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The Characterization of Leadership within Undergraduate Engineering Design Teams through Case Study Analysis

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THE CHARACTERIZATION OF LEADERSHIP
WITHIN UNDERGRADUATE ENGINEERING DESIGN TEAMS
THROUGH CASE STUDY ANALYSIS

A Thesis
Presented to
the Graduate School of
Clemson University

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

by
Gary S. Palmer II
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Accepted by:
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ABSTRACT

The purpose of this research is to clearly define leadership that exists within engineering project teams. Leadership can be applicable to any field of study and is heavily researched in business management. Sources which review leadership classify this topic in reference to managerial styles, leadership types and styles, emotional intelligence, and work climate. However, there are few sources which define leadership specifically within engineering environments. The motivation of this research is driven by the absence of defining and observing consistency in engineering leadership through the research's experience in engineering teams. Existing leadership is defined in this research through conducting two studies which examined two undergraduate engineering design teams. These exploratory case studies used data collection methods such as an ethnographic study, interviewing, written surveys, and documentation analysis to explain the occurrences of leadership throughout each case study. The information from these case studies was combined through intra- and inter-method triangulation. Then, the results and conclusions from each study were extracted by triangulating within and across each of the data collection methods. Through these two case studies, leadership clearly existed across both cases and task oriented leadership was the more dominant leadership type found. There were other leaders which were established as task and interpersonally oriented leaders and non-leaders were found to have considerable leadership characteristics in both cases. Lastly, interviewing, ethnographic study, and questionnaires should be applied to find leadership within engineering design teams.

DEDICATION

I dedicate this to my family, immediate, distant and nuclear. Thanks to Gary Sr., Linnette, and Thomas for all of their never-ending support, love, and encouragement. Without it I would not know how this daunting task would have been completed. I would like to dedicate this to my family in Maryland, New York, and Florida and my Godparents in Maryland for being with me every step of the way. Lastly to my friends back home, even though you may dislike my new residence, I'll be back soon.

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CHAPTER ONE: MOTIVATION

The objective of this research is to identify how leadership affects engineering design projects. Specifically, two case studies are conducted to understand the role of leadership. In the first case study, senior design students enrolled in a capstone design class and coached by a graduate student were tasked with designing a crimping device for installation of the seal on a sport activity vehicle's rear-hatch. In the second case study, faculty, graduate, and undergraduate students designed and built a large system for soft soil off-vehicle endurance testing of tires. These case studies will be used to explore how leadership is perceived, influenced, and defined in engineering projects. Leadership is a characteristic which is researched within the structure of the group because its presence is one out of many variables which can explain the progression of the engineering design projects. Whether and what type of leadership exists within the group is a question which this research seeks to answer. In emotional intelligence, this is defined as the ability to manage ourselves and others, has a capability called social skills. Social skills include traits such as communication, building bonds, and visionary leadership [1]. This capability of emotional intelligence is one of five ways to describe its type of leadership, such as self-awareness, management of emotions, motivation and empathy, and as the group advances through the design process.

Leadership is expressed as a quality within executives, management, and team leaders. This research will concentrate on the leadership within the team itself and the motivation of some or all of the members within the group to accomplish the construction

of a rear seal crimping device (Chapter Four:) and endurance testing device (Chapter Five:). Even though the research on team members sharing leadership is limited, the question still exists whether team members can demonstrate leadership qualities without the assistance of a team leader. Research in this field illustrates that the leadership of the team leaders and managers transfers to the team members [1]. Therefore, as leadership exists within the framework of the team, this research seeks to determine its affects and perceptions within the engineering design teams. This has been seen with the researcher's experience and is illustrated through the following examples. These examples serve to motivate the objective of this research.

The motivation of this research stems from previous group project experiences which the researcher has participated in. The researcher has experienced team projects since freshmen year of college in 2002. The teams from these projects consisted of different team sizes, collegiate years, knowledge base of each team member and disciplines and their reflection provides how dissimilar each experience is. An objective view of the team projects is required to acquire the total understanding of each personality, occurrence of leadership, and whether success was gained throughout each team project. The showcase of team projects will provide an extensive collection of engineering cases where leadership has affected the success of the project.

1.1 Freshman Year (Introduction to Engineering Course)

The first project, which was experienced on a collegiate level, was an engineering class group project to construct a human powered water pump. Each group included four to five students, who were all at the same level of education. This was a general

engineering class, so there were students who have declared their major and undecided, and have not undergone any prerequisite or major courses. The teacher of this course lectured the coursework which is needed to construct the device and provided support when the group required assistance. The group setting in which the researcher was involved consisted of five team members and there were three different personality types which existed. The first personality type between two team members was strong and outspoken. The second personality type shared by one team member was silent and passive and the third personality of the last two team member was balanced between passive and aggressive.

The mixture of three personality types resulted in several characteristics which led to the group dynamic. The two stronger personality types were always in opposition when making decisions to progress the construction of the water pump. Therefore, building bonds, communication, influence, conflict management, teamwork, and collaboration were all leadership traits which affected the progress of this team project. The opposing team members created a separation within the group for a short period of time. The management and leadership of the group transferred to one of the stronger personality types and the other resisted the consequential leadership and environment created by this shift. This was resolved immediately with a discussion with the professor of this course and helped with the completion of the team project.

The success of this project was determined by the group winning the competition at the end of the semester to transfer three gallons of water from one canister to another as quickly as possible. The outcome of this group's water pump was second place in a

class with ten teams. The double-acting single piston water pump was defeated by a single-acting single piston pump with a large piston diameter and diminutive outlet diameter. Through all of the differences of opinion, the rebellion of one team member did not deter the bonding, communication, and teamwork of the other four members of the team. This is also an example of another capability within emotional intelligence which is self-management. The adaptability of the team to recover from their shortcomings and complete the project illustrates the leadership exhibited by the team.

1.2 Sophomore Year (Introduction to Design)

The second engineering project occurred sophomore year in the fall of 2003 and the goal was to redesign a laundry carrier. This experience was different than the first because this group project took place within a special program called Quality Enhancement Systems and Teams, or QUEST. This was a three-year multi-disciplinary program which focuses on cross-functional collaboration, innovation, quality management, and teamwork. Therefore, this program's goal was to train and educate the participants in teamwork and collaborating with students in other disciplines. The students in the first year of the program participated in a retreat to get to know their teammates better before they started on their project. This team consisted of six students who were all sophomores, and there were three pairs of shared personalities within the group but only two students had the same discipline.

