer evaluations provide all the team members feedback from their peers (teammates). This can be done anonymously or open, however, the point is to gain an understanding of how the team views its current performance and where improvements can be made.

Providing Technical Feedback

- Providing critical or positive feedback regarding a design decision or a technical concept. This can be done in a formal or an informal matter and can be done internal or external to the team.

Monitor and Guide Team Tasks

Definition: As team is actively involved in work, the team's progress and performance must be monitored to ensure the team is on target for reaching their goals. This leadership functions deals with examining the team's processes, performance, and the external team context. This includes evaluating the team's progress towards task completion with regards to the resources available to the team, the external environment, and individual team member roles [2].

Examples

Evaluating Team Performance

- Tracking the team's completion of goals and work steps as it works towards achieving a larger team goal or the team mission.

Surveys Team Members

- Asks the team members where they're at with their tasks to better understand the current state of the team.

Identify Need for External Resources

- Monitoring the teams processes and determine if external resources are required to complete the tasks in a more efficient way.

Manage Team Boundaries

Definition: Managing the relationships between the team and the external environment (other teams, the larger organization, customers, and other influences on the team). Managing team boundaries also includes buffering the team from the impacts of external events and making sure that the team is capable of reacting to a changing external environment.

The team's boundary must be tight so that the team roles and relationships are understood, a sense of teamwork is established, and the team can be recognized by other teams and organizations. However, the team's boundary must also be loose so that it can adapt and react to external events and changes in scenario. This leadership function involves managing the state of the team boundary throughout the course of the project [2].

Examples

Establishing a Team Boundary

- Creating a standard process for team members to interact with the external influences. This process will dictate how information flows to, from, and through the team.

Managing the Team's Relationships

- Establishing relationships with other teams or the external organization is a key part of managing the team's boundaries. Teams often times have to work with other teams and interact with the larger organization they are a part of. To be effective, teams need to effectively manage their relationships with other entities.

Challenging the Team

Definition: Challenging the team with respect to their performance levels, processes, standards (rules & regulations), and attitudes. The goals of challenging a team are to improve their performance output, working relationships, or strengthen the identity of the team. All of these goals aim to make the team more effective.

Challenging the status quo and making sure that team mates do not become stagnant increases the team's focus toward their goals and relationships [2].

Examples

Raising Performance Goals

- Increasing the performance goals of a team as the team progresses through the action phase of a project makes the team come together and refocus to achieve the new, higher, performance goals. This challenge could be brought on by external events (customer demand, organizational push, or other events external to the team), or by internal events (team is stagnant, performance is low, or team is now working hard enough).

Challenge Teammates to Get to Know their Peers

- Challenging the team to get to know each other might be necessary if the team is newly minted and has not had the time to get to know each other through work. Additionally, if a team is not functioning well as a project progresses, challenging the team to get to know each out will provide an opportunity for the team's performance to improve.

Perform Team Task

Definition: Taking a more active role in the team tasks. Performing work required for the team activity or project. This can be done individually or participating with other teammates [2].

This is aimed at external leaders who are not involved in the day to day activity, but can be considered for internal leaders responsible for portions of team projects or internal leaders assisting other members with their tasks [2].

Examples

Working on a Team Task

- If an internal team leader is responsible for completing a portion of the team project, the act of working on the task is considered performing a team task.

Solve Problems

Definition: Diagnose and solve any problems that keeps the team from realizing and achieving its potential. This is a crucial function of team leadership as team leaders must be able to identify problems that are holding their teams back and then provide effective and timely solutions. Any problems the team faces can be addressed by the leader (team relations, task oriented, or external influences) [2].

Examples

Internal Conflict Resolution

- Solving problems amongst team members. These problems may be relational or related to team tasks.

Logistical Problems

- Identifying potential logistical problems between the team and the external environment. Making sure the expectations for the team are realistic and providing logical solutions to the logistic challenges.

Provide Resources

Definition: Acquiring financial, informational, material, and personnel resources for the team to use to complete their tasks and achieve the team mission. First, the resources must be secured before they can be provided to the team. The resources acquired can be for task oriented situations or to support and motivate the team or improve team relations [2].

Examples

Increasing Team Budget

- Increasing the team's budget when necessary. This could involve raising funds for the project as a team, or going to the organization and requesting an increase in the team's budget.

Providing Personnel

- Increasing the team size when the amount of work is greater than the working capacity of the team.

Outsourcing Work

- Identifying work that can be done external of the team and reducing the work load by providing a service that can accomplish any non-essential work.

Encourage Team Self-Management

Definition: Encouraging the team to manage itself and perform its own leadership functions. This involves encouraging (and helping) the team solve task and teamwork related problems on their own. Additionally, encouraging teams to establish their own resources and relationships with external partners (organizational, customers, etc…) [2].

Examples

Having the Team Solve its Own Problems

- Standing back and letting team members resolve the task and relational problems within the team.

Letting the Team Establish Goals

- Having the team set the performance goals and timeline for their execution.

Encouraging Team Leadership

- Encouraging the team to perform the leadership functions on their own.

Support Social Climate

Definition: Supporting the team's social climate involves dealing with interpersonal issues that may hinder the team's performance. This also includes finding ways to motivate the team and make their work feel relevant to keep the team members involved. This function focuses and making sure the team is functioning as a unit and that there are not team issues hindering performance [2].

Examples

Motivating Team Members

- Finding ways to make sure that the team is motivated to accomplish the tasks and goals besides the sole fact that the due data is approaching.

Resolving Any Social Conflicts

- Immediately solving social conflicts in a way that reduces an impact to the team's performance and allows for all team members to resume normal work.

Ensuring Equal Treatment

- Making sure that all team members are treated equally regardless of their team position or any social beliefs.

Consideration

Definition: Showing concern and respect for individual team members. Being friendly and approachable so that all team members feel comfortable discussing any team or project issues. It is important to treat all group members the same way and do not hold any member above the team or treat any member worse than the others [1].

Examples

Treat all Team Members the Same

- Making sure that the team members are all treated equally when they perform well or poorly.

Being Friendly and Open to Discussion

- Brining a snack or coffee to teammates to keep the motivation high or to build trust to create an open dialog.

Empowerment

Definition: The act of strengthening an individual's beliefs in his or her sense of effectiveness. This is the process of building confidence in team members by increasing their self-confidence [3].

Examples

Allowing Team Members the Chance to Try New Things

- Giving team members the opportunity to test their skills through new tasks lets them know that they have the confidence of their leader, thus building their self-confidence.

Encouraging Words

- Positively reinforcing the team through verbal feedback, written feedback, and other forms of positive feedback.

Supportive in Stressful Situations

- Letting team members know that they have the support and confidence during tough conditions (task or personal related).

Engineering Design Space Definitions

The design space needs to be coded to track what aspect of the design space the team is working on when a leadership function is observed. The design space is broken into three categories, Problem Space, Solution Space and Project Space.

Problem Space

Problem space is defined as working on understanding the problem, the users, or the use cases. This includes developing new requirements, questioning the customer regarding their needs, and developing a problem statement.

Solution Space

The solution space contains any work revolving around the design of potential solutions. The design of potential solutions includes concept development, concept evaluation, identification of functions, embodiment design, detailed design, fabrication, and testing. Any stage of prototyping is also included in the solution space.

Project Space

The project space is defined as any situation where the team is not dealing directly with the problem or the solution. Examples include, but are not limited to, planning team meeting/work sessions, identifying team goals for the semester, assigning responsibilities to team members, evaluating team performance, and many others.

Engineering Design Activities Definitions

Synthesis

The creation of new material that is relevant to the problem, solution, or project. The creating a requirement, function structure, or physically constructing a prototype is considered synthesizing new design information or material [4–6]. Note, there are other types of design analyses available to design teams and that this is an incomplete list.

Analysis

Analysis of design problem, solution, and project deals with studying the current design information and materials available to the design team. Some examples of analysis include a Finite Element Analysis (FEA) of a structural component of their design, a Failure Modes Effects Analysis (FMEA) of the design solution, or a cost analysis of the design solution [4–6]. Note, there are other types of design analyses available to design teams and that this is an incomplete list.

Decision Making

Decision making activities include the review of analysis and the current design information to change the direction of the design team, identify new tasks that need to be completed, move forward with one concept over others. Decision making activities can include one team member or multiple [4–6]. The list of decision making activities is not complete, however, these present some of the activities that coders may observe.

Transformation

Transformation activities are the process of taking design information in one representational state and transforming it into another. Examples of this include, but are not limited to, transforming a sketch of a solution into a 3D CAD model and taking a list of handwritten requirements and creating a complete requirement sheet [5].

Communication

Communication includes any communication of design information or material internal or external to the design team. Examples of communication can include emailing, updating face to face, calling, texting, etc. design information to customers, advisers, teammates, vendors, or other entities associated with the project. Communication involves all domains of the design space. Design team members can communicate problem, solution, and project information internal and external to the team. Communication also includes calling for new goals, structure, or new design information. For example, identifying that a team needs to create a function structure is communicating a new goal, not synthesizing new design material.

References

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[4] Pahl G., Beitz W., Blessing L., Feldhusen J., Grote K.-H. H., and Wallace K., 2013, *Engineering Design: A Systematic Approach*, Springer-Verlag London Limited, London.

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APPENDIX B

COMPLETE CODING RESULTS

Complete - Pilot Code								
Rater A								
Start Time	**End Time**	**Duration**	**Number**	**Function (Acronym)**	**Per. A**	**Per. B**	**Per. C**	**Per. D**
0:01:26	0:01:48	0:00:22	1	SM	L	F	F	F
0:05:01	0:05:05	0:00:04	2	SM	F			L
0:05:21	0:05:27	0:00:06	3	TD	F	L		
0:05:29	0:06:28	0:00:59	4	TD	F			L
0:06:30	0:07:50	0:01:20	5	TD	F		L	F
0:07:51	0:08:54	0:01:03	6	SM	F	F	F	L
0:09:15	0:11:47	0:02:32	7	EG	F	L		L
0:11:52	0:11:58	0:00:06	9	MB	L			
0:14:10	0:15:36	0:01:26	10	TD	F	F	L	F
0:17:57	0:19:00	0:01:03	11	SM	F	F	F	L
0:19:05	0:19:25	0:00:20	12	SM	F	F	L	F
0:19:26	0:20:35	0:01:09	13	SM	F	F	F	L
0:23:49	0:24:20	0:00:31	14	SM	F	L	F	L
0:24:32	0:24:47	0:00:15	16	SM	L		F	L
0:25:10	0:25:34	0:00:24	18	SM			L	F
0:25:45	0:26:18	0:00:33	19	SM	F		L	F
0:27:30	0:29:30	0:02:00	20	SM		F	F	L
0:27:50	0:28:14	0:00:24	21	TD			F	L
0:29:40	0:29:55	0:00:15	22	SM	F		F	L
0:30:24	0:31:05	0:00:41	23	SM	F	F	F	L
0:31:27	0:32:53	0:01:26	24	SM	F	F	F	L
0:32:55	0:33:33	0:00:38	25	SM			F	L
0:34:00	0:34:40	0:00:40	26	PT		F	L	F
0:34:41	0:35:28	0:00:47	27	SM	F	F	F	L
0:35:29	0:37:17	0:01:48	28	SM		F	L	F
0:37:26	0:37:35	0:00:09	29	SM	F	F	F	L
0:37:38	0:38:12	0:00:34	30	SM	L	F	F	F
0:38:33	0:39:20	0:00:47	31	SM	F	F	F	L
0:39:29	0:40:00	0:00:31	32	SM		F	F	L
0:40:01	0:40:42	0:00:41	33	PT	F	F	L	F
0:40:43	0:41:04	0:00:21	34	SP		F	L	F
0:41:05	0:41:32	0:00:27	35	SM	L	F	F	
Rater B								
Start Time	**End Time**	**Duration**	**Number**	**Function (Acronym)**	**Per. A**	**Per. B**	**Per. C**	**Per. D**
0:01:12	0:01:52	0:00:40	1	SP	L			
0:01:53	0:02:04	0:00:11	2	SP			L	
0:02:06	0:02:09	0:00:03	3	SP	L			
0:02:10	0:02:24	0:00:14	4	SP		L		
0:04:00	0:04:10	0:00:10	5	SM			L	
0:04:45	0:05:15	0:00:30	6	SM	F		L	
0:05:39	0:06:30	0:00:51	7	SM	F		L	
0:06:40	0:07:50	0:01:10	8	SM				
0:07:50	0:08:54	0:01:04	9	SM	F	F		L

0:09:10	0:10:20	0:01:10	10	SP	F	F		L
0:23:12	0:24:00	0:00:48	11	SM	F	F	L	F
0:24:29	0:25:20	0:00:51	12	PT	F	F	L	F
0:25:21	0:25:30	0:00:09	13	PF			F	L
0:25:31	0:27:19	0:01:48	14	PT			L	
0:27:21	0:28:48	0:01:27	15	TD			F	L
0:29:18	0:29:28	0:00:10	16	TD			F	L
0:30:07	0:30:15	0:00:08	17	MB	L			
0:30:48	0:31:00	0:00:12	18	PF			L	F
0:31:05	0:31:20	0:00:15	19	SM			L	
0:31:21	0:32:45	0:01:24	20	SPS				L
Rater C								
Start Time	**End Time**	**Duration**	**Number**	**Function (Acronym)**	**Per. A**	**Per. B**	**Per. C**	**Per. D**
0:01:09	0:02:24	0:01:15	1	SP	L	F	F	
0:02:25	0:02:43	0:00:18	2	SM	F	F	L	
0:04:59	0:05:30	0:00:31	3	TD	F	L		
0:05:35	0:06:33	0:00:58	4	TD	F			L
0:06:34	0:07:59	0:01:25	5	TD	F	F	L	F
0:08:15	0:09:18	0:01:03	6	SSC	F	L	F	F
0:13:10	0:13:59	0:00:49	7	SM	F	F	F	L
0:16:48	0:16:59	0:00:11	8	PF		F	F	L
0:18:05	0:18:27	0:00:22	9	SPS	F	F	F	L
0:20:10	0:20:44	0:00:34	10	SM	F	F	F	L
Rater A'								
Start Time	**End Time**	**Duration**	**Number**	**Function (Acronym)**	**Per. A**	**Per. B**	**Per. C**	**Per. D**
0:01:15	0:02:47	0:01:32	1	SP	L	F	F	F
0:03:06	0:04:31	0:01:25	2	SM	F	L	F	F
0:04:53	0:06:35	0:01:42	3	SM	F	F		L
0:06:36	0:08:12	0:01:36	4	TD	F		L	
0:08:13	0:09:07	0:00:54	5	SM	F	F		L
0:09:23	0:11:45	0:02:22	6	SP	F	F		L
0:11:48	0:12:50	0:01:02	7	SP	F	L		F
0:13:04	0:13:50	0:00:46	8	SM	F	F	F	L
0:14:14	0:16:34	0:02:20	9	TD			L	F
0:16:42	0:20:44	0:04:02	10	SM	F	F	F	L
0:21:17	0:22:11	0:00:54	11	SM	L	F		F
0:23:18	0:24:24	0:01:06	12	SM	F	F	L	F
0:24:28	0:24:52	0:00:24	13	SM	F	F	F	L
0:25:12	0:25:45	0:00:33	14	SM			L	F
0:25:46	0:26:00	0:00:14	15	SM	F	F	L	
0:26:01	0:27:20	0:01:19	16	PT	F	F	L	F
0:27:21	0:29:50	0:02:29	17	SM		F	F	L
0:30:25	0:31:20	0:00:55	18	SM	F	F	L	F
0:31:21	0:32:51	0:01:30	19	SM	F	F	F	L
0:32:53	0:34:10	0:01:17	20	SM		F	F	L
0:34:11	0:34:40	0:00:29	21	PT		F	L	F

0:34:41	0:35:28	0:00:47	22	PF	F	F	F	L
0:35:30	0:36:12	0:00:42	23	SM		F	L	F
0:36:13	0:36:20	0:00:07	24	PT			L	F
0:36:21	0:36:22	0:00:01	25	PF		F	F	L
0:36:24	0:37:18	0:00:54	26	SM		L	F	F
0:37:20	0:37:27	0:00:07	27	PT		F	L	F
0:37:28	0:37:40	0:00:12	28	PF		F	F	L
0:37:41	0:38:11	0:00:30	29	SM	L	F	F	
0:38:19	0:40:00	0:01:41	30	SM	F	L	F	F
0:40:01	0:40:35	0:00:34	31	PT	F	F	L	F
0:40:38	0:41:05	0:00:27	32	SP			L	F

Complete - Case Study Code									
General Info.				Time Recording			Leadership		Design Ac
Team	Week	Week #	Number	Start Time	End Time	Duration	Leadership Function	Type	Design Space
Team A	9/18/2017	Week 2	1	0:03:33	0:03:47	0:00:14	SP	Transition	Solution
Team A	9/18/2017	Week 2	2	0:03:50	0:04:34	0:00:44	SM	Transition	Project
Team A	9/18/2017	Week 2	3	0:04:38	0:05:00	0:00:22	EG	Transition	Project
Team A	9/18/2017	Week 2	4	0:13:25	0:13:50	0:00:25	SP	Transition	Solution
Team A	9/18/2017	Week 2	5	0:14:25	0:15:37	0:01:12	PR	Action	Project
Team A	9/18/2017	Week 2	6	0:16:17	0:16:25	0:00:08	SP	Transition	Problem
Team A	9/18/2017	Week 2	7	0:16:25	0:16:31	0:00:06	SP	Transition	Problem
Team A	9/18/2017	Week 2	8	0:16:31	0:18:19	0:01:48	TD	Transition	Problem
Team A	9/18/2017	Week 2	9	0:25:48	0:26:00	0:00:12	SP	Transition	Project
Team A	9/18/2017	Week 2	10	0:31:16	0:33:00	0:01:44	SM	Transition	Problem
Team A	9/18/2017	Week 2	11	0:32:37	0:33:42	0:01:05	SM	Transition	Problem
Team A	9/18/2017	Week 2	12	0:49:17	0:49:45	0:00:28	PT	Action	Solution
Team A	9/18/2017	Week 2	13	0:50:20	0:51:17	0:00:57	PT	Action	Problem
Team A	9/18/2017	Week 2	14	0:51:20	0:52:20	0:01:00	PT	Action	Solution
Team A	9/18/2017	Week 2	15	0:53:20	0:53:26	0:00:06	C	Interpersonal	Solution
Team A	9/18/2017	Week 2	16	0:00:45	0:01:30	0:00:45	MG	Action	Solution
Team A	9/18/2017	Week 2	17	0:04:19	0:06:22	0:02:03	PF	Transition	Solution
Team A	9/18/2017	Week 2	18	0:06:54	0:07:31	0:00:37	PR	Action	Solution
Team A	9/18/2017	Week 2	19	0:09:12	0:10:00	0:00:48	PR	Action	Solution
Team A	9/25/2017	Week 3	1	0:00:00	0:00:30	0:00:30	MB	Action	Project
Team A	9/25/2017	Week 3	2	0:00:30	0:01:25	0:00:55	SM	Transition	Project
Team A	9/25/2017	Week 3	3	0:01:30	0:01:59	0:00:29	SP	Transition	Project
Team A	9/25/2017	Week 3	4	0:02:00	0:03:45	0:01:45	EG	Transition	Project
Team A	9/25/2017	Week 3	5	0:04:19	0:04:57	0:00:38	SP	Transition	Project
Team A	9/25/2017	Week 3	6	0:04:58	0:09:09	0:04:11	MB	Action	Project
Team A	9/25/2017	Week 3	7	0:09:10	0:09:42	0:00:32	SM	Transition	Solution
Team A	9/25/2017	Week 3	8	0:09:43	0:10:21	0:00:38	SP	Transition	Project
Team A	9/25/2017	Week 3	9	0:11:35	0:11:43	0:00:08	MG	Action	Project
Team A	9/25/2017	Week 3	10	0:14:38	0:15:08	0:00:30	MG	Action	Project
Team A	9/25/2017	Week 3	11	0:15:09	0:15:20	0:00:11	MG	Action	Solution
Team A	9/25/2017	Week 3	12	0:17:28	0:17:43	0:00:15	SM	Transition	Solution

ctivity Coding	Individual Behavior Coding				Attendance				Upper Level Leadership Behaviors	
Design Activity	Per. A	Per. B	Per. C	Per. D	Per. A	Per. B	Per. C	Per. D	Function (Full)	Phase
Communication	F		L			A		A	Structure and Plan	Transition
Communication	L		F			A		A	Sensemaking	Transition
Synthesis	F		L			A		A	Establish Expectations and Goals	Transition
Communication	F	L	F					A	Structure and Plan	Transition
Synthesis	L		F					A	Provide Resources	Action
Communication	F	F	L					A	Structure and Plan	Transition
Communication	F	L	F					A	Structure and Plan	Transition
Communication	F	L	F					A	Train and Develop	Transition
Synthesis	L	F							Structure and Plan	Transition
Synthesis	L	F							Sensemaking	Transition
Synthesis		L	F	F					Sensemaking	Transition
Synthesis	L	F	F						Performing Team Task	Action
Synthesis	F	L							Performing Team Task	Action
Synthesis	F	L	F	F					Performing Team Task	Action
Synthesis	F	L							Consideration	Transition/Action
Synthesis	F	L							Monitor and Guide Team Tasks	Action
Decision Making	F	F		L					Provide Feedback	Transition
Communication	F	F		L					Provide Resources	Action
Communication	F			L					Provide Resources	Action
Communication	F	F	F	L					Manage Team Boundaries	Action
Communication	L	F	F	F					Sensemaking	Transition
Synthesis	F			L					Structure and Plan	Transition
Synthesis	F	L		F					Establish Expectations and Goals	Transition
Synthesis	F	L							Structure and Plan	Transition
Communication	F	F	F	L					Manage Team Boundaries	Action
Decision Making	L	F		F					Sensemaking	Transition
Decision Making	F	L							Structure and Plan	Transition
Communication	F			L					Monitor and Guide Team Tasks	Action
Communication	F	L		F					Monitor and Guide Team Tasks	Action
Synthesis	F			L					Monitor and Guide Team Tasks	Action
Decision Making	F	F	L						Sensemaking	Transition

Behavior Category
Task Oriented
Task Oriented
Task Oriented
Task Oriented
Task Oriented
Task Oriented
Task Oriented
Task Oriented
Task Oriented
Task Oriented
Task Oriented
Task Oriented
Task Oriented
Task Oriented
Relational Oriented
Task Oriented
Task Oriented
Task Oriented
Task Oriented
Task Oriented
Task Oriented
Task Oriented
Task Oriented
Task Oriented
Task Oriented
Task Oriented
Task Oriented
Task Oriented
Task Oriented
Task Oriented
Task Oriented

Behavior Observed
Stated that a function model should be made
Questioned the progress reporting forms (budget..)
Set the plan and goals for the meeting
Entered and suggested to start a function model
Provided wifi login info to person C
Suggested updating constraints/criteria
Suggested increasing detail of constraints/criteria to a PDS doc
Provided informal training on the format and content of a PDS
Stating she will start the weekly report
Brought up considering new things in the problem statement (clearance on machine)
Discussed and then reacted constraint regarding clearance and material stickup
Begins to create FS on the board
Creates a simple problem statement while A documents it on the board
Begins filling out function structure
Reassures teammate
Says that the team should split the grouping into automatic and manual
Provides resource of how to do function tree/structure (function modeling guidelines)
Provides example of a function tree
States that the team should go talk to the adviser before working to get an understanding on if they need to build
Trying to understand if they will be building a prototype or not
Plans out how the rest of the first half of the semester will unfold
Establish goals for the midterm
States plan for today's meeting
Team goes to see if the adviser is available for a meeting
States that the advisers want them to fine tune function model and then its decided that is what they will do
States plan that team can work on function model and then meet with adviser tomorrow since they were not available
Makes sure that person B is the only one who can work on the function model on their computer
Brings team back on track by returning to the functions structure
States PA should project to the monitor to help with the team working on the function structure
Says that advisers do not want energy type

Team A	9/25/2017	Week 3	13	0:17:52	0:18:03	0:00:11	MB	Action	Project
Team A	9/25/2017	Week 3	14	0:18:22	0:18:33	0:00:11	PF	Transition	Solution
Team A	9/25/2017	Week 3	15	0:18:34	0:18:46	0:00:12	PF	Transition	Solution
Team A	9/25/2017	Week 3	16	0:18:48	0:20:27	0:01:39	SM	Transition	Solution
Team A	9/25/2017	Week 3	17	0:20:52	0:21:12	0:00:20	SP	Transition	Project
Team A	9/25/2017	Week 3	18	0:21:14	0:22:04	0:00:50	SM	Transition	Solution
Team A	9/25/2017	Week 3	19	0:24:03	0:24:08	0:00:05	MG	Action	Project
Team A	9/25/2017	Week 3	20	0:24:09	0:26:55	0:02:46	PT	Action	Solution
Team A	9/25/2017	Week 3	21	0:28:34	0:29:06	0:00:32	MG	Action	Project
Team A	9/25/2017	Week 3	22	0:29:50	0:29:57	0:00:07	PR	Action	Solution
Team A	9/25/2017	Week 3	23	0:29:58	0:30:49	0:00:51	TD	Transition	Solution
Team A	9/25/2017	Week 3	24	0:31:50	0:34:41	0:02:51	SM	Transition	Solution
Team A	9/25/2017	Week 3	25	0:35:45	0:36:11	0:00:26	SM	Transition	Solution
Team A	9/25/2017	Week 3	26	0:36:38	0:37:07	0:00:29	SM	Transition	Solution
Team A	9/25/2017	Week 3	27	0:38:40	0:39:00	0:00:20	PT	Action	Solution
Team A	9/25/2017	Week 3	28	0:39:34	0:39:35	0:00:01	E	Interpersonal	Project
Team A	9/25/2017	Week 3	29	0:40:10	0:40:52	0:00:42	PF	Transition	Solution
Team A	9/25/2017	Week 3	30	0:42:15	0:42:23	0:00:08	PF	Transition	Solution
Team A	9/25/2017	Week 3	31	0:42:34	0:43:32	0:00:58	SM	Transition	Solution
Team A	9/25/2017	Week 3	32	0:43:43	0:43:51	0:00:08	MG	Action	Project
Team A	9/25/2017	Week 3	33	0:43:51	0:43:56	0:00:05	MG	Action	Solution
Team A	9/25/2017	Week 3	34	0:45:00	0:45:44	0:00:44	TD	Transition	Solution
Team A	9/25/2017	Week 3	35	0:46:06	0:47:17	0:01:11	SM	Transition	Solution
Team A	9/25/2017	Week 3	36	0:47:24	0:47:57	0:00:33	SP	Transition	Solution
Team A	9/25/2017	Week 3	37	0:48:00	0:48:12	0:00:12	PF	Transition	Solution
Team A	9/25/2017	Week 3	38	0:48:16	0:49:01	0:00:45	SM	Transition	Solution
Team A	9/25/2017	Week 3	39	0:00:30	0:01:00	0:00:30	SM	Transition	Solution
Team A	9/25/2017	Week 3	40	0:01:00	0:02:09	0:01:09	EG	Transition	Solution
Team A	9/25/2017	Week 3	41	0:02:12	0:03:00	0:00:48	PF	Transition	Solution
Team A	9/25/2017	Week 3	42	0:03:15	0:03:40	0:00:25	PR	Action	Project
Team A	9/25/2017	Week 3	43	0:04:35	0:05:03	0:00:28	SM	Transition	Solution
Team A	9/25/2017	Week 3	44	0:05:04	0:07:27	0:02:23	PT	Action	Solution
Team A	9/25/2017	Week 3	45	0:07:30	0:07:45	0:00:15	PF	Transition	Solution
Team A	9/25/2017	Week 3	46	0:10:00	0:10:12	0:00:12	PF	Transition	Solution