Each student took the Myers-Briggs test, a personality indication test, and it was found that there were three pairings of the same personality. One pairing of personality types was extremely extroverted and the other pairing, including the researcher, were

moderately extroverted. The other two students in the group were introverted and this did not cause any difficulties within the chemistry of the team. All members of the group diligently completed the work which was handed in front of them and communicated well with each other. One member of the group arose as the leader because of his willingness to undertake assignments and was the most vocal at meetings. Also as an engineering student, he was the one to evolve the customer requirements to engineering specifications. This was a significant step in the project and allowed the others to proceed with completing the remaining steps of the project.

The eventual leader of this team showed several types of leadership to help the team excel as much as possible. His leadership was a combination of authoritative and pacesetter leadership skills which often has a negative effect on a group because it is used inappropriately [1]. Authoritative leadership is where one person mobilizes the team toward a vision and pacesetter leadership expects excellence and leads by example. These characteristics are what separated one member of the team and is what helped the group succeed. The goal of this project was accomplished and that was to successfully redesign a laundry carrier. The efforts from the team members, especially from the leader which emerged, led to an excellent grade in the class. However, the next team project does not have a positive ending or emergent leader within the duration of the project.

1.3 Junior Year (Fluid Dynamics Class)

The next engineering project took place in Fluid Dynamics class in the fall of 2005. The team consisted of four members who were all friends with one another and in

junior year of college. They each entered the class with the same amount of prerequisite coursework and the deliverable for this project was to make the most aerodynamic Formula One car. This project transpired for the duration of one half of a semester and used the knowledge gained from within the course to complete the project. The environment of this group was different because the camaraderie which existed between the group members has been at least two years. The examination of this group's chemistry is unlike the group from the second project since the chemistry existed outside of the project.

The goal of the project also included using software to determine the flow characteristics of the Formula One model. Unfortunately, one member of the group was knowledgeable of the software used to complete the project. Inherently, this appointed the most knowledgeable team member as the leader of the group but this was short-lived because he was an introverted individual. There was another member who initiated conversations, organization for meetings, and division of work within the group. This member had a disadvantage of not comprehending the project but used his strengths to progress the group through the project. For this project, leaders emerged in different manners and showed that managing roles can arise from engineering design projects.

The leadership quality of the more knowledgeable team member was through task oriented leadership. This team member was more concerned with the performance of the group, what particular tasks needed to be completed, and the completion of the project. On the other hand, the second leader who came forward was an interpersonal and affiliative leader. This member of the group managed the personalities and duties of the

group by outwardly communicating and discovering each member's strengths and weaknesses. Once he was able to find that information, he was able to assist the first leader and facilitate the total amount of work throughout the entire group. Even though two types of leadership arose within this group, the collection of the team's work ethic culminated to an average score on the project which was deemed as unsuccessful.

1.4 Fifth Year (Six Sigma Course)

The fourth project, that is also an example of leadership in engineering design group projects, is a Six Sigma project at the University of Maryland – University Hospital. Six Sigma is a method which aspires to improve the quality of manufacturing, business, and general processes. This is accomplished by looking at the current outputs of the process and identifying, removing, and changing the causes of defects by increasing standardization and minimizing the variability of the process. There were three members of the group which needed to determine and solve the root causes behind the non-value added time with the reading of X-rays. This project occurred in the fall of 2006 and the three members of the group were matched based on their interest in working with University of Maryland – University Hospital. There were two engineering and one business student but all members of the group were learning new material from this course simultaneously. Since this was a new course and learning experience for everyone in the group, leadership emerged from one student's experience in group projects.

The start of one team member's leadership did not start at the assigning of the project, yet at the first meeting where the team members congregated to discuss the project. One moment where the leader realized his position within the group was when

he noticed being the first to address the group at every meeting. This leadership existed through the distributing of work throughout the group, collection of data for the project, and combining of thoughts and individual sections for the interim and final reports. Since the first day, it was expected of him to be the constant variable in the group and because of that, one member decreased his work ethic and relied on the emergent leader to cover for his mistakes and mediocre work. The engineering project itself continued and progress was being made with the University of Maryland – University Hospital as the team compensated for the lack of effort from one teammate.

All three team members ended the project by pressing forward and generating new ideas to complete the project. This was encouraged by the leader of the group which exhibited a democratic leadership style, which is also known as affiliative leadership. Democratic leadership is where the leader builds a consensus with the group through participation and being knowledgeable of the team's personalities which allows a more interpersonal relationship with the group. The goal of the project was to remove unnecessary parts of the x-ray collecting process, decrease the time it took for them to record the evaluation of their x-rays and provide a systematic process which a doctor can follow. This goal was achieved and the teacher felt that the process and reports were excellent. In this example, the use of an affiliative leader proved to be beneficial and important for unpleasant portion of the project.

1.5 Concluding Thoughts

Table 1.1 provides a summary of all the different engineering design project examples. These projects vary in objective, group size, leadership styles and outcomes.

The common thread through all of these projects is how the different styles of leadership affected the dynamic of the groups. This dynamic influenced the outcomes of these projects.

Table 1.1: Summary of Introductory Projects

Project Name	Objective	Group Size	Leadership Exhibited	Project Outcome
Intro. To Engineering	Piston Pump	5	Coercive	2 nd Place
Intro. To Design	Redesign Laundry Carrier	6	Authoritative & Pacesetting	Excellent Report and Presentation
Fluid Dynamics	Aerodynamics of F1 Vehicle	4	Affiliative	Average Report
Six Sigma	UM Hospital X-Ray Process	3	Affiliative	Usable Change of the Process

From these observations made in the previous four sections, engineering design project groups exhibit a multitude of leadership types and styles. This is initially apparent because there are many different personalities and people which exist in engineering. From the four examples given, do these examples clearly denote leadership within each group? These observations state that leadership existed in these semester long projects, yet there are no metrics or systematic way of determining whether leadership had a presence within these groups. In this research, case study research is used to establish whether leadership is unmistakably present within engineering design project teams.

1.6 Research Questions

Each of these examples of leadership within a team dynamic shows that different results occur from different execution of leadership styles. The ability of leadership to arise within a team dynamic helps the team advance to the conclusion of the project. For

engineering projects, leadership helps to expedite the formulation of a product which solves the initial problem. Therefore, the intent of this research is to determine how the path to solving the problems of engineering problems are affected by the different types of leadership exerted throughout a project's period of time. There are two different case studies which are prepared to display the leadership and answer these questions surrounding the research. The questions are:

- Can leadership be clearly identified in engineering design project teams?
- How will leadership be identified in engineering design project teams?
- What leadership types are found students within engineering project teams?
- What leadership traits are contributed by the undergraduate students from the leadership types shown in engineering project groups?
- What is the reasoning behind the leadership types seen within engineering project groups?
- Is case study research the correct method to conduct this research?
- What data collection methods are needed to complete each case study?
- What data collection methods are needed specifically for identifying leadership in engineering design project teams?

These questions will be answered throughout the entirety of this research. Chapter Two: will give a literature review on leadership. This chapter entails the many different types of leadership including emotional intelligence, examples of technical leadership, and transformational leadership. Next, Chapter Three: provides a synopsis of

case studies and the relationship between that and the research questions for this thesis. In Chapter Four:, the first case study of the ME 402 Senior Design Project uses four data collection methods to determine whether leadership exists in this particular group. Then, Chapter Five: discusses the second case study based on the leadership within the construction of a lunar wheel endurance testing device. Chapter Six: provides the results found from these two case studies and explores the patterns of leadership affects between both engineering design projects. Lastly, Chapter Seven: summarizes the findings and concludes with the ability of where this research can be developed further.

CHAPTER TWO: LITERATURE REVIEW

The first documentation concerning leadership can be found in the writings of Confucius when he defined it as relationships, values, process, and moderation [2,3]. Leadership has changed and has been growing over time. Once researchers began to explore the characteristics of leadership, its modern research focuses in the context of technical groups with studies involving executives or project managers being conducted through self-evaluation or by the team members. These evaluations consist of surveys handed to companies which range from financial to construction businesses. Within each of these types of companies, there are different types of leadership exuded, emotional intelligence, and climates or motivational factors which influence leadership.

For example, collaborative design is an avenue which companies have been using to become more competitive in global markets. Engineering design is defined as a systematic design process which endeavors to satisfy the customer through four steps, which are task clarification, conceptual, embodiment, and detailed design stages [4,5,6]. Yet in collaborative design, team members contribute to an interactive design team structure by aiming to achieve a common goal [7,8,9]. Ostergaard [10,9] divided this common goal into three primary approaches which exist for modeling in collaborative design and they are methodology, workflow, and socio-technical frameworks.

Ostergaard [9] also developed a taxonomy which highlighted top level attributes, such as team composition, communication, distribution, design approach, information, and nature of the problem, which needed to be investigated. Within the team

composition attribute, leadership style is a sub-level which is addressed. As a component within collaborative design, this factor has many variables which can change the outcome of a collaborative design. In this chapter, the variety of leadership styles is concentrated on with an addition to emotional intelligence and climate.

2.1 Leadership Types

In 1938, Bernard researched the differences between leaders who valued the relationships in the group versus the ones who were engaged with the process [11,3]. These two types of leadership are common within literature and are complete opposites. Leaders who are relationship types are more concerned with building and sustaining relationships within the group. These leaders also believe that establishing relationships within the group is more important than the problem. On the other hand, process leaders are apt to control the methods in which the problem or project is solved. Therefore, the argument within this model is whether controlling the relationships or the process more important for a leader of a group. Table 2.1 shows the differences between Confucius' and Bernard's definitions of leadership.

Table 2.1: First Summary of Leadership Traits

Leadership Traits	Descriptions	Confucius [2]	Bernard [11]
Relationships	Focus on building teamwork	X	X
Values	Fostering respect and merit	X	
Process	Focus on completing tasks	X	X
Moderation	Practicing self-control	X	

In 1974, Katz [12] showed that there are three managerial skills, conceptual, technical, and human, which are dependent upon the rank of the manager within the

organization. The work with managerial styles continued in the 1970s, where Bass [13] introduced styles such as direction, negotiation, consultation, participation, and delegation. The summary of Katz and Bass' leadership types are shown below in Table 2.2. Directive management style is set by the manager accomplishing their goal by telling the team members what to do and how to complete a project. Negotiative style of leadership means that there is an implementation of political strategic methods and bargaining with the team members for the manager to obtain their results. Consultative management style applies the deliberation the team members to the decision making process. The manager continually has the authority to do whatever is necessary for the project. Within participative leadership, a consensus is made with the team members and the manager for decisions made. The mutual agreement between the leader and team members helps the team progress through a project together. Lastly, a delegative style of management means that the work is divided amongst the group and they are willing to make their own decisions.

Table 2.2: Second Summary of Leadership Traits

Leadership Traits	Descriptions	Katz [12]	Bass [13]
Conceptual	Notice the project as a whole	X	
Technical	Practical knowledge of the subject	X	
Human	Interaction with others in the group	X	
Directive	Setting out tasks the group must follow		X
Negotiation	Bargain with team members before making decisions		X
Consultation	Discuss with team members before making decisions		X
Participation	Consensus with team and leader before decision		X
Delegation	Divide work amongst team		X

In 1990, two styles of leadership emerged from research on gender's influence on leadership styles which are task and interpersonally oriented leadership. These are two basic types of leadership which differentiates themselves by the primary actions used to manage teams. Task oriented leadership are characteristics which are targeted towards accomplishing the required tasks of the project. Other behaviors include having team members follow the rules and procedures, maintaining high standards for performance, and abiding by the structure established by the leader [14]. Interpersonally oriented leadership is where the emotions and morale of the team members are assessed on a regular basis, which allows the leader to connect and understand each individual within the team. This approach to leadership develops trust and considers the welfare of the team members to build cohesiveness and relationships so the team works better. Task and interpersonally oriented styles of leadership are related to gender stereotypes about

their differences in behavior [14]. The stereotype of men as aggressive, dominant and independent and the women as sensitive, understanding, sympathetic is proven to not matter in leadership of companies. Since the managers and executives are choosing men and women from similar criteria, then these stereotypes are proven to be false.

Task and interpersonally oriented leadership styles yielded two more types of leadership which are democratic and autocratic leadership. Democratic leadership is also known as participative leadership because the goal in this style of leadership to obtain a consensus upon decisions made within the team. This is difficult when a small amount of team members disapprove of the majority wants to accomplish. However, democratic leadership allows the team members gain more ownership of the project and the leader values the input provided by the team members. The notion of collaborative decision making introduces an uncertainty of interpersonal skills where leaders who behave in an autocratic manner may struggle [14]. An autocratic leader believes that the direction and decision making of the group is solely their occupation and not the team members' obligation. This means that the only chance for collaboration in this structure is after the direction is created and to accomplish tasks from which the vision is made.