Communication	F		F	L					Manage Team Boundaries	Action
Synthesis	L	F							Provide Feedback	Transition
Synthesis	F	F		L					Provide Feedback	Transition
Synthesis	F	L	F	F					Sensemaking	Transition
Synthesis	L			F					Structure and Plan	Transition
Decision Making	F	F	L	F					Sensemaking	Transition
Communication	L	F							Monitor and Guide Team Tasks	Action
Synthesis	F	L	F	F					Performing Team Task	Action
Communication	L		F						Monitor and Guide Team Tasks	Action
Communication	L		F						Provide Resources	Action
Communication	F		L	F					Train and Develop	Transition
Synthesis	F	L	F	F					Sensemaking	Transition
Communication	F	L							Sensemaking	Transition
Communication	F	L	F						Sensemaking	Transition
Synthesis	F	L		F					Performing Team Task	Action
Communication	F	L							Empowerment	Transition/Action
Decision Making	F	L		F					Provide Feedback	Transition
Decision Making	F	F		L					Provide Feedback	Transition
Communication	F	L		F					Sensemaking	Transition
Synthesis	L	F		F					Monitor and Guide Team Tasks	Action
Decision Making	F			L					Monitor and Guide Team Tasks	Action
Communication	F		L						Train and Develop	Transition
Communication	F	L		F					Sensemaking	Transition
Decision Making	F	L							Structure and Plan	Transition
Decision Making	F		F	L					Provide Feedback	Transition
Communication	F	L							Sensemaking	Transition
Synthesis	F	L							Sensemaking	Transition
Synthesis	F	L	F	F					Establish Expectations and Goals	Transition
Synthesis	F	F	L	F					Provide Feedback	Transition
Communication	F	F	F	L					Provide Resources	Action
Communication	F		F	L					Sensemaking	Transition
Synthesis	F		F	L					Performing Team Task	Action
Communication	F	L		F					Provide Feedback	Transition
Synthesis			L	F					Provide Feedback	Transition

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Emailing adviser for meeting
States that there should be no loop
Provides feedback on language of function model
Working on implementing feedback from advisers
Asks per D to start the power point for the week
Interpreting comments from an email and changing the function model based on their feedback
Brings team back on track by returning to the functions structure
Working on functions structure with team
Brings team back on track
Provides example of a morph chart
Teaching the team about how to use a morphological chart
Interpreting example morph chart and making it work for this project
Explaining how the morph chart is organized
Explaining how the morph chart is organized
States using maneuvering for a header
Reassures PA that they are doing the correct thing on the function structure
Changes the format of the morph chart
States rack and pinion needs to go under both categories
Explains how you an have two concepts satisfy two functions without best
States that this is a good start and that tomorrow they can get feedback on the progress to further improve the morph chart
States that the morph chart needs more concepts for translation
Explains how to evaluate all of the concepts that the morph chart creates
Explaining the miscommunication between the advisers with regards to the team's scale, and how to move forward with the scale selection
Explains that the team needs to review the pds to ensure the requirement (criteria) weights are accurate before using them in the morph chart
States that the team needs another function of weight measurement in the morph chart
Explains why weight measurement is a separate function
States controls should be listed as a function
Establishes that the team needs to do research on controllers for their project
States options for the controllers in the morph chart
Sent out presentation for this weeks update to the team to start editing
Explains how the contraints and criteria in the PDS drive the morph chart
Adding items from the pds to the morph chart
Justifying why a spring scale works
States the morph chart options for controls are too generic

Team A	10/2/2017	Week 4	1	0:06:19	0:06:30	0:00:11	EG	Transition	Project
Team A	10/2/2017	Week 4	2	0:06:35	0:06:43	0:00:08	SP	Transition	Project
Team A	10/2/2017	Week 4	3	0:10:43	0:10:53	0:00:10	PR	Action	Solution
Team A	10/2/2017	Week 4	4	0:10:54	0:13:08	0:02:14	TD	Transition	Solution
Team A	10/2/2017	Week 4	5	0:13:30	0:16:05	0:02:35	SP	Transition	Project
Team A	10/2/2017	Week 4	6	0:17:58	0:18:23	0:00:25	SPS	Action	Project
Team A	10/2/2017	Week 4	7	0:23:10	0:23:52	0:00:42	SM	Transition	Project
Team A	10/2/2017	Week 4	8	0:25:48	0:25:57	0:00:09	MG	Action	Solution
Team A	10/2/2017	Week 4	9	0:30:48	0:30:50	0:00:02	MG	Action	Solution
Team A	10/2/2017	Week 4	10	0:36:40	0:36:48	0:00:08	MG	Action	Solution
Team A	10/2/2017	Week 4	11	0:43:50	0:44:30	0:00:40	MG	Action	Solution
Team A	10/2/2017	Week 4	12	0:44:40	0:45:10	0:00:30	SM	Transition	Solution
Team A	10/9/2017	Week 5	1	0:11:39	0:16:11	0:04:32	PR	Action	Solution
Team A	10/9/2017	Week 5	2	0:17:46	0:18:01	0:00:15	SP	Transition	Solution
Team A	10/9/2017	Week 5	3	0:18:04	0:18:06	0:00:02	SP	Transition	Project
Team A	10/9/2017	Week 5	4	0:19:41	0:21:25	0:01:44	MG	Action	Project
Team A	10/9/2017	Week 5	5	0:21:26	0:21:50	0:00:24	PR	Action	Solution
Team A	10/9/2017	Week 5	6	0:22:17	0:22:20	0:00:03	SP	Transition	Project
Team A	10/9/2017	Week 5	7	0:22:21	0:23:04	0:00:43	SP	Transition	Project
Team A	10/9/2017	Week 5	8	0:23:05	0:23:09	0:00:04	MG	Action	Project
Team A	10/9/2017	Week 5	9	0:23:10	0:23:17	0:00:07	EG	Transition	Project
Team A	10/9/2017	Week 5	10	0:23:17	0:23:43	0:00:26	SP	Transition	Project
Team A	10/9/2017	Week 5	11	0:24:30	0:24:44	0:00:14	SP	Transition	Project
Team A	10/9/2017	Week 5	12	0:24:44	0:25:15	0:00:31	MB	Action	Solution
Team A	10/9/2017	Week 5	13	0:25:37	0:27:30	0:01:53	MG	Action	Solution
Team A	10/9/2017	Week 5	14	0:29:00	0:29:15	0:00:15	PR	Action	Project
Team A	10/9/2017	Week 5	15	0:29:31	0:37:52	0:08:21	PT	Action	Solution
Team A	10/9/2017	Week 5	16	0:38:49	0:39:04	0:00:15	PF	Transition	Solution
Team A	10/9/2017	Week 5	17	0:29:38	0:42:00	0:12:22	PT	Action	Solution
Team A	10/9/2017	Week 5	18	0:42:10	0:42:30	0:00:20	PF	Transition	Solution
Team A	10/9/2017	Week 5	19	0:43:21	0:43:35	0:00:14	PR	Action	Solution
Team A	10/9/2017	Week 5	20	0:44:08	0:44:14	0:00:06	MG	Action	Project
Team A	10/9/2017	Week 5	21	0:44:14	0:44:31	0:00:17	EG	Transition	Project
Team A	10/9/2017	Week 5	22	0:44:33	0:44:44	0:00:11	SP	Transition	Project

Synthesis	L			F		A	A		Establish Expectations and Goals	Transition
Synthesis	F			L		A	A		Structure and Plan	Transition
Communication	F			L		A	A		Provide Resources	Action
Communication	F			L		A	A		Train and Develop	Transition
Synthesis	F			L		A	A		Structure and Plan	Transition
Decision Making	F			L		A	A		Solve Problems	Action
Communication	F			L		A	A		Sensemaking	Transition
Synthesis	F			L		A	A		Monitor and Guide Team Tasks	Action
Synthesis	F			L		A	A		Monitor and Guide Team Tasks	Action
Synthesis	F			L		A	A		Monitor and Guide Team Tasks	Action
Decision Making	F			L		A	A		Monitor and Guide Team Tasks	Action
Communication	F			L		A	A		Sensemaking	Transition
Communication		L		F	A		A		Provide Resources	Action
Analysis		L	F	F	A				Structure and Plan	Transition
Communication		F		L					Structure and Plan	Transition
Communication	F			L					Monitor and Guide Team Tasks	Action
Synthesis	F	L	F	F					Provide Resources	Action
Synthesis	L	F							Structure and Plan	Transition
Synthesis	F	L	F	F					Structure and Plan	Transition
Communication	L	F							Monitor and Guide Team Tasks	Action
Synthesis	F	L							Establish Expectations and Goals	Transition
Synthesis	F	L	F	F					Structure and Plan	Transition
Synthesis	L			F					Structure and Plan	Transition
Analysis	F			L					Manage Team Boundaries	Action
Analysis		L		F					Monitor and Guide Team Tasks	Action
Communication	L	F	F	F					Provide Resources	Action
Analysis	F	L	F	F					Performing Team Task	Action
Synthesis	F			L					Provide Feedback	Transition
Communication	F	L	F	F					Performing Team Task	Action
Decision Making	F	F		L					Provide Feedback	Transition
Analysis	F			L					Provide Resources	Action
Communication	L	F							Monitor and Guide Team Tasks	Action
Decision Making	F	L							Establish Expectations and Goals	Transition
Decision Making	L	F							Structure and Plan	Transition

Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented

Stated that they will do the sensitivity test in the meeting
Stated they should each do a sensitivity test independently and then compare results
Provides example of sensitivity analysis to teammate
Goes through an example of how to do a sensitivity analysis
States that each criteria should have a sensitivity analysis and that each person should do one. Do them individually and then come up with a group one
Comes up with a format for the entire team to prevent missunderstandings when analyzing the sensitivity analysis
Clarifying the importance and the impact of the sensitivity analysis
Letting person A know that they cannot start work yet, as the template is not ready yet
Finishes template and lets person a know they can start work
Updating template with formulas for easier calculations for entire team
States that cost should be inversed because you want to put a high value on a low cost
Elaborating how the sensitivity analysis will generate a concept from the morphological chart
Demonstrating a video of a concept that is similar to the team's design concept
States that Person B will present the FBD and have teammates check the work
States D is working on the motor selection
Bringing Person A up to speed on the tasks being done and sharing the resource from Person B
Offers to provide pump for demo (follows through at the end of the semester)
Offers the question of what needs to be done in the meeting/this week
States that Person B will present the FBD and have teammates check the work (assigns people to check work), assigns people to do other work, plans to c
Asks what the goals are for the meeting /week
States that the goals for the week are to establish two separate mechanism designs
States that even within one mechancism the teams can do separate feature designs
Asks person d to create the power point for the week so that more work can be added to it later
Discusses a conversation with a faculty member (non advier) regarding their function model
Explaining and helping Person C become familiar with the mechanism that will be used for the design
Took off work for the month of Nov. to help with the team build (time resource)
Presents work on FBD for feedback (explaining work to team)
Suggested using a bearing in the design for better function
Presents the 4 bar linkage mechanism to the team
States that the team should go with option A because of safety reasons
Finds an example problem to check their design agaisnt
Brings up the persentation to understand what the team will be presenting
Establishes goals for the presentation
Divides takes for person A and B for the next working chunk of the meeting