Goodwin [15] continued the research of essential project management skills by adding negotiating skills to what Katz has defined earlier. Conceptual skills are similar to the visionary skills which are talked about by topics in leadership. It is defined in the research as the ability to see the organization or project as a whole, recognize how the various functions of the organization depend on one another, and how changes can affect the outcome of the project. With conceptual skills, the project manager is able to plan for

approaching work and potential problems which may occur during the project. The absence of foresight from a project manager's perspective has the ability to be detrimental to the end result of the project. Human skills are also known as social skills and understanding the individuals within the project team is important to execute. The development of teamwork is important for the project manager and methods of building human skills involve power and influence [15]. Technical skills must also be a portion of management qualities because the credibility of the project manager is established from their knowledge. Lastly, negotiating skills for managers in a group dynamic is needed because there can be disagreements with one another. Negotiating uses the previous three skills to develop credibility and the ability to produce a sound argument. Eagly and Goodwin's leadership traits are compared in Table 2.3.

Table 2.3: Third Summary of Leadership Traits

Leadership Traits	Descriptions	Eagly [14]	Goodwin [15]
Task	Delegates tasks and focuses on the project goals	X	
Interpersonal	Building relationships with the team	X	
Democratic	Leader takes input from the team and makes decision	X	
Autocratic	Team must follow decisions from the leader	X	
Conceptual	Notice the project as a whole		X
Technical	Practical knowledge of the subject		X
Human	Interaction with others in the group		X
Negotiation	Bargain with team members before making decisions		X

In addition to the management of the team, project managers have a great amount of responsibility from the executives to execute their vision and complete the task before them [15]. Project managers have the challenge of having multiple team members and assuring that each team member will cooperate and help complete the task. With these circumstances, the project manager has to answer to the executives in charge on a periodic basis and continually take direction from them as well. Many organizations have a hierarchical structure for employees to determine the chain of command but this does not include coordination of work flow. The work flow is not the organization's philosophy or the job requirements of each type of employee but the means of which employees in different levels of hierarchy interact and collaborate to accomplish tasks.

These hierarchies and collaborations are examined further within the initial study of the Multifactor Leadership Questionnaire (MLQ) derived seven factors of leadership from Bass [16]. These factors were charisma, inspirational, intellectual stimulation, individualized consideration, contingent reward, management-by-exception and laissez-faire leadership. For a more high order of modeling, these factors were broken into two arenas of leadership, transformational and transactional. Transformational leadership [16] is divided into charisma, inspirational, intellectual stimulation, and individualized consideration.

Charisma is the ability to instill loyalty and enthusiasm with the team members to gain their appeal for carrying out a task. Inspiration or motivation is similar to charisma because the vision of your group has to be appealing to your group, yet optimism is communicated, meaning is provided to the tasks given and a strong sense of purpose is

acquired. Intellectual stimulation consists of the nurturing and development of creativity and ideas within individuals. As the encouragement and solicitation of ideas increase, then the team members' simulation increase with more variety of thoughts and deeper thinking. Another trait which attends to coaching within the group is individualized consideration. Individualized consideration concentrates on the needs and concerns of the team members and is intended to provide support and empathy. These characteristics combine to yield the transformational leadership type.

For transactional leadership [16], contingent reward, management-by-exception, and laissez-faire leadership are included. Table 2.4 shows the delineation of each leadership trait to leadership type. Contingent reward is where the leader offers a reward to the group for completing the tasks set. This goal is not agreed by the group but is given by the leader, which makes the reward conditional. The factor of management-by-exception was split into two categories, active and passive. Active management-by-exception is where there is active monitoring of task completion and execution, so when problems arise they are resolved quickly to keep a high level of performance. Passive management-by-exception is a technique where problems are not actively sought out and are corrected when they occur. Passive management-by-exception is a reactive quality and active management-by-exception is a more purposeful ability of leadership. Laissez-faire leadership is where the leader relinquishes or avoids responsibility and making decisions for the group.

Table 2.4: Fourth Summary of Leadership Traits

	Leadership Traits	Descriptions	Avolio and Bass [16]
Transformational	Charisma	Exuding charm or appeal to team members	X
	Intellectual Stimulation	Challenges assumptions and decisions made	X
	Inspirational Motivation	Expressing inspiring words to team members	X
	Individualized Consideration	Leader attends to each team member's needs	X
Transactional	Contingent Reward	Providing reward in exchange for mutual goals	X
	Management-by-Exception	Making corrections when rules are not followed	X
	Laissez-Faire	Avoids responsibility and making decisions	X

The research on leadership types has grown from defining managerial skills to evaluating leadership aspects. In the early stages on leadership research, conceptual, negotiating, and technical skills were being examined. Now, more social attributes are being established as one of the pertinent traits needed to balance with either technical or task related skills. The next dimension of leadership which will be discussed is emotional intelligence, which focuses on the understanding of emotions from the team members and leaders themselves.

2.2 Emotional Intelligence

The history of emotional intelligence begins with Salovey and Mayer [17] when they produced the phrase emotional intelligence when conducting studies on emotion in combination with thought. Emotional intelligence is used as a measure of leadership capabilities but it determines how well leaders control their own and other's emotions.

This type of control is useful in controlling the morale and performance of the group in many forms of situations which arise. Emotional intelligence is also known as an array of non-cognitive competences and skills which influences one's ability to succeed in pressuring and demanding group dynamics [18]. In Table 2.5, Caruso and Salovey [19] created steps which models the basic ideas of Emotional Intelligence.

Table 2.5: Four Skills of Emotional Intelligence [19]

Emotional Intelligence Steps	Descriptions
Identify Emotion	Become aware of emotions. Express emotions.
Use Emotion	Let emotions influence thinking. Match emotion to the task.
Understand Emotion	Find out what emotions mean. Conduct what-if analyses.
Manage Emotion	Stay open to emotions. Integrate emotions into thinking.

The relationship between emotional intelligence and leadership behavior is in existence through this research. A majority of the research which explores the positive correlations of leadership within project teams learn that transformational and transactional leadership characteristics are found in those cases. Through both the emotional quotient and intelligence tests, studies examine the team members' evaluations of their leaders and project managers. One study examined the leadership styles of 49 managers and found three competencies of transformational leadership and one of transactional leadership were positively correlated. Another study was conducted by Palmer [20] where several correlations were found between transformational leadership and emotional intelligence, yet two motivating or climatic perceptions were found during this study, monitoring and managing emotions. In these studies, emotional intelligence has demonstrated that its traits are important for leaders to gain control of their team and perform the best under any circumstance with the correct style of leadership. These

studies receive evaluations from the team members looking specifically at the team leader's performance and not of their peers.

The importance of human or social skills for a project manager is important because of their interaction with their team members and superiors. There is a high level of interaction for project managers from building relationships to ensuring and monitoring the success of the project to managing conflicts with the project team [21]. Emotional intelligence is a topic where these human skills are defined and assessed through the performance of project managers in the workplace. On the other hand, the intelligence quotient does not determine outstanding job performance and has failed to provide viable criteria for educational and organizational means [22,23,21]. Emotional intelligence yields four characteristics within two competencies, self-awareness and self-management in the personal competence and social awareness and relationship management in the social competence.

These aspects of emotional intelligence are known for project managers but the evaluation of team members in reference to emotional intelligence is lacking research. Research in project climate gauges whether the leader's performance changes due to the motives of the team members but the performance of the team is deemed by the leader of the project team and not their performance. These characteristics of emotional intelligence have been used by subordinates to evaluate their managers and managers to evaluate themselves and other management. Therefore, emotional intelligence needs to be researched within the realm of team members to evaluate their peers and themselves. This is information which gives value to the managers to determine what characteristics

seen from the team is needed for a successful project and recognize when a team member is impeding the progression of the project. **Error! Reference source not found.** provides more characteristics used in literature on emotional intelligence.

Table 2.6: More Emotional Intelligence Characteristics

Emotional Intelligence Definitions	Trait 1	Trait 2	Trait 3	Trait 4
Cooper and Sawaf [24]	Literacy	Fitness	Depth	Alchemy
Goleman [22]	Motivate Oneself	Control Impulses	Regulate Moods	Avoid Distress
Goleman et al. [25]	Self-Awareness	Self-Management	Social Awareness	Relationship Management
Cooper and Orioli [26]	Resilience	Relationships	Decision Making	Vision

In addition to emotional intelligence, thirteen leadership behaviors were used to investigate the leadership of project managers. Through a literature review, sharing and open communication, punishing and delegating were identified as other leadership behaviors exhibited through project managers. Sharing and open communication is where the leader shares any information throughout the group and entire organization [21]. Punishing leadership behavior is a style characterized by giving negative feedback and punishment to those who show an unpleasant work performance [21]. A delegating leadership style warrants the ability to delegate and distribute work and transferring authority and responsibility to lower positions [21].

The method used to evaluate these leadership behaviors consisted of dividing the group into low and high emotional intelligence scores to compare each to leadership behaviors. These studies found a positive correlation with having more open

communication and proactive leadership styles in the project managers with high emotional intelligence scores. Experimentally finding these leaders with high emotional intelligence and leadership behaviors which exhibit better social and communication skills helps the development of more capable technical leaders. However, the reasons behind these traits were not investigated further but only elaborated upon. Therefore, the climate of groups and individuals has been researched to determine the reasoning behind the cause of increased interpersonal skills among technical groups.

2.3 Group Climate

The climate of a group determines the style in which the project manager will embrace, however, the motives of the team members need to be questioned. The origin of climate and perception gained from the team members has an enormous bearing on the leader's assessment of the group dynamic and what actions to proceed with. Since leadership is a psychological subject, the knowledge of the relationship between emotional intelligence and transformational leadership produces the ability to train leaders effectively in any field of study. In addition to the significance of relationships, technical skills are a part of the leadership traits which need ample consideration as well. The balance between these two characteristics and transactional leadership is the key to an optimal leader.

Researching deeper into emotional intelligence, more studies are found of methods to determine the facets in which this type of leadership displays. Goleman [27] introduces leadership by evaluating a study done with a company by taking a random sample of 3,871 executives from a pool of 20,000. From that study, they were able to

find six leadership styles derived from the principles of emotional intelligence. Emotional intelligence is the ability to manage ourselves and others effectively through self-awareness, self-management, social awareness, and social skills. Within those four categories, there are twenty competencies which are characteristics which are exhibited through the performance and relationships between leader and team members. Through these four categories and twenty competencies, the six leadership styles that were generated are coercive, authoritative, affiliative, democratic, pacesetter, and coaching leadership.

Furthermore, McClelland found that having strength within six or more competencies was far more effective than the latter [27]. This produced a new study which set out to research more connectivity between leadership, emotional intelligence, climate and performance. Table 2.7 shows the study done on climate and performance relative to the leadership from emotional intelligence. Climate is broken down into six factors such as flexibility, responsibility, standards, rewards, clarity, and commitment. This table shows the correlation between the climates and leadership styles. Therefore, this recommends what type of climate to induce while using a particular leadership style. While four out of the six leadership styles show a positive correlation, these styles should not be heavily relied on individually.

Table 2.7: Climate v. Leadership Styles [27]

	Coercive	Authoritative	Affiliative	Democratic	Pacesetting	Coaching
Flexibility	-.28	.32	.27	.28	-.07	.17
Responsibility	-.37	.21	.16	.23	.04	.08
Standards	.02	.38	.31	.22	-.27	.39
Rewards	-.18	.54	.48	.42	-.29	.43
Clarity	-.11	.44	.37	.35	-.28	.38
Commitment	-.13	.35	.34	.26	-.20	.27
Overall	-.26	.54	.46	.43	-.25	.42

The positive overall values show which types of leadership should be implemented and the negative correlating values shows which leadership styles should be used with caution. The negative correlating values are a combination of the feedback found within each climatic category. In pacesetting style of leadership, responsibility is the only positive value and for coercive leadership, standard is the only positive value found. These evaluations are conveying that these leadership styles should be used in instances where these climates are observed more than others. For engineering projects, the determination of correct climates leads to the corresponding leadership style for any stage throughout the project.

Knowing the correlating values of climate relative to each type of leadership allows for the leader to know what leadership style to adapt to when these climates arise within a group setting. The translation of these findings is applicable to engineering group projects and other fields. The research in this thesis proves that these ratings are applied through every hierarchical level in a company or group project. Once the team members evaluate one another in reference to the climate of the group dynamic, the

foundation of issues develop within each type of leadership style exhibited by each individual member. This research which has previously been established offers the ability to correlate their data to this research using individual members of the team. Emotional intelligence puts forward an application of individual evaluation through its definition of knowing each team member's distinct emotions.

Emotional intelligence is defined as the ability to perceive emotions, to access and generate emotions to assist thought, to understand emotions and emotional knowledge, and to reflectively regulate emotions so as to promote emotional and intellectual growth [28,29]. The purpose of emotional intelligence is to use your emotions to help the leadership traits emanate throughout the group. Emotional intelligence is based from one's ability to recognize and regulate emotions which are from the leader and others [27]. Throughout teamwork, the leader can use emotional intelligence to control the emotions of the group. These emotions are transmitted from the leader to the team in either a positive or negative light. Depending on each perception that is given by the leader, the performance of the group is also affected by those emotions.