Team A	10/9/2017	Week 5	23	0:49:50	0:50:10	0:00:20	MG	Action	Project
Team A	10/9/2017	Week 5	24	0:03:43	0:04:24	0:00:41	SP	Transition	Solution
Team A	10/9/2017	Week 5	25	0:06:50	0:07:53	0:01:03	PF	Transition	Solution
Team A	10/9/2017	Week 5	26	0:14:05	0:15:00	0:00:55	SM	Transition	Problem
Team B	9/19/2017	Week 2	1	0:02:06	0:02:10	0:00:04	MB	Action	Project
Team B	9/19/2017	Week 2	2	0:13:57	0:16:26	0:02:29	PR	Action	Problem
Team B	9/19/2017	Week 2	3	0:16:28	0:16:52	0:00:24	PT	Action	Solution
Team B	9/19/2017	Week 2	4	0:16:52	0:17:42	0:00:50	SM	Transition	Problem
Team B	9/19/2017	Week 2	5	0:18:41	0:18:58	0:00:17	E	Interpersonal	Solution
Team B	9/19/2017	Week 2	6	0:19:19	0:20:07	0:00:48	SP	Transition	Solution
Team B	9/19/2017	Week 2	7	0:20:07	0:22:10	0:02:03	SM	Transition	Problem
Team B	9/19/2017	Week 2	8	0:24:00	0:24:05	0:00:05	PF	Transition	Problem
Team B	9/19/2017	Week 2	9	0:24:06	0:24:32	0:00:26	SM	Transition	Problem
Team B	9/19/2017	Week 2	10	0:24:37	0:24:58	0:00:21	SM	Transition	Problem
Team B	9/19/2017	Week 2	11	0:25:01	0:25:15	0:00:14	EG	Transition	Problem
Team B	9/19/2017	Week 2	12	0:25:40	0:25:50	0:00:10	SM	Transition	Solution
Team B	9/19/2017	Week 2	13	0:25:50	0:27:15	0:01:25	PF	Transition	Solution
Team B	9/19/2017	Week 2	14	0:27:25	0:27:35	0:00:10	SP	Transition	Project
Team B	9/19/2017	Week 2	15	0:27:57	0:28:26	0:00:29	PT	Action	Problem
Team B	9/19/2017	Week 2	16	0:28:26	0:30:09	0:01:43	SM	Transition	Problem
Team B	9/19/2017	Week 2	17	0:31:00	0:31:47	0:00:47	SM	Transition	Problem
Team B	9/19/2017	Week 2	18	0:31:47	0:32:10	0:00:23	PF	Transition	Problem
Team B	9/19/2017	Week 2	19	0:32:31	0:32:33	0:00:02	PF	Transition	Project
Team B	9/19/2017	Week 2	20	0:32:38	0:32:40	0:00:02	MB	Action	Problem
Team B	9/19/2017	Week 2	21	0:32:58	0:33:17	0:00:19	E	Interpersonal	Solution
Team B	9/19/2017	Week 2	22	0:32:58	0:33:30	0:00:32	PT	Action	Solution
Team B	9/19/2017	Week 2	23	0:33:31	0:36:30	0:02:59	SM	Transition	Solution
Team B	9/19/2017	Week 2	24	0:36:41	0:37:23	0:00:42	EG	Transition	Project
Team B	9/19/2017	Week 2	25	0:37:23	0:38:01	0:00:38	SP	Transition	Project
Team B	9/19/2017	Week 2	26	0:38:09	0:39:03	0:00:54	SM	Transition	Project
Team B	9/19/2017	Week 2	27	0:41:51	0:41:56	0:00:05	SP	Transition	Project
Team B	9/19/2017	Week 2	28	0:41:56	0:42:00	0:00:04	SP	Transition	Project
Team B	9/19/2017	Week 2	29	0:42:20	0:43:25	0:01:05	SM	Transition	Problem
Team B	9/19/2017	Week 2	30	0:43:39	0:45:16	0:01:37	CT	Transition	Problem

Communication		L	F						Monitor and Guide Team Tasks	Action
Analysis	F	L							Structure and Plan	Transition
Analysis		F		L					Provide Feedback	Transition
Decision Making	F	F	F	L					Sensemaking	Transition
Communication	L	F	F	F				A	Manage Team Boundaries	Action
Communication	L	F	F					A	Provide Resources	Action
Synthesis	F	L	F					A	Performing Team Task	Action
Communication	F	L	F					A	Sensemaking	Transition
Decision Making	L	F							Empowerment	Transition/Action
Synthesis	F	F		L					Structure and Plan	Transition
Communication	F	F		L					Sensemaking	Transition
Communication	F			L					Provide Feedback	Transition
Communication	L		F	F					Sensemaking	Transition
Communication	F		F	L					Sensemaking	Transition
Synthesis	L	F	F	F					Establish Expectations and Goals	Transition
Synthesis	L			F					Sensemaking	Transition
Synthesis	F		F	L					Provide Feedback	Transition
Decision Making	F		F	L					Structure and Plan	Transition
Synthesis	L		F						Performing Team Task	Action
Communication	F	F	L	F					Sensemaking	Transition
Communication	F		F	L					Sensemaking	Transition
Communication	F	L	F	F					Provide Feedback	Transition
Communication	L			F					Provide Feedback	Transition
Communication	F	F		L					Manage Team Boundaries	Action
Communication	F	F		L					Empowerment	Transition/Action
Synthesis			F	L					Performing Team Task	Action
Communication	F		L	F					Sensemaking	Transition
Synthesis	F			L					Establish Expectations and Goals	Transition
Synthesis	L		F	F					Structure and Plan	Transition
Analysis	F		L	F					Sensemaking	Transition
Synthesis	F			L					Structure and Plan	Transition
Synthesis	L			F					Structure and Plan	Transition
Decision Making	F		L	F					Sensemaking	Transition
Decision Making	F	L	F	F					Challenging the Team	Action

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Checking with teammate to see what they were working on and if they needed help
Expaining the calculations that were done, and has teammate independently check equations
Providing technial feedback that affected the FBD calculations - didn’t change outcome, but important to note it was accepted
Comes up with requirement of lift time (not stated as a requirement so it is listed in the solution phase)
Texted Person D to see if they were attending the team meeting.
Telling Person C what they missed at the trip to the plant.
Presents the dual drive concept
Clarifying why the device cannot be battery powered
Acknowledges that the dual drive is a good idea, but cannot be achieved due to the space constraints
Discusses how the team should break their system into different components and create a morphological chart
Interprets the customer's constraints as a way to use a conveyer system
Clarifies the requirement
Discusses functionality of device
Discusses functionality of device
Presents the idea of dual purpose system (load/unload)
How would this work due to constraints
Must have a way to go back in without hitting the outside
Cannot do the the ergonomic scoring today due to lack of material
Adding constraint
Discussing use of forklift and its effect on design
Claifying the two options for the general constaints / design possibilities
Presents the possibility space behind the unit
Gives good feedback that his text is ready
Sends message to sponsors
Says person B's concept is cool
Presents Pivot Point idea
Communicating the function of the previously presented solution
Explain how the team must present their data and show how they achieved their design
States that the team should use the design process provided by the advisers to communicate where they are in the process.
Interprets what the advisers want at the midterm
Plans to start excel spreadshee showing different design options
Goal to have team progress report done but the end of the meeting.
Discussing the mobility constraint/criteria and deciding it should be a criteria not a constraint
Says that the team should try to get the device over to the table. Thus saying the team should make concepts to achieve mobility.

Team B	9/19/2017	Week 2	31	0:45:17	0:46:20	0:01:03	PF	Transition	Problem
Team B	9/19/2017	Week 2	32	0:46:20	0:47:06	0:00:46	SM	Transition	Problem
Team B	9/19/2017	Week 2	33	0:47:45	0:48:04	0:00:19	TD	Transition	Problem
Team B	9/19/2017	Week 2	34	0:49:46	0:49:53	0:00:07	SM	Transition	Project
Team B	9/19/2017	Week 2	35	0:51:22	0:51:45	0:00:23	EG	Transition	Project
Team B	9/19/2017	Week 2	36	0:00:59	0:01:25	0:00:26	EG	Transition	Project
Team B	9/19/2017	Week 2	37	0:01:25	0:01:45	0:00:20	SM	Transition	Problem
Team B	9/19/2017	Week 2	38	0:04:11	0:04:26	0:00:15	MG	Action	Project
Team B	9/19/2017	Week 2	39	0:04:45	0:05:39	0:00:54	DM	Transition	Project
Team B	9/19/2017	Week 2	40	0:05:35	0:05:47	0:00:12	SSC	Interpersonal	Project
Team B	9/19/2017	Week 2	41	0:08:13	0:08:20	0:00:07	MG	Action	Project
Team B	9/19/2017	Week 2	42	0:09:30	0:09:35	0:00:05	SP	Transition	Project
Team B	9/27/2017	Week 3	1	0:06:20	0:06:34	0:00:14	SP	Transition	Project
Team B	9/27/2017	Week 3	2	0:07:07	0:07:36	0:00:29	SP	Transition	Project
Team B	9/27/2017	Week 3	3	0:07:39	0:07:59	0:00:20	SP	Transition	Project
Team B	9/27/2017	Week 3	4	0:08:00	0:08:15	0:00:15	SM	Transition	Project
Team B	9/27/2017	Week 3	5	0:08:16	0:08:18	0:00:02	SP	Transition	Project
Team B	9/27/2017	Week 3	6	0:08:19	0:08:40	0:00:21	EG	Transition	Project
Team B	9/27/2017	Week 3	7	0:10:05	0:10:30	0:00:25	MB	Action	Project
Team B	9/27/2017	Week 3	8	0:10:40	0:14:00	0:03:20	SM	Transition	Project
Team B	9/27/2017	Week 3	9	0:18:40	0:19:50	0:01:10	SP	Transition	Project
Team B	9/27/2017	Week 3	10	0:19:51	0:21:10	0:01:19	PF	Transition	Problem
Team B	9/27/2017	Week 3	11	0:25:33	0:26:18	0:00:45	MB	Action	Project
Team B	9/27/2017	Week 3	12	0:26:19	0:26:40	0:00:21	TD	Transition	Solution
Team B	9/27/2017	Week 3	13	0:30:16	0:31:45	0:01:29	SM	Transition	Solution
Team B	9/27/2017	Week 3	14	0:31:48	0:32:13	0:00:25	EG	Transition	Project
Team B	9/27/2017	Week 3	15	0:32:23	0:33:33	0:01:10	EG	Transition	Project
Team B	9/27/2017	Week 3	16	0:36:08	0:36:10	0:00:02	SP	Transition	Project
Team B	9/27/2017	Week 3	17	0:36:11	0:38:00	0:01:49	PR	Action	Solution
Team B	9/27/2017	Week 3	18	0:38:17	0:39:30	0:01:13	SM	Transition	Project
Team B	9/27/2017	Week 3	19	0:39:31	0:40:40	0:01:09	PT	Action	Solution
Team B	9/27/2017	Week 3	20	0:40:41	0:42:55	0:02:14	SM	Transition	Solution
Team B	9/27/2017	Week 3	21	0:43:23	0:43:55	0:00:32	EG	Transition	Solution
Team B	9/27/2017	Week 3	22	0:47:26	0:48:00	0:00:34	SM	Transition	Solution

Decision Making	L	F	F	F					Provide Feedback	Transition
Communication	F	F		L					Sensemaking	Transition
Communication	F	F	F	L					Train and Develop	Transition
Communication	L		F	F		A			Sensemaking	Transition
Synthesis	F			L					Establish Expectations and Goals	Transition
Synthesis	F	F	F	L					Establish Expectations and Goals	Transition
Decision Making	F	F		L					Sensemaking	Transition
Synthesis	L	F	F	F					Monitor and Guide Team Tasks	Action
Synthesis	F		L	F					Define Mission	Transition
Communication	L	F	F						Support Social Climate	Action
Communication	L			F					Monitor and Guide Team Tasks	Action
Synthesis	L	F	F	F					Structure and Plan	Transition
Synthesis	L	F	F					A	Structure and Plan	Transition
Synthesis	L	F	F					A	Structure and Plan	Transition
Synthesis	F		L					A	Structure and Plan	Transition
Synthesis	L		F					A	Sensemaking	Transition
Synthesis	F	L						A	Structure and Plan	Transition
Synthesis	L	F	F					A	Establish Expectations and Goals	Transition
Communication	F	L						A	Manage Team Boundaries	Action
Communication	F	F	L					A	Sensemaking	Transition
Synthesis	L	F	F	F					Structure and Plan	Transition
Synthesis	F	L							Provide Feedback	Transition
Synthesis		L	F						Manage Team Boundaries	Action
Synthesis	F			L					Train and Develop	Transition
Communication	F			L					Sensemaking	Transition
Synthesis	L		F	F					Establish Expectations and Goals	Transition
Decision Making	F		F	L					Establish Expectations and Goals	Transition
Synthesis	L	F	F	F					Structure and Plan	Transition
Decision Making		F	F	L					Provide Resources	Action
Decision Making	L	F	F	F					Sensemaking	Transition
Synthesis		F	F	L					Performing Team Task	Action
Communication		F	F	L					Sensemaking	Transition
Decision Making		F	F	L					Establish Expectations and Goals	Transition
Communication		F	F	L					Sensemaking	Transition

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States that the team should try to integrate moving the device, but as a possibility not a final design choice
Clarifying that the team will aim to move the device out from under the laser cutter, but criteria is to guide it to the tables
Trains Person B on the importance of must/should when doing constraints and criteria
Claifies that the ergonomic score must be the smallest number (per feedback from the advisers on a progress report that was unclear)
States that the team should be more consistent in their language of constraints and criteria
States how the team should actually phrase the requirements moving forward
Discuss that the team should not throwout the no-pinch points requirment because of the advisers feedback.
Brings the team back on task
Teaking the problem statement
Jokes about the advisers reacting to the new problem statement
Brings the team back on task
Says the whole team needs to do the weekly report right now
Says that they should change their tasks and the functional diagram
States that person A will change the function structure format (lines)
States that the team should show the concepts and place under functions in the function structure
States that the team received feedback that he should do the black box (from adviser)
States that the team needs to update the gnat chart
Creates the goal that the team needs to do the black box per the advisers' feedback
Talking about what the other team's perspective is
Discussing how the advisers and sponsor are on different pages in the project and what the expectations are for the team
Comes up with the plan for what needs to be done in the current meeting
Provided feedback on how to do the black box model
Goes to see if a graduate student knows where the graduate adviser's office are
Provides technical feedback on function structure (formatting)
Clarifying the function structure format that was introduced in the previous code
Presents goals for the meeting today
Discusses how to present the concepts in the presentation (establishing the expectation of how to do it)
States that he/she will start making presentation
Researches how to perform weighted analysis, provides demonstration from previous class (4010)
States that the team should quickly present the problem statement without going into detail
Performed weighting
Demonstrated how the weighting was done and how to do evaluate the solutions based off of the weighting
Describes how to rate each solution based off of the weighting
Clarifying what travel automation is