In this case, Goleman [27] created an emotional competency model which evaluates five categories of 25 competencies related to work performance. These five categories are self-awareness, self-regulation, motivation, empathy, and social skills. The most important category for teamwork would be social skills which include influence, communication, conflict management, leadership, change catalyst, building bonds, collaboration and cooperation, and team capabilities. These competencies are the core principles behind the notion of teamwork. Leaders can effectively lead their teams by

using emotional intelligence and more specifically, the competencies to control the team's emotions. Elliott describes this effectiveness through six similar leadership styles: visionary, coaching, affiliative, democratic, pacesetter, and commanding. Each style has a distinct competency which distinguishes itself away from the others. The ones which are labeled with positive climates are great for any particular time but are strongest when used appropriately. However the two labeled with a negative climate, are often misused. Therefore, the style of leadership is a positive for the situation in which it is needed for.

The research within the thesis is determining whether these leadership styles have an effect on engineering projects. If these leadership styles are seen within the group dynamic, then the degree of how much leadership styles are observed will determine its effect on engineering projects. The effect upon the engineering projects involves different members of the team exhibiting one or more of these leadership styles. Whether each member of the group appropriately uses a particular leadership style is also an effect on the engineering design project. A positive or negative use of leadership does produce an effect on the outcome of the engineering project. Through the case studies in this research, a conclusion is drawn of what leadership styles and climates dictate the progression of an engineering group project.

2.4 Technical Leadership

This is one previous study suggests that technical leadership is effective through the demands of certain behaviors and strategies. This is derived from the notion of technical professionals having a mentality of autonomy, which leads to ambition and

control of their goals and achievements. The desire for seclusion means that the technical individuals want a large role in developing goals and making decisions [30]. A challenge for technical leaders is having the ability to merge both the ambitious and egotist nature of the technical professions while making sure they are accomplishing the goals of the company. In this research, the students have their own agendas in mind as far as school is concerned. Not only do they want to succeed with the engineering project ahead of them but they also want to have the highest grade point average possible as well. The projects evaluated in the future of this thesis have grades associated with them but they have other courses which have to be completed to their liking.

Technical professionals want to succeed but also achieve success with the hardest challenges while using a high level of skill and effort to complete those challenges [30]. These challenges and achievements generate excitement and motivation within the technical professionals to showcase their abilities to the company and apply themselves to future objectives. The movement of these technical people to the realm of leadership is another challenge to confront because they are technically minded individuals. Often technical professions who have done well within a company are promoted based on their technical competence, which leads to short-term managerial success because interpersonal effectiveness is needed for long-term success [30]. Within a group dynamic, the individualistic minded group members may or may not succeed based upon the members within their group. The mixture of technical and interpersonal individuals allows the group members who are more focused on the technical aspect of the project to progress with their own work. However, groups with all autonomous individuals may

not share as much information or help each other with the problem because they are each trying to solve the problem individually.

Statistics from this paper show that eighty percent of the technical leaders showed either limited or nonexistent past training of technical professionals and 91 percent said they would find benefit from future training. The survey used also found that successful leaders in multiple projects need to coach for peak performance, run organizational interference, orchestrate the professional development of their subordinates, and expand individual productivity [30]. Running organizational interference and orchestrating professional development are high order tasks for managers and executives to delineate, however the other aspects of being a technical leader are applicable to leadership within the group dynamic. By coaching other team members in the group, listening, asking questions, and facilitating are all aspects which effective technical leaders use to help procure the achievements of the more technical members in the group.

A balance between support and criticism is needed for coaching individuals to be as successful as possible. In addition to coaching, encouraging innovation and creativity is another way to lead technical individuals. Using techniques which cultivates productivity within technical professionals, such as clarifying roles, establishing goals, identifying and securing resources, and implementing information exchange systems has a positive outcome for the completion of the task [30]. Therefore, leadership is proven to exist within the technical community through these characteristics.

Within the realm of product development and teamwork, leadership is researched to determine the focus of how leadership styles affect the learning in cross-functional

teams, how it relates to the preconditions of teamwork, and how leadership styles contribute to an innovative climate [31]. Therefore, Norrgren and Schaller [31] have researched several models used previously in literature to determine how project managers' style affects teamwork and its preconditions. Since teams generally take the attitude and expectations from the project manager, teamwork is heavily and directly related to the project manager's approach. There are three leadership styles that are being used for comparison and developed by Ekvall and Arvonen [32], which are production-centered, employee-centered, and change-centered leadership.

These leadership styles are evaluated against work climates and learning strategies. Climate is a perceiving element which indirectly measures the performance of leadership and provides the capacity of organizations for change and innovation [33,32,31]. This particular climate dimension has ten indices and learning strategies has eight indices regarding how they relate to the leadership of project managers. There is not any confusion between the actual leadership of the project managers and the perception of their leadership. Climate provides variables outside the leadership of the managers and to accomplish certain environments within the team, these factors need to be employed by the leader. The climate which is encountered by the students in this research will gain perceptions of their environment from one another. Therefore, climate is needed to gain the knowledge of how much the perception captured within each individual determine their leadership style.

The overachievement of leaders has also been examined in organizations and defined motives which are the notions behind the leaders wanting to overachieve.

Overachievement is not necessarily a harmful element if the leaders are striving for achievements successfully, however, the drive and attitude of the leader may traverse to a horrible condition. Since the focus is solely on the tasks and goals of the project, the team members are forgotten and performance decreases. Overachievers are more likely to be more aggressive and commanding which belittles the team members and crushes their self-esteem and optimism. This type of leader tends to think that if the project team achieves the goal by the structure which the leader put forth, as long as the project is completed successfully, then the project team accepts the path which was made. The motivation behind this leader is clearly the accomplishment of the goal with a high level of success.

Motivation is defined by three characteristics which all exist in everyone in some form and conveyed when needed. The first motive is achievement, which is the premise of the research and is the source of willpower for the leaders which wish to succeed the most. The next motive is affiliation and this motive is similar to the leadership styles which involve maintaining relationships and connections with the team members. Lastly, power is the third motive and is broken down into two forms. The first form of power is personalized, where the leader gains strength from controlling others and socialized power is when the leader's strength is increased by the empowerment of the team members [34]. These motives differ from climate because climate gives the perception of each leadership style. Motives are the underlying reasons for the aggressive and non-aggressive approaches to a leader's success within a project.

Discovering the motives of each of the group members is diverting away from what needs to be explored for gaining the possible existence of leadership within the project team. Climates are essential to determining the perceiving behaviors during particular instances and these factors clearly influence the type of leadership which arises. Motives were correlated against yielding strong and energizing versus neutral or demotivating climates in this research. Leadership styles are used to create an atmosphere between the leader and team members so the goals can be accomplished in a collaborative manner. Climates create perceptions of the correct and incorrect forms of leadership for certain projects, however motives are objectives which can be gained through the course of the project. These motives affect the climate within the team because the team members longitudinally observe changes to the leader's way of thinking and not their style.