Team B	9/27/2017	Week 3	23	0:48:08	0:52:31	0:04:23	SM	Transition	Problem
Team B	9/27/2017	Week 3	24	0:00:00	0:01:20	0:01:20	PF	Transition	Problem
Team B	9/27/2017	Week 3	25	0:02:20	0:03:10	0:00:50	PF	Transition	Solution
Team B	9/27/2017	Week 3	26	0:04:03	0:04:20	0:00:17	SP	Transition	Project
Team B	9/27/2017	Week 3	27	0:04:21	0:04:38	0:00:17	PT	Action	Problem
Team B	9/27/2017	Week 3	28	0:04:39	0:04:56	0:00:17	PF	Transition	Problem
Team B	9/27/2017	Week 3	29	0:04:57	0:05:08	0:00:11	PT	Action	Problem
Team B	9/27/2017	Week 3	30	0:05:09	0:05:13	0:00:04	PF	Transition	Problem
Team B	10/3/2017	Week 4	1	0:02:41	0:02:57	0:00:16	MG	Action	Project
Team B	10/3/2017	Week 4	2	0:02:58	0:03:20	0:00:22	MB	Action	Project
Team B	10/3/2017	Week 4	3	0:03:21	0:03:40	0:00:19	EG	Transition	Project
Team B	10/3/2017	Week 4	4	0:03:40	0:03:52	0:00:12	MG	Action	Project
Team B	10/3/2017	Week 4	5	0:04:02	0:05:00	0:00:58	MB	Action	Project
Team B	10/3/2017	Week 4	6	0:05:00	0:05:46	0:00:46	MB	Action	Project
Team B	10/3/2017	Week 4	7	0:05:47	0:06:20	0:00:33	MB	Action	Project
Team B	10/3/2017	Week 4	8	0:07:36	0:08:00	0:00:24	MB	Action	Project
Team B	10/3/2017	Week 4	9	0:19:55	0:20:15	0:00:20	MG	Action	Project
Team B	10/3/2017	Week 4	10	0:26:18	0:26:34	0:00:16	MG	Action	Project
Team B	10/3/2017	Week 4	11	0:26:48	0:27:07	0:00:19	SP	Transition	Project
Team B	10/3/2017	Week 4	12	0:27:07	0:28:26	0:01:19	SM	Transition	Project
Team B	10/3/2017	Week 4	13	0:28:40	0:29:11	0:00:31	MG	Action	Project
Team B	10/3/2017	Week 4	14	0:29:35	0:29:44	0:00:09	PF	Transition	Project
Team B	10/3/2017	Week 4	15	0:30:00	0:30:05	0:00:05	SP	Transition	Project
Team B	10/3/2017	Week 4	16	0:31:40	0:32:23	0:00:43	PF	Transition	Project
Team B	10/3/2017	Week 4	17	0:33:13	0:33:45	0:00:32	SM	Transition	Solution
Team B	10/3/2017	Week 4	18	0:33:45	0:33:47	0:00:02	EG	Transition	Project
Team B	10/3/2017	Week 4	19	0:33:47	0:33:50	0:00:03	SP	Transition	Project
Team B	10/3/2017	Week 4	20	0:34:50	0:35:02	0:00:12	SP	Transition	Project
Team B	10/3/2017	Week 4	21	0:35:15	0:35:23	0:00:08	MG	Action	Project
Team B	10/3/2017	Week 4	22	0:35:35	0:35:48	0:00:13	MB	Action	Project
Team B	10/3/2017	Week 4	23	0:37:35	0:37:51	0:00:16	MG	Action	Project
Team B	10/3/2017	Week 4	24	0:39:24	0:39:52	0:00:28	SM	Transition	Project
Team B	10/3/2017	Week 4	25	0:39:52	0:41:13	0:01:21	SM	Transition	Solution
Team B	10/3/2017	Week 4	26	0:48:14	0:48:19	0:00:05	MG	Action	Project

Decision Making	F	F	F	L					Sensemaking	Transition
Decision Making	F	L	F	F					Provide Feedback	Transition
Synthesis		F	F	L					Provide Feedback	Transition
Synthesis	L	F							Structure and Plan	Transition
Analysis	F	F	F	L					Performing Team Task	Action
Synthesis		F	L	F					Provide Feedback	Transition
Analysis	F	F	F	L					Performing Team Task	Action
Synthesis			F	L					Provide Feedback	Transition
Communication	L		F			A		A	Monitor and Guide Team Tasks	Action
Communication	L		F			A		A	Manage Team Boundaries	Action
Synthesis	L		F			A		A	Establish Expectations and Goals	Transition
Communication	L		F			A		A	Monitor and Guide Team Tasks	Action
Communication	F	L	F					A	Manage Team Boundaries	Action
Communication	L	F	F					A	Manage Team Boundaries	Action
Communication	F	L	F					A	Manage Team Boundaries	Action
Communication	L	F	F					A	Manage Team Boundaries	Action
Communication		F	F	L	A				Monitor and Guide Team Tasks	Action
Communication			F	L	A				Monitor and Guide Team Tasks	Action
Synthesis			L	F	A				Structure and Plan	Transition
Communication	L	F	F	F					Sensemaking	Transition
Communication	L	F	F	F					Monitor and Guide Team Tasks	Action
Decision Making	F		L	F		A			Provide Feedback	Transition
Synthesis	F		L	F		A			Structure and Plan	Transition
Communication	F		L	F		A			Provide Feedback	Transition
Communication	F	F	F	L					Sensemaking	Transition
Communication		L		F					Establish Expectations and Goals	Transition
Communication		F	F	L					Structure and Plan	Transition
Synthesis		L		F					Structure and Plan	Transition
Communication	L	F							Monitor and Guide Team Tasks	Action
Communication		L	F	F					Manage Team Boundaries	Action
Communication		F	L						Monitor and Guide Team Tasks	Action
Communication	L	F							Sensemaking	Transition
Decision Making		F	F	L					Sensemaking	Transition
Communication		F	L	F					Monitor and Guide Team Tasks	Action

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Recommends that the criteria about moving to tables should be removed and then defends why it should be removed
States that the criteria should not be removed, but the weight should be as low as possible so that it is still captured, but not important
States that the concepts should be evaluated for cost
States that Person B and Person A should update the gnatt chart next
Updated criteria to include only what the team wants to evaluate their concepts off of
Offers to include adaptability in the criteria
Updated criteria to include only what the team wants to evaluate their concepts off of
Suggests that the criteria should include safety
Updating tasks and information
Updating on feedback from sponsor and advisers
Goals for the meeting are finish progress report and finish preentation
Checks with person C to understand if person D is coming to the meeting
Reports back on a conversation with the adviser regarding prototype space
Reports back on a conversation with a different team
Continues discussing conversation from the adviser
Goes to talk to adviser
Brings team back on task regarding the progress report
Brings team back on task regarding the progress report
Morph Chart is due Thursday
Interprets and presents feedback from conversation with adviser
Checks on status of progress report and if team members have reviewed it
Changed future task to refine weighted analysis
States that teams needs to do the weighted analysis by Thursday
Provides feedback on progress report
States that the team should not be using the weighted analysis to select a concept, but only to remove bad ones
States that the team will down select to one solution in october (end of october)
States the he will begin adding weighted analysis totals up
Will begin working on weighted analysis total as well
Checking to see on the status of the presentation and if the team has started it
Stating the team should reach out to the sponsor to try and get them to respond to an email
Make sure that both team members are not working on the same thing
Making sense of the feedback from the advisers regarding the agenda slide
Clarifying how the weighted analysis should be done
Make sure that both team members are not working on the same thing

Team B	10/3/2017	Week 4	27	0:49:48	0:50:00	0:00:12	SM	Transition	Solution
Team B	10/3/2017	Week 4	28	0:05:15	0:07:52	0:02:37	SPS	Action	Solution
Team B	10/10/2017	Week 5	1	0:02:00	0:03:00	0:01:00	SM	Transition	Solution
Team B	10/10/2017	Week 5	2	0:03:37	0:03:40	0:00:03	SP	Transition	Project
Team B	10/10/2017	Week 5	3	0:03:50	0:04:00	0:00:10	SM	Transition	Solution
Team B	10/10/2017	Week 5	4	0:04:49	0:04:56	0:00:07	SP	Transition	Project
Team B	10/10/2017	Week 5	5	0:04:56	0:05:43	0:00:47	MB	Action	Project
Team B	10/10/2017	Week 5	6	0:08:30	0:08:55	0:00:25	MG	Action	Project
Team B	10/10/2017	Week 5	7	0:08:56	0:10:03	0:01:07	SP	Transition	Project
Team B	10/10/2017	Week 5	8	0:10:45	0:11:20	0:00:35	SP	Transition	Project
Team B	10/10/2017	Week 5	9	0:14:30	0:16:10	0:01:40	ESM	Action	Project
Team B	10/10/2017	Week 5	10	0:16:32	0:17:05	0:00:33	SM	Transition	Solution
Team B	10/10/2017	Week 5	11	0:18:04	0:18:22	0:00:18	ESM	Action	Solution
Team B	10/10/2017	Week 5	12	0:18:23	0:21:47	0:03:24	SM	Transition	Project
Team B	10/10/2017	Week 5	13	0:21:48	0:22:08	0:00:20	SM	Transition	Project
Team B	10/10/2017	Week 5	14	0:22:09	0:24:30	0:02:21	SP	Transition	Project
Team B	10/10/2017	Week 5	15	0:24:49	0:27:50	0:03:01	SM	Transition	Solution
Team B	10/10/2017	Week 5	16	0:28:50	0:29:47	0:00:57	SP	Transition	Project
Team B	10/10/2017	Week 5	17	0:29:49	0:31:06	0:01:17	SM	Transition	Project
Team B	10/10/2017	Week 5	18	0:32:00	0:33:12	0:01:12	SP	Transition	Project
Team B	10/10/2017	Week 5	19	0:33:13	0:33:49	0:00:36	PR	Action	Project
Team B	10/10/2017	Week 5	20	0:33:50	0:33:58	0:00:08	SP	Transition	Project
Team B	10/10/2017	Week 5	21	0:34:59	0:01:24	0:01:46	SP	Transition	Project
Team B	10/10/2017	Week 5	22	0:01:39	0:03:00	0:01:21	PR	Action	Solution
Team B	10/10/2017	Week 5	23	0:02:55	0:04:03	0:01:08	SP	Transition	Project
Team B	10/10/2017	Week 5	24	0:04:04	0:07:25	0:03:21	SP	Transition	Project
Team B	10/10/2017	Week 5	25	0:08:45	0:10:20	0:01:35	MG	Action	Problem
Team B	10/10/2017	Week 5	26	0:11:44	0:12:00	0:00:16	MG	Action	Project
Team B	10/10/2017	Week 5	27	0:12:15	0:12:33	0:00:18	SP	Transition	Solution
Team B	10/10/2017	Week 5	28	0:13:05	0:13:30	0:00:25	PF	Transition	Problem
Team B	10/10/2017	Week 5	29	0:13:47	0:17:48	0:04:01	SM	Transition	Solution
Team B	10/10/2017	Week 5	30	0:17:52	0:18:00	0:00:08	MG	Action	Project
Team B	10/10/2017	Week 5	31	0:22:44	0:22:48	0:00:04	MG	Action	Project
Team B	10/10/2017	Week 5	32	0:22:49	0:26:30	0:03:41	ESM	Action	Project

Communication		F	F	L					Sensemaking	Transition
Synthesis			F	L					Solve Problems	Action
Synthesis	L		F						Sensemaking	Transition
Synthesis	L	F	F	F					Structure and Plan	Transition
Decision Making	F		L						Sensemaking	Transition
Synthesis			L	F					Structure and Plan	Transition
Synthesis			F	L					Manage Team Boundaries	Action
Communication	F	F	F	L					Monitor and Guide Team Tasks	Action
Synthesis	F	F	L	F					Structure and Plan	Transition
Synthesis	F	F	L	F					Structure and Plan	Transition
Synthesis	F	F	L	F					Encourage Team Self Management	Action
Decision Making	F		L						Sensemaking	Transition
Decision Making	F			L					Encourage Team Self Management	Action
Communication	F	F	L	F					Sensemaking	Transition
Communication	F			L					Sensemaking	Transition
Synthesis	F	F	L	F					Structure and Plan	Transition
Communication	F	F	L	F					Sensemaking	Transition
Synthesis	F		L						Structure and Plan	Transition
Decision Making		F	L	F					Sensemaking	Transition
Synthesis	F		L	F					Structure and Plan	Transition
Communication		L	F	F					Provide Resources	Action
Synthesis	F		L						Structure and Plan	Transition
Communication	F		F	L					Structure and Plan	Transition
Communication	F	F	L	F					Provide Resources	Action
Synthesis	F		L	F					Structure and Plan	Transition
Synthesis	F		L	F					Structure and Plan	Transition
Communication	F	L	F	F					Monitor and Guide Team Tasks	Action
Communication	F	F	L	F					Monitor and Guide Team Tasks	Action
Communication	F	F	L	F					Structure and Plan	Transition
Communication	F	L		F					Provide Feedback	Transition
Synthesis	F	F	L	F					Sensemaking	Transition
Communication	F	F	L	F					Monitor and Guide Team Tasks	Action
Communication	L	F	F	F					Monitor and Guide Team Tasks	Action
Synthesis	F	F	L	F					Encourage Team Self Management	Action

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Clarified how to select between multiple options in the weighted analysis
Fixed a problem with the teammates excel code
Presenting and interpreting a faculty member's advice for their function model
Stated that the team should no longer make changes to the function model
Interpreting feedback from advisers for function structure appearance edits
States that the team needs to reach out to the sponsor regarding the ergonomic scoring
Sends message to sponsor
states what is the team doing for the progress report (brining the team back no task)
States plan for peoples task and that the team has to finish the pds
States that the team needs to list individuals for tasks due
Encourages team members to set up their own tasks for the progress report
States that the team should not have a drive train due to the complexity
States that its up to Person A to determine the number of motors
Clarifying that the teammates needs to identify goals that will show their concept has well thought out math behind it to support their claim as a design sc
Further clarifying how teammates should select their goals
States that the team should categorize all their calculations goals via each subsystem as a team on the board and then synthesizing the goals
Clarifying the function of the device in regards to safety
Creating additional calculations that are required for each subsystem
Down selecting concepts based on the advisers' feedback
Continues to establish a plan of things that need to be done for each subsystem
Prodivides resouce example
Establishes that mounting needs to be considered
Creating a plan of activities for the HMI
Providing an example of how to do a HMI
Come up with three panel concepts and CAD drawings
Coming up with plan of action for electronics and integration
Bringing the team back on track with a discussion regarding a criteria
Checking to see if anything else is needed for electronics
Clarifies that the safety system is separate than the other systems, despite that it works to guard them
States that the sponsor's light curtain does not effect their team's at this point
Clarifying how the team's light curtain would work and expanding curtain idea is presented and accepted
Keeps team on task after the light curtain discussion
Brings team back on track
Encourages team members to set up the due dates and timelines for the tasks for their specific subsections

Team C	9/13/2017	Week 1	1	0:00:30	0:01:15	0:00:45	SM	Transition	Project
Team C	9/13/2017	Week 1	2	0:02:46	0:02:50	0:00:04	MG	Action	Project
Team C	9/13/2017	Week 1	3	0:04:05	0:04:11	0:00:06	DM	Transition	Problem
Team C	9/13/2017	Week 1	4	0:07:25	0:07:57	0:00:32	SM	Transition	Project
Team C	9/13/2017	Week 1	5	0:08:04	0:08:24	0:00:20	SP	Transition	Project
Team C	9/13/2017	Week 1	6	0:11:06	0:11:24	0:00:18	MG	Action	Project
Team C	9/13/2017	Week 1	7	0:12:53	0:13:38	0:00:45	EG	Transition	Project
Team C	9/13/2017	Week 1	8	0:14:00	0:14:45	0:00:45	SM	Transition	Project
Team C	9/13/2017	Week 1	9	0:14:45	0:14:56	0:00:11	MB	Action	Project
Team C	9/13/2017	Week 1	10	0:15:52	0:16:29	0:00:37	SM	Transition	Project
Team C	9/13/2017	Week 1	11	0:20:12	0:20:20	0:00:08	SP	Transition	Project
Team C	9/13/2017	Week 1	12	0:20:21	0:20:42	0:00:21	PF	Transition	Project
Team C	9/13/2017	Week 1	13	0:20:43	0:21:19	0:00:36	SP	Transition	Project
Team C	9/13/2017	Week 1	14	0:21:20	0:21:34	0:00:14	PF	Transition	Project
Team C	9/13/2017	Week 1	15	0:21:35	0:22:50	0:01:15	PF	Transition	Project
Team C	9/13/2017	Week 1	16	0:23:25	0:24:40	0:01:15	SM	Transition	Project
Team C	9/13/2017	Week 1	17	0:26:07	0:26:17	0:00:10	MG	Action	Project
Team C	9/13/2017	Week 1	18	0:26:18	0:26:40	0:00:22	SP	Transition	Solution
Team C	9/13/2017	Week 1	19	0:29:40	0:30:10	0:00:30	PT	Action	Project
Team C	9/13/2017	Week 1	20	0:31:38	0:32:00	0:00:22	SM	Transition	Project
Team C	9/13/2017	Week 1	21	0:35:03	0:35:14	0:00:11	SM	Transition	Project
Team C	9/13/2017	Week 1	22	0:35:15	0:35:34	0:00:19	SM	Transition	Project
Team C	9/13/2017	Week 1	23	0:37:14	0:39:05	0:01:51	PF	Transition	Project
Team C	9/13/2017	Week 1	24	0:40:37	0:41:30	0:00:53	PF	Transition	Project
Team C	9/13/2017	Week 1	25	0:45:34	0:46:14	0:00:40	PF	Transition	Project
Team C	9/13/2017	Week 1	26	0:00:56	0:01:30	0:00:34	PF	Transition	Project
Team C	9/20/2017	Week 2	1	0:01:44	0:03:57	0:02:13	SP	Transition	Project
Team C	9/20/2017	Week 2	2	0:05:40	0:05:51	0:00:11	MG	Action	Project
Team C	9/20/2017	Week 2	3	0:08:36	0:09:10	0:00:34	MG	Action	Project
Team C	9/20/2017	Week 2	4	0:11:00	0:12:13	0:01:13	PT	Action	Project
Team C	9/20/2017	Week 2	5	0:14:02	0:14:22	0:00:20	SM	Transition	Project
Team C	9/20/2017	Week 2	6	0:15:00	0:19:30	0:04:30	PT	Action	Solution
Team C	9/20/2017	Week 2	7	0:20:27	0:20:33	0:00:06	SP	Transition	Project
Team C	9/20/2017	Week 2	8	0:23:19	0:23:44	0:00:25	SM	Transition	Problem

Communication	L		F	F		A			Sensemaking	Transition
Communication		F	L			A			Monitor and Guide Team Tasks	Action
Decision Making	L		F			A			Define Mission	Transition
Communication	F		L			A			Sensemaking	Transition
Synthesis	F		L			A			Structure and Plan	Transition
Synthesis	F	F	L			A			Monitor and Guide Team Tasks	Action
Synthesis	F	L	F						Establish Expectations and Goals	Transition
Communication	L		F						Sensemaking	Transition
Communication		F	L						Manage Team Boundaries	Action
Communication	F	F	L	F					Sensemaking	Transition
Synthesis	L		F						Structure and Plan	Transition
Synthesis	F		F	L					Provide Feedback	Transition
Synthesis	L		F	F					Structure and Plan	Transition
Synthesis	F		F	L					Provide Feedback	Transition
Synthesis	F	L	F	F					Provide Feedback	Transition
Communication	L	F	F	F					Sensemaking	Transition
Communication	L	F	F						Monitor and Guide Team Tasks	Action
Communication		L	F						Structure and Plan	Transition
Communication	F	L	F						Performing Team Task	Action
Communication	F	L	F						Sensemaking	Transition
Communication		F	L						Sensemaking	Transition
Synthesis	F	L	F						Sensemaking	Transition
Communication	F	L	F						Provide Feedback	Transition
Communication		L		F					Provide Feedback	Transition
Communication	L	F	F						Provide Feedback	Transition
Communication	F	L							Provide Feedback	Transition
Decision Making	F	L		F					Structure and Plan	Transition
Communication	L		F						Monitor and Guide Team Tasks	Action
Communication	L	F		F					Monitor and Guide Team Tasks	Action
Communication	L	F	F	F					Performing Team Task	Action
Communication	L		F	F					Sensemaking	Transition
Synthesis	F	L	F	F					Performing Team Task	Action
Communication			L	F					Structure and Plan	Transition
Decision Making		L	F						Sensemaking	Transition

Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented

Raises the issue that the advisers have not given guidelines for presentations and content
Communicates with teammate who is on the way and not at the meeting
Says to remain with the current problem statement until they receive other feedback
Telling person A the length of the presentations for the design reviews
Says that the team should present the progress report and a plan for future work
While Per C's computer was not working, they checked on the progress on the team on creating the power point
States what the team should include on this weeks presentation
States that the presentation is up to what the advisers want and that there is a lot of ambiguity
States that they will reach out to a member of another team to understand what is expected for the presentation
Clarifies the time the team has to present and the time they have for Q&A with the advisers
Planning out the agenda and outline for the presentation
Says that the outline should start with some of the research that the team has done vs. just the problem statement
Continues to plan the presentation
States that the team should have plans for the future in the presentation
Says that the tasks should be arranged completed and then future and also says there should be info about team roles
Leads discussion regarding the projects overall budget and how end devliverables will be effected
Brings the team back on task
States that next week after the visit, the team will have concepts to solve the problem
States that the team could talk about the current machines that textron uses in the background sections (brining the team back on task)
Questions whether the slides can be tweaked after they are turned in. Also tells the team the slides are due.
Per B brings the group back on track and presents mixed adviser requests for timing, Per C decides with the earliest time
Interprets that the team needs a photo for their cover slide
Lists ideas for the background section for Per. A
States that the team needs a slide on the background of the problem
Team should remove some cost information from the presentation because of the ambiguity of the project state
Says that the team should move the problem statement after the problem statement background slide
States wants some concept development in the powerpoint, but then offers it to be done next week
Brings the team back on task by asking them where should the Function model go in the presentation
Organizing who is doing what in the presentation (gnatt outline and agenda)
Reorganizing the presentation
Changing presentation based off of feedback from advisers
Modifying Function strucuture with team input
Assigning themselve a part of the presentation to complete
Determining how to number the constrains and criteria

Team C	9/20/2017	Week 2	9	0:26:25	0:27:07	0:00:42	SSC	Interpersonal	Problem
Team C	9/20/2017	Week 2	10	0:36:49	0:37:10	0:00:21	PF	Transition	Project
Team C	9/20/2017	Week 2	11	0:40:06	0:40:15	0:00:09	MG	Action	Project
Team C	9/20/2017	Week 2	12	0:41:54	0:42:17	0:00:23	SP	Transition	Project
Team C	9/20/2017	Week 2	13	0:42:45	0:43:28	0:00:43	PF	Transition	Project
Team C	9/20/2017	Week 2	14	0:45:25	0:46:30	0:01:05	MG	Action	Project
Team C	9/20/2017	Week 2	15	0:46:52	0:47:07	0:00:15	E	Interpersonal	Project
Team C	9/20/2017	Week 2	16	0:47:30	0:48:00	0:00:30	MG	Action	Project
Team C	9/20/2017	Week 2	17	0:49:59	0:50:12	0:00:13	SP	Transition	Project
Team C	9/20/2017	Week 2	18	0:50:25	0:50:45	0:00:20	PF	Transition	Project
Team C	9/20/2017	Week 2	19	0:01:00	0:01:08	0:00:08	PF	Transition	Project
Team C	9/20/2017	Week 2	20	0:04:09	0:04:40	0:00:31	PF	Transition	Project
Team C	9/20/2017	Week 2	21	0:07:30	0:07:55	0:00:25	MG	Action	Project
Team C	9/27/2017	Week 3	1	0:16:39	0:17:10	0:00:31	MG	Action	Project
Team C	9/27/2017	Week 3	2	0:17:23	0:18:30	0:01:07	EG	Transition	Project
Team C	9/27/2017	Week 3	3	0:19:15	0:20:33	0:01:18	SM	Transition	Solution
Team C	9/27/2017	Week 3	4	0:20:42	0:21:10	0:00:28	E	Interpersonal	Solution
Team C	9/27/2017	Week 3	5	0:22:00	0:22:45	0:00:45	MB	Action	Solution
Team C	9/27/2017	Week 3	6	0:22:49	0:23:20	0:00:31	SM	Transition	Problem
Team C	9/27/2017	Week 3	7	0:23:42	0:23:50	0:00:08	MG	Action	Solution
Team C	9/27/2017	Week 3	8	0:24:07	0:24:34	0:00:27	MB	Action	Project
Team C	9/27/2017	Week 3	9	0:24:35	0:24:39	0:00:04	PR	Action	Project
Team C	9/27/2017	Week 3	10	0:24:57	0:25:36	0:00:39	PF	Transition	Solution
Team C	9/27/2017	Week 3	11	0:26:43	0:26:47	0:00:04	SP	Transition	Solution
Team C	9/27/2017	Week 3	12	0:27:31	0:27:48	0:00:17	SSC	Interpersonal	Project
Team C	9/27/2017	Week 3	13	0:28:55	0:29:05	0:00:10	MG	Action	Solution
Team C	9/27/2017	Week 3	14	0:30:50	0:32:00	0:01:10	SM	Transition	Solution
Team C	10/4/2017	Week 4	1	0:01:50	0:02:30	0:00:40	MG	Action	Project
Team C	10/4/2017	Week 4	2	0:05:25	0:05:56	0:00:31	MG	Action	Project
Team C	10/4/2017	Week 4	3	0:06:11	0:06:22	0:00:11	SP	Transition	Project
Team C	10/4/2017	Week 4	4	0:07:14	0:07:18	0:00:04	SP	Transition	Project
Team C	10/4/2017	Week 4	5	0:07:18	0:07:24	0:00:06	EG	Transition	Project
Team C	10/4/2017	Week 4	6	0:09:50	0:09:55	0:00:05	MG	Action	Project
Team C	10/4/2017	Week 4	7	0:10:18	0:11:00	0:00:42	SM	Transition	Project