When project managers leads a group, the task is known but the way in which the task is accomplished is the main idea. The leader immediately thinks of how the task is going to be complete with the assembly of the team members. Research within the development of leadership within technical fields yields a more specific analysis of the research within this thesis. Research has been done on leadership but the research is on leadership as a general discipline. Yet, a study has been done on leadership which discovered that managing highly specialized technical professionals with traditional principles of leadership may only lead to minimal success [30,35]. The models developed in the 1980s are being used to observe the leadership within technical organizations to establish if those traditional models are viable. One well tested

measurement instrument is the Multi-Factor Leadership Questionnaire (MLQ) and it distinguishes the differences between transactional and transformational leadership. There has been criticism of MLQ for its lack of validity and psychometric problems [36,37,35], but there have also been results concluding that MLQ does succeed and produce feasible outcomes [38,35].

The research is using transactional and transformational leadership as a known constant within technical projects and observing the differences of leadership in successful and unsuccessful projects. Transformational leadership, similar to the style of democratic leadership, is a style which is characterized by attributed charisma, idealized influence, intellectual stimulation, and individualized consideration. On the other hand, transactional leadership is based upon contingent reward, management-by-exception, and technical leadership. Figure 1 shows a conceptual framework of what the research believes dictates the success of projects. The figure shows transactional leadership leading to low project success and transformational leadership in combination with technical leadership steering towards high project success. For applying a psychological model to a technical project, this conceptual model predicts that a blend of social and technical skills leads to high success on technical projects. This model was proven through the team members' ratings of the project managers and needs to be explored further in this research.

Since this research is determining the successful leadership of the project managers, the only difference is the examination of team members against one another. The perception of leadership within the team, even though a leader is involved, is missing

from this initial research. Whether both transformational and technical leadership is the solution for this case, the examination among peers may yield a difference result.

2.5 Research Hypotheses

The first definition of leadership is through task and interpersonally oriented from Eagly [14]. This definition is followed by a second definition of leadership, which is similar to Eagly's definition, from Bass and Avolio [16], where they define leadership as transformational and transactional leadership. From this point, task and interpersonally oriented leadership will be used interchangeably with transactional and transformational leadership respectively. These two studies will use the definitions of leadership to record leadership within the two groups. Then, we will use the definitions of motivation and climate within the second case study in Chapter 5 to determine possible climates which trigger leadership within engineering project groups.

These two case studies will provide the opportunity establish a pattern of leadership within engineering groups. The first case study uses a written survey, interviewing, and an ethnographic study to triangulate the data to find consistent results. The second case study uses two forms of written surveys, interviewing, and an observatory study to determine the characteristics of leadership within engineering groups. By using three or more methods of qualitative and quantitative data in each study, the results found will determine whether there are distinct relationships within and comparatively against each case study.

Primary Hypothesis: The leaders of the group will clearly be identified by the team members.

Secondary Hypothesis 1: Leaders will be identified by high scores in both task (transactional) and interpersonal (transformational) qualities.

Secondary Hypothesis 2: Leaders are not the only team members which exhibit leadership traits and activities.

Secondary Hypothesis 3: Leaders, once initially established, will remain stable throughout the duration of the design project.

CHAPTER THREE: CASE STUDIES

Well developed experiments, tests, or trials with clear analysis of these methods yields sound data and provides clear solutions. However, a well constructed case study yields clear results with many types of methods which provides more substantial analysis of solving a problem. Case studies are a means of which methods are used to explain phenomena within a given problem [39]. These methods consist of three or more qualitative and quantitative analyses which will give a triangulation of data. The triangulation of data supplies the robustness of the data in which the conclusions found from the methods used in the case study are confident and accurate.

There are also many variations of case studies found within literature. Within a case study, cases exist which are individual studies with certain parameters. A case study encompasses either a single case or multiple cases to solve a problem. Case studies with a single case provide the normal triangulation of data to develop analysis. A case study with multiple cases has either case with differing or similar variables to determine whether there is an established pattern or contrast within the data found. For a case study which seeks to find a similar pattern within multiple cases, it is called literal replication. A case study which purposefully examines multiple cases to find contrasting arguments is called theoretical replication. Within this chapter, multiple aspects of case studies, such as various types and methods used, are discussed to provide an extensive background of this topic.

3.1 Case Study Categories

3.1.1 Explanatory Case Studies

Explanatory case studies attempt to explain a phenomenon which takes course throughout the entirety of a case. Within an explanatory case study, it is aiming to achieve an accurate representation of the facts of the case, thoughts of alternative explanations of these facts and a conclusion which is parallel to the facts [40]. The sequencing in which these facts and conclusions are drawn is constructed with both linear and non-linear paths. This is one advantage to implementing explanatory case studies because there is not a systematic process for building or comparing these types of cases. Furthermore, explanatory case studies are welcome to the addition of more variables and complexity. Therefore, the means in which the case study is developed and implemented is not as important the actual facts and conclusions found from the study. There are three derivations of explanatory case studies that exist, which are knowledge driven, problem solving, and social interaction theories.

3.1.1.1 Knowledge Driven Theory

Knowledge driven theory is applied to the advancement of applied research through innovations, inventions, and commercial products or services [39]. Therefore, the process taken to produce this technology is a straightforward sequence. Whether it is the scientific process or Six Sigma, the purpose of this theory is to constantly produce new technology and products. This is also defined as a technology-push process where the researchers continually create new ideas for products and services [39].

3.1.1.2 Problem Solving Theory

The problem solving theory involves the identification of a problem so that the study is solved correctly. The problem needs to be identified from the individuals or organization within the study and not by the researcher conducting the study [39]. This is known as the demand-pull process where the user helped define the initial problem and prepared to implement the solution [39]. However, if the problem is developed incorrectly or poorly by the users, then the researchers have to redefine the problem from the information found within the study. Then, test and assess the alternatives to the new problem found to continue the case study.

3.1.1.3 Social Interaction Theory

This theory does not have a linear path and welcomes the ability to interact with the subjects throughout the study. The social interaction theory focuses on the attributes of persons, expression of these attributes and the relation of personal attributes toward others in the group [39]. There is an overlap of communication which exists between the research group and the users. The communication is not suppose to focus on the research endeavor of the study but the objective of the communication is to increase the exposure of each other's viewpoints throughout the case study [39]. The effect of advantageous communication within this type of case study allows the researcher to positively alter the case study to extract the most plausible data. The users within the study also offer the researchers what their needs are and the researchers can adapt to those needs.