Communication	F	F	L	F					Support Social Climate	Action
Communication	L	F							Provide Feedback	Transition
Communication	F	L	F						Monitor and Guide Team Tasks	Action
Communication	F	L	F						Structure and Plan	Transition
Communication	L	F	F						Provide Feedback	Transition
Communication	L		F	F					Monitor and Guide Team Tasks	Action
Communication	L			F					Empowerment	Transition/Action
Communication	L		F	F					Monitor and Guide Team Tasks	Action
Communication		L		F					Structure and Plan	Transition
Communication	L		F	F					Provide Feedback	Transition
Communication	F		L						Provide Feedback	Transition
Communication	F	F	F	L					Provide Feedback	Transition
Communication	F	F	L						Monitor and Guide Team Tasks	Action
Communication	L	F		F			A		Monitor and Guide Team Tasks	Action
Synthesis	F	L							Establish Expectations and Goals	Transition
Decision Making	F	L		F					Sensemaking	Transition
Synthesis	F			L					Empowerment	Transition/Action
Communication	L	F	F	F					Manage Team Boundaries	Action
Communication	F		L						Sensemaking	Transition
Communication	L	F		F					Monitor and Guide Team Tasks	Action
Communication	F	F	L	F					Manage Team Boundaries	Action
Communication	F	F	L	F					Provide Resources	Action
Decision Making	L			F					Provide Feedback	Transition
Decision Making	L		F						Structure and Plan	Transition
Communication	F		L	F					Support Social Climate	Action
Communication	F	F		L					Monitor and Guide Team Tasks	Action
Synthesis	L	F		F					Sensemaking	Transition
Communication	L		F	F					Monitor and Guide Team Tasks	Action
Communication	F		L	F					Monitor and Guide Team Tasks	Action
Synthesis	L	F	F	F					Structure and Plan	Transition
Synthesis	L		F						Structure and Plan	Transition
Synthesis	F		L						Establish Expectations and Goals	Transition
Communication			F	L					Monitor and Guide Team Tasks	Action
Decision Making	L		F	F					Sensemaking	Transition

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Jokes about team roles
Providing feedback on how to make the presentation better
States that the team should put the presentation up on the screen to test the formatting
States that if it is blurry they can spend time on it tomorrow to fix it.
States that the team should put the pdf file alone so that it is more clear to read
Checking the status of various slides in the presentation and the various tasks completed
Says that Person D did a good job on the gnatt outline
Checking on the formatting of slides
Needs to have a function model
Providing feedback on how to make the presentation formatting concise
Slide titles need to be changed
Suggests change of picture on the title
Test presentation on screen for formatting
Starts off meeting by bringing up the power point and checking the status
States that the team should come up with ideas for certain functions for a morph chart (this week), evaluate concepts (next week), model in the future
Making sense of the feedback regarding the function model
States that an overhead crane is a great lifting mechanism (idea from another teammate (A))
Discusses an idea that Team B was working with
Elaborates on the current process
Brings the team back on task
Liaising with sponsor regarding questions that they answered
Sends out response to the team
Providing feedback on how to fill out morph chart (stay generic with concepts, not specific)
States to focus on the lift mechanism before trying other options
States that the advisers held on to the responses for 5 days without sending them to the teams directly (team agrees with sarcasm)
Prompts team to change perspective to generate more concepts
Discussing possibility of translation using mechanical advantage
Establishes what needs to be changed with the PowerPoint
Stated that the team needed to update presentation dates
Stated the teams should pull up the morph chart and updated it
States that the team should begin selecting concepts
States that the team should begin generating cost options
Brings team back on track
Interprets feedback from advisers and distinguishes how to move forward

Team C	10/4/2017	Week 4	8	0:11:05	0:11:15	0:00:10	SM	Transition	Project
Team C	10/4/2017	Week 4	9	0:11:20	0:11:30	0:00:10	EG	Transition	Project
Team C	10/4/2017	Week 4	10	0:14:39	0:15:26	0:00:47	SM	Transition	Project
Team C	10/4/2017	Week 4	11	0:15:40	0:16:10	0:00:30	MG	Action	Project
Team C	10/4/2017	Week 4	12	0:18:18	0:18:35	0:00:17	SP	Transition	Project
Team C	10/4/2017	Week 4	13	0:19:50	0:25:30	0:05:40	SM	Transition	Solution
Team C	10/4/2017	Week 4	14	0:27:06	0:27:44	0:00:38	MG	Action	Project
Team C	10/4/2017	Week 4	15	0:29:50	0:30:00	0:00:10	MG	Action	Project
Team C	10/4/2017	Week 4	16	0:30:05	0:30:16	0:00:11	MB	Action	Project
Team C	10/4/2017	Week 4	17	0:30:20	0:30:42	0:00:22	MG	Action	Project
Team C	10/4/2017	Week 4	18	0:31:22	0:31:46	0:00:24	PF	Transition	Project
Team C	10/4/2017	Week 4	19	0:33:00	0:33:10	0:00:10	EG	Transition	Project
Team C	10/4/2017	Week 4	20	0:33:41	0:34:20	0:00:39	SM	Transition	Solution
Team C	10/4/2017	Week 4	21	0:35:30	0:36:27	0:00:57	SM	Transition	Solution
Team C	10/4/2017	Week 4	22	0:37:35	0:38:03	0:00:28	MG	Action	Solution
Team C	10/4/2017	Week 4	23	0:38:40	0:39:50	0:01:10	PT	Action	Solution
Team C	10/4/2017	Week 4	24	0:39:55	0:42:25	0:02:30	PT	Action	Solution
Team C	10/4/2017	Week 4	25	0:43:12	0:43:25	0:00:13	PT	Action	Solution
Team C	10/4/2017	Week 4	26	0:45:42	0:45:55	0:00:13	PT	Action	Solution
Team C	10/4/2017	Week 4	27	0:45:57	0:46:15	0:00:18	PF	Transition	Solution
Team C	10/4/2017	Week 4	28	0:46:17	0:48:05	0:01:48	PT	Action	Solution
Team C	10/4/2017	Week 4	29	0:49:18	0:50:37	0:01:19	PT	Action	Solution
Team C	10/4/2017	Week 4	30	0:05:42	0:06:18	0:00:36	PF	Transition	Project
Team C	10/4/2017	Week 4	31	0:06:15	0:06:40	0:00:25	MG	Action	Project
Team C	10/4/2017	Week 4	32	0:06:45	0:07:30	0:00:45	MG	Action	Project
Team C	10/4/2017	Week 4	33	0:07:31	0:08:00	0:00:29	PT	Action	Solution
Team C	10/4/2017	Week 4	34	0:08:01	0:08:30	0:00:29	SSC	Interpersonal	Project
Team C	10/11/2017	Week 5	1	0:07:05	0:09:03	0:01:58	MB	Action	Project
Team C	10/11/2017	Week 5	2	0:09:50	0:10:35	0:00:45	MG	Action	Project
Team C	10/11/2017	Week 5	3	0:11:17	0:11:47	0:00:30	EG	Transition	Solution
Team C	10/11/2017	Week 5	4	0:14:22	0:14:43	0:00:21	MB	Action	Solution
Team C	10/11/2017	Week 5	5	0:14:44	0:15:15	0:00:31	SPS	Action	Solution
Team C	10/11/2017	Week 5	6	0:16:35	0:16:50	0:00:15	SM	Transition	Solution
Team C	10/11/2017	Week 5	7	0:17:26	0:18:15	0:00:49	MB	Action	Problem

Decision Making	F			L					Sensemaking	Transition
Synthesis	L		F						Establish Expectations and Goals	Transition
Communication	L	F	F	F					Sensemaking	Transition
Communication	L		F						Monitor and Guide Team Tasks	Action
Communication	L	F	F	F					Structure and Plan	Transition
Decision Making	L	F	F	F					Sensemaking	Transition
Communication	F	F	L						Monitor and Guide Team Tasks	Action
Synthesis	L		F						Monitor and Guide Team Tasks	Action
Communication	F		L	F					Manage Team Boundaries	Action
Communication	F		L	F					Monitor and Guide Team Tasks	Action
Decision Making	L		F						Provide Feedback	Transition
Synthesis	L		F						Establish Expectations and Goals	Transition
Decision Making	F	L	F						Sensemaking	Transition
Decision Making	L	F	F	F					Sensemaking	Transition
Decision Making	F	F	F	L					Monitor and Guide Team Tasks	Action
Decision Making	L	F	F	F					Performing Team Task	Action
Synthesis	L	F	F	F					Performing Team Task	Action
Synthesis	L	F	F	F					Performing Team Task	Action
Synthesis	L	F	F	F					Performing Team Task	Action
Decision Making	F	L							Provide Feedback	Transition
Synthesis	L	F	F	F					Performing Team Task	Action
Synthesis	L	F	F	F					Performing Team Task	Action
Decision Making	F	F	L	F					Provide Feedback	Transition
Communication	F	F	F	L					Monitor and Guide Team Tasks	Action
Communication	F	F	L						Monitor and Guide Team Tasks	Action
Synthesis	L	F	F	F					Performing Team Task	Action
Communication	L	F	F	F					Support Social Climate	Action
Communication	L	F	F					A	Manage Team Boundaries	Action
Communication	L	F	F					A	Monitor and Guide Team Tasks	Action
Synthesis	L	F						A	Establish Expectations and Goals	Transition
Communication	F			L					Manage Team Boundaries	Action
Synthesis	F			L					Solve Problems	Action
Synthesis	F		F	L					Sensemaking	Transition
Communication	F		L	F					Manage Team Boundaries	Action

Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented

Decides how to interpret second piece of feedback
States team needs to update visual aspects of the presentation
Interprets feedback from advisers and distinguishes how to move forward (title)
Gathering information on whether the team had requirements (standards) in the presentation
If the team comes up with a solution then they will include that in the slide show
Interpreting feedback regarding the function structure (human interaction)
Contacted other teams for space requirements
Checks to see if the team has any other concerns at this point
States the team should reach out to sponsor
Checks to see if person B is updating the morph chart
States that the team does not need to add questions into the presentation
Establishes that the team needs to perform a weighted analysis
Decides on how to change function structure based off of adviser feedback
Leads conversation regarding what categories to use for the weighted analysis
Established method of how to weight the criteria
Determining the weights for each category
Person A leads the group discussion and performing of the weighted analysis
Person A leads the group discussion and performing of the weighted analysis
Person A leads the group discussion and performing of the weighted analysis
Provides feedback on adding reliability as a category for the weighted analysis
Person A leads the group discussion and performing of the weighted analysis
Person A leads the group discussion and performing of the weighted analysis
Questioning whether the team needs the problem statement in the presentation, decision made to lead if for the midterm
Checks on status of requirements and function model for presentation
Trying to get more questions for the sponsor
Person A leads the group discussion and performing of the weighted analysis
Cracks joke about function model, venting frustration regarding feedback from advisers
Discussing a conversation with another group
Stating status of teams' progress and their material cost, information
States that rough solidworks should be done by next Tuesday
Updating the team to the status of the motors and how they function
Stating a way to make the motors in question work with prox switches
Identifying that the height stack up include the mounting plate they need to have
Provides specific resource from sponsor

Team C	10/11/2017	Week 5	8	0:18:16	0:18:30	0:00:14	SM	Transition	Problem
Team C	10/11/2017	Week 5	9	0:19:20	0:19:27	0:00:07	PF	Transition	Solution
Team C	10/11/2017	Week 5	10	0:20:00	0:21:49	0:01:49	SM	Transition	Solution
Team C	10/11/2017	Week 5	11	0:21:48	0:22:00	0:00:12	SM	Transition	Solution
Team C	10/11/2017	Week 5	12	0:22:05	0:22:40	0:00:35	PF	Transition	Solution
Team C	10/11/2017	Week 5	13	0:23:55	0:24:10	0:00:15	MG	Action	Project
Team C	10/11/2017	Week 5	14	0:24:10	0:25:00	0:00:50	MB	Action	Project
Team C	10/11/2017	Week 5	15	0:28:28	0:28:52	0:00:24	SM	Transition	Project
Team C	10/11/2017	Week 5	16	0:29:30	0:29:35	0:00:05	MB	Action	Project
Team C	10/11/2017	Week 5	17	0:33:05	0:33:15	0:00:10	MG	Action	Project
Team C	10/11/2017	Week 5	18	0:33:40	0:35:20	0:01:40	PT	Action	Solution
Team C	10/11/2017	Week 5	19	0:36:00	0:36:05	0:00:05	PT	Action	Solution
Team C	10/11/2017	Week 5	20	0:37:11	0:38:30	0:01:19	PT	Action	Solution
Team C	10/11/2017	Week 5	21	0:38:54	0:39:35	0:00:41	PT	Action	Solution
Team C	10/11/2017	Week 5	22	0:40:00	0:41:09	0:01:09	SM	Transition	Solution
Team C	10/11/2017	Week 5	23	0:47:18	0:47:26	0:00:08	MG	Action	Project
Team C	10/11/2017	Week 5	24	0:04:31	0:08:05	0:03:34	MG	Action	Project
Team C	10/11/2017	Week 5	25	0:08:05	0:08:50	0:00:45	SP	Transition	Project
Team C	10/11/2017	Week 5	26	0:14:40	0:15:00	0:00:20	MG	Action	Project
Team C	10/11/2017	Week 5	27	0:15:17	0:15:36	0:00:19	SP	Transition	Project
Team C	10/11/2017	Week 5	28	0:15:00	0:16:30	0:01:30	SP	Transition	Project
Team C	10/11/2017	Week 5	29	0:16:30	0:17:07	0:00:37	SP	Transition	Project
Team C	10/11/2017	Week 5	30	0:17:18	0:18:00	0:00:42	MG	Action	Project
Team C	10/18/2017	Week 6	1	0:02:12	0:02:48	0:00:36	MG	Action	Project
Team C	10/18/2017	Week 6	2	0:06:35	0:07:50	0:01:15	SM	Transition	Solution
Team C	10/18/2017	Week 6	3	0:10:30	0:11:15	0:00:45	MG	Action	Solution
Team C	10/18/2017	Week 6	4	0:15:39	0:15:45	0:00:06	MG	Action	Project
Team C	10/18/2017	Week 6	5	0:22:57	0:23:00	0:00:03	MG	Action	Project
Team C	10/18/2017	Week 6	6	0:23:03	0:23:11	0:00:08	MB	Action	Project
Team C	10/18/2017	Week 6	7	0:26:00	0:27:16	0:01:16	MG	Action	Project
Team C	10/18/2017	Week 6	8	0:27:17	0:27:35	0:00:18	MG	Action	Project
Team C	10/18/2017	Week 6	9	0:30:41	0:30:47	0:00:06	MG	Action	Project
Team C	10/18/2017	Week 6	10	0:30:52	0:31:18	0:00:26	SM	Transition	Project
Team C	10/18/2017	Week 6	11	0:31:19	0:31:48	0:00:29	SP	Transition	Project

Synthesis	F	F	F	L					Sensemaking	Transition
Decision Making	L		F	F					Provide Feedback	Transition
Decision Making	L		F	F					Sensemaking	Transition
Communication	L		F	F					Sensemaking	Transition
Communication	F	L		F					Provide Feedback	Transition
Communication	L	F		F					Monitor and Guide Team Tasks	Action
Communication	F	L	F	F					Manage Team Boundaries	Action
Decision Making	F	F	F	L					Sensemaking	Transition
Communication	L	F	F	F					Manage Team Boundaries	Action
Communication	L	F	F	F					Monitor and Guide Team Tasks	Action
Synthesis	L	F	F	F					Performing Team Task	Action
Synthesis	L	F	F	F					Performing Team Task	Action
Synthesis	L	F	F	F					Performing Team Task	Action
Synthesis	L	F	F	F					Performing Team Task	Action
Communication		F	L						Sensemaking	Transition
Communication	F	F	L						Monitor and Guide Team Tasks	Action
Decision Making	F	L	F	F					Monitor and Guide Team Tasks	Action
Decision Making	F	F	F	L					Structure and Plan	Transition
Communication	F	F	L	F					Monitor and Guide Team Tasks	Action
Synthesis	F	L	F	F					Structure and Plan	Transition
Synthesis	L			F					Structure and Plan	Transition
Synthesis	L	F		F					Structure and Plan	Transition
Communication	F	L	F	F					Monitor and Guide Team Tasks	Action
Communication			L	F	A	A			Monitor and Guide Team Tasks	Action
Communication			L	F	A	A			Sensemaking	Transition
Synthesis			F	L	A	A			Monitor and Guide Team Tasks	Action
Communication			L	F	A	A			Monitor and Guide Team Tasks	Action
Communication		F	L		A				Monitor and Guide Team Tasks	Action
Communication		L		F	A				Manage Team Boundaries	Action
Communication		F	L	F	A				Monitor and Guide Team Tasks	Action
Communication			F	L	A				Monitor and Guide Team Tasks	Action
Communication			F	L	A				Monitor and Guide Team Tasks	Action
Communication		L	F	F	A				Sensemaking	Transition
Communication		F	F	L	A				Structure and Plan	Transition

Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented

Interpreting sponsor's feedback from tour
States that a concept is too big of a safety concern
Deciding that using the casters with the motors will work, but discussing the power concerns
States that the team does not need to design mounting bracket, and that the team can straight mount the casters to the rack
Provides feedback saying that the team's design work should include the controls system
Checking the status of the power point
Bringing person D up to speed on the conversation from the people from the other team
Deciding how to use and present the function model
Discusses what the other teams are designing to benchmark
Brings the team back on track and says lets do the reliability score for each concept
Leads weighting activity
Leads weighting activity - Translation
Continues leading while performing the weighting
Continues leading while performing the weighting
Provides feedback on how to improve the function structure based on advisers comments
Checked to see if Person A would put the morphchart into the presentation
Checks to see if the team is presenting any other options and states that they should present another
States that the team should only present one solution and say that they are performing research for additional concepts due next week at the midterm
Brought the team back on task
Stated the team should establish cost estimates and solidworks files for next week
Establishes that Person D should reach out and obtain CAD files for one part and that Person A will be able to model the rest.
States that they need to call their wheel source back to obtain additional drawings regarding the 1/4 hp 6" wheel
Communicating with teammates to update the status of their open tasks
Updates teammate with what has been done to the update and powerpoint
Providing update on a team concept idea that is not going to work due to calculations
Updating team concerns based on light curtain disucssion
Stated that Person C completed a task thus bringing the team back on track
Updating team on what has been done in the powerpoint and that nothing is finalized
Checking to see if the team received a response from the sponsor
Updating teammate one issues with the light curtain
Obtaining information from one of Person C's tasks
Updates team on status of videos for powerpoint
Clarifies how the concepts are supposed to work
Plans how the team should present the concepts in their presentation

Team C	10/18/2017	Week 6	12	0:40:44	0:43:51	0:03:07	ESM	Action	Project
Team C	10/18/2017	Week 6	13	0:44:00	0:44:30	0:00:30	SPS	Action	Project
Team C	10/18/2017	Week 6	14	0:47:30	0:48:23	0:00:53	SM	Transition	Problem
Team C	10/18/2017	Week 6	15	0:04:20	0:05:33	0:01:13	SP	Transition	Project
Team C	10/18/2017	Week 6	16	0:10:00	0:10:20	0:00:20	MG	Action	Project
Team C	10/18/2017	Week 6	17	0:11:30	0:12:00	0:00:30	MG	Action	Project
Team C	10/18/2017	Week 6	18	0:12:01	0:13:00	0:00:59	SP	Transition	Project

Synthesis		F	L		A				Encourage Team Self Management	Action
Synthesis		F	F	L	A				Solve Problems	Action
Communication		F	F	L	A				Sensemaking	Transition
Decision Making		F	L	F	A				Structure and Plan	Transition
Decision Making		F	L	L	A				Monitor and Guide Team Tasks	Action
Decision Making			L	F	A				Monitor and Guide Team Tasks	Action
Decision Making			F	L	A				Structure and Plan	Transition

Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented	Task Oriented

Encourages teammates to look over and adjust the pro and cons list
Solves problem of large video file
Interpreting the problem area
Plans out the general presentation flow
Discusses why to put lower cost analysis in
Describes why it is necessary to put worst case senario
Describes how to organize presentation

APPENDIX C

IRB CONSENT FORM

Information about Being in a Research Study
Clemson University

Engineering Design Teams: Undergraduate Team Member Behavior Case Study

Description of the Study and Your Part in It

Dr. Summers, Dr. Shuffler, and Doug Chickarello are inviting you to take part in a research study. Dr. Summers is a professor at Clemson University. Dr. Shuffler is an assistant professor at Clemson University. Mr. Chickarello is a Masters student at Clemson University, running this study with the help of Dr. Summers and Dr. Shuffler. The purpose of this research is to investigate team member behaviors in collaborative design teams.

Your part in the study will be to participate in normal course activities. With your permission, a minimum of 1 design team meeting per week, lasting 1 hour, will be video and audio recorded. The meeting can consist of anything the design team needs to work on for their project. The meetings will be recorded in 135 Fluor Daniel building. Additionally, each design review (lasting 30 mins) will be recorded. Finally, any emails sent to/from any team member will be copied to a team email account set up by the team. After the semester is completed (grades assigned) the team will provide the password of the email account to Mr. Chickarello. There is a possibility that a brief interview or short surveys will be requested/issued at the end of the semester.

It will take you about 25 hours spread throughout the academic semester to be in this study. However, none of this time will be additional time required to complete the ME 4020 course.

Risks and Discomforts

We do not know of any risks or discomforts to you in this research study.

Possible Benefits

Participants of this study will be granted unlimited access to room 135 Fluor Daniel building during the Fall 2017 semester (after safety training has been completed). Participants will be able to use this room and the equipment/materials available in it to complete their ME 4020 Capstone design projects. Although 1 meeting per week is required to occur in 135, the team may meet more than once and can use the room and resources whenever they are needed.

The research team reserves the right to cancel access to room 135 Fluor Daniel in the case that equipment is damaged or goes missing, the equipment is used inappropriately, or if the participants do not meet in the room for a minimum of 1 hour per week for research data collection.

Protection of Privacy and Confidentiality

We will do everything we can to protect your confidentiality. Your names will be coded using aliases in all the video and audio data recorded. Names will be removed from interview and survey responses and replaced with aliases. Records will be maintained for seven years as part of the research documentation. Your identity will not be disclosed in any publication or presentation that may result from this study.

Choosing to Be in the Study

You do not have to be in this study. You may choose not to take part and you may choose to stop taking part at any time. You will not be punished in any way if you decide not to be in the study or to stop taking part in the study. Choosing to stop this study at any time also ends the participants access to 135 Fluor Daniel building. If you decide not to take part or to stop taking part in this study, it will not affect your grade in any way.

Contact Information

If you have any questions or concerns about this study or if any problems arise, please contact Dr. Joshua Summers at Clemson University at 864-656-3295.

If you have any questions or concerns about your rights in this research study, please contact the Clemson University Office of Research Compliance (ORC) at 864-656-0636 or irb@clemson.edu. If you are outside of the Upstate South Carolina area, please use the ORC's toll-free number, 866-297-3071.

Consent

I have read this form and have been allowed to ask any questions I might have. I agree to take part in this study.

Participant's signature: ____________________________________ Date: _________________

A copy of this form will be given to you.

APPENDIX D

SPONSOR REDIRECTION EMAIL

Important Project Redirection from SPONSOR after Midterm Review

Mon, Oct 23, 2017 at 11:13 AM

***To ALL Teams** --- Please focus on the below email project redirection on from SPONSOR [REPRESENTATIVE A and REPRESENTATIVE B] based on their evaluation of the Midterm progress and results. All 3 teams will now be working in a coordinated fashion to develop one full-scale working prototype by 7 December. Each team will now have its own technical focus (see below), but with close coordination by all teams for the complete design of the prototype.*

- **Lift mechanism/table – Team A**
- **Movement – Team C**
- **HMI/implementation and controls – Team B**

To meet their critical milestones (the first two being 30 October and 6 November by COB), all 3 teams should plan on coordination meetings several times per week in addition to the Thursday afternoon review with GRADUATE COACH and I. All 3 teams will also attend the Thursday review meeting together for the entire duration, about 1 ½ to 2 hours, to facilitate team discussions and review of design concepts based on each teams technical focus.

I'd like to meet briefly with each team today or tomorrow to review your understanding of these important changes in the project direction and address any issues you may have going forward. At least the team leader/liaison and the main CAD modeler/designer should come by my office in MECHANICAL ENGINEERING BUILDING. I'm open today (Monday) from about 10 to 3, and tomorrow (Tuesday) from 11 to 12 and 2 to 4. On Wednesday, I'm open from about 9 to noon.

Thank you,

SPONSOR Advisory Team

PS --- (1) Your Midterm Report that's due on 26 October will keep its original focus based on the initial project definition and your Midterm report and presentation will be graded on that basis; (2) Your Tuesday progress reports and draft PP's for Wednesday will continue as before but with a revised project statement reflecting this redirection and technical focus for each team; (3) your final report will focus on your new technical charge and how incorporated into the complete full-scale prototype design using the same format as the Midterm report…

Email Note from SPONSOR below highlighting project changes and milestones going forward

FACULTY ADVISER,

I'd like to thank you and each of the teams for preparing their midterm presentations for us last Thursday. Each team brought great ideas to the table. That said, we've got a new direction we think will not only benefit the teams, but will produce a tangible product we can implement, use and continue to test in our facility. Up until now, the primary objective for each team has been to develop, design and build a unit separately. While this is a great idea, we think it would better suit us, as well as each team, to instead come together to design one central unit. In doing so, this would allow each team to devote the time necessary to develop and produce a working solution to each part of the machine.

We suggest that the work be split as follows:

- **Lift mechanism/table – Team A**
- **Movement – Team C**
- **HMI/implementation and controls – Team B**
- **One Full-Scale Working Prototype with Documentation – All 3 teams working on coordinated effort**

We felt each team had their own strengths in different concentrations of the machine, and we'd like to capitalize on that to ensure project completion is achievable. Additionally, real-world engineering objectives change constantly, so their ability to adapt and move forward is not only important, but valuable. Per our discussion following the presentations last Thursday, this is the direction we'd like to pursue and are confident the students can fulfill what we're asking. Please let us know if you have any additional questions.

Below are several important milestones:

- **October 30th – Provide list of materials needed for fabrication of parts to SPONSOR, such as steel sheet, bar stock etc…**
- **November 6th – All CAD models and drawings due to SPONSOR for fabrication – cutting and machining of any metal components**
- **November 6th – Place component orders for significant components – hydraulic cylinders, pumps, motors. I suggest scheduling a phone conference with us to go through BOM prior to November 6th. – Work with REPRESENTATIVE B to set up meeting.**
- **November 13th – SPONSOR will target this date to complete fabrication of parts – this will depend on internal work load as well.**
- **November 14th – SPONSOR Deliver components to Clemson.**
- **November 15-December 7th – build**
- **December 7th – Final Presentation to SPONSOR of working device.**

Thank you,

SPONSOR REPRESENTATIVE A

Manufacturing Engineer

Fabrication

SPONSOR CONTACT
INFORMATION WAS
REMOVED

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FACULTY ADVISER

FACULTY ADVISER CONTACT

INFORMATION REMOVED

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