3.1.2 Exploratory Case Studies

The goal of an exploratory case study is to discover theory by directly observing a social phenomenon in its raw form [41,39]. Collecting data and doing fieldwork to build a case is only good enough for pilot case studies. Once preliminary data is found from the initial data gathering, then a development of final definitions and hypotheses occur for a more formal study and support. Unlike other types of case studies, the results found from exploratory case studies do not have to be followed by another case study. More social research is expected to ensue after the exploratory case studies are finished.

3.1.3 Descriptive Case Studies

Descriptive case studies cover the scope and depth of an object being described [39]. The objects consist of individuals, groups, organizations, companies, and products. The scope of the case study and the depth in which to evaluate the objects is upon the researcher's discretion. In any research arena, the scope should be defined explicitly to determine what the key factors need to be retrieved. The depth of the research has to be sufficient to divulge the necessity of exploration. One of the most important aspects of descriptive case studies is the justifications behind the phenomenon being described. Failure to justify the critical factors of the phenomenon will produce rambling data and undesirable reasoning of the case study [39].

3.1.4 Examples of Case Study Research

Case study research in engineering design has led to insights in design method development, design tool development, and the application of prototyping. Teegavarapu

and Summers [42] used case studies to identify patterns which constitute a framework for research and development of systematic methods. Multiple case studies internally and externally allowed the research to gain patterns and develop those conclusions. These two types of case studies led to the model of developing systematic methods for design problems which cannot use previously defined design tools.

Case studies were also used in Miller's [43] research to map the information flow throughout multiple design processes. Three case studies were used to test and verify the Design Enabler Information Maps method, which creates a visualization of the design process to better suit the design problem given to a designer. Then in Stowe's [44] research, the relationships of effective prototyping were established through case study research. Interviews, an ethnographic study, and documentation analysis were used to identify the common factors seen in successful prototyping.

Engineering design has also used case studies to validate its research in other works. Hernandez et al. [45] improved the standardization of components through case studies involving the evaluation of production systems. Agogino and Hsi [46] used case studies to evaluate each design variable to assist learning within engineering design and different perspectives were gained as each case study was conducted. Within these case studies, triangulation will develop patterns within and across the data collection methods described in this chapter. Table 3.1 summarizes all of the case study research explained within this section.

Table 3.1: Summary of Case Study Research in Engineering Design

Engineering Design Research	Description	Case Study Type	Authors
Design Method Development	Systematic methods through pattern recognition	Explanatory	Teegavarapu and Summers [42]
Design Enabler Information Maps	Visualization of information flow through patterns	Explanatory	Miller [43]
Prototyping Application	Effective prototyping through relationships	Explanatory	Stowe [44]
Product Families Standardization	Standardization of product modeling	Explanatory	Hernandez et al. [45]
Engineering Design Education	Helping engineering design through learning assistance	Explanatory	Agogino and Hsi [46]

3.2 Data Collection Methods

3.2.1 Ethnographic Study

An ethnographic study is where the researcher is embedded within a particular situation, group dynamic, or culture to study unknown characteristics. This researching technique entails real-world problem solving and planning behaviors which will expose classifications and patterns [47]. For example, if the researcher desires to know the design process of a company, then the researcher assumes a position within the company as a designer [48,49]. The ethnographic approach also aims to provide a description of the implicit rules, traditions and behavioral patterns of a group [48]. The main method in which these behaviors and patterns are tabulated is simply by observation. The observation which exists within the situation can be more or less structured and once the study becomes more structured, then hypotheses emerge from the investigation [50,48].

3.2.2 Interviewing

Interviewing is a question and answer process where the researcher receives information from individuals on targeted topics [49]. Questions that are created for interviews should be centered on the information needed to help answer research questions. If the interview questions are in a sequence or flow, the ease of answers increases. The purpose of extracting information from individuals is to compare the answers given to the experiences tabulated from other areas of research within the study. This method has the subjects recall information from recent memory to obtain their viewpoint from within the study.

3.2.3 Observatory Study

An observatory study adds another viewpoint from the researcher's perspective looking outside of the situation being encountered. Unlike the ethnographic study, the researcher does not immerse with the culture or group. As the observing progresses, the researcher should be able to understand the reasoning behind important events and changes which occur. These observations transpire as long as the researcher needs to find the right amount of information. A hypothesis is drawn from research, and then it is decided upon by the researcher to investigate and observe the situation to validate the hypothesis.

3.2.4 Documentation Analysis

Documentation analysis simply examines the documentation created from the team over the period of time during the project. The documentation criterion is based

upon the type, who created the document, and what the document is used for. The types of documentation which could be seen are weekly reports, Microsoft Excel sheets, conference papers, and drawings. Each member of the group will submit their documents which they have created and they will be corroborated with the other data collection methods.

3.2.5 Written Survey

Surveys are similar to the interview process, yet they directly take the subjects thoughts and translate them to a written form. There are three types of written surveys: evaluations, questionnaires, and interviews. The questions asked or method of survey is important to receive the correct answer. In questionnaires, whether a question should be written by the subject or given by the researcher is waged with good reason. The researcher has the option of giving answers to the subjects by multiple choices (selecting one choice), ranking, selecting multiple answers, and Likert scale. Within a questionnaire or evaluation, the Likert scale is used as a technique to gauge how much they strongly agree, and strongly disagree, or whether an object is valued high or low [51]. By selecting any of these types of survey options shown in Table 3.2, there must be ample time given to the subjects to obtain optimal results.

Table 3.2: Summary of Data Collection Methods

Data Collection Methods	Data Collection Type	Case Study Usage
Ethnographic Survey	Qualitative and Quantitative	Chapter 4
Interviewing	Qualitative	Chapter 4 and 5
Observatory Study	Qualitative	Chapter 4 and 5
Documentation Analysis	Qualitative	Chapter 5
Written Survey	Quantitative	Chapter 4 and 5

3.3 Conclusions

This chapter has given an overview of case studies and information about what they are and how different types of case studies are used to establish certain types of deductions. There are three types of case studies, descriptive, explanatory and exploratory, which are used in different scenarios to derive specific data to make those deductions. Within those three types of case studies, there are many types of quantitative and qualitative data which can be applied. However, Chapter Four's case study will use ethnographic data, observatory study, written survey and interviewing and Chapter Five's case study will use two written surveys, observatory study and interviewing. Chapter Four's case study has a longitudinal study, where the other three sets of data compliments the process of that study. The Chapter Five case study implements an evaluation sheet which encompasses the leadership and emotional traits which they could have possibly exhibited over the project's span.

CHAPTER FOUR: ME 402 CASE STUDY

Initially, this case study originated to determine how leadership was established in engineering project groups. However, this study has become valuable to determine the leadership characteristics which existing within engineering project groups. Leadership in engineering groups is reticent because of the stereotypical personality of an engineer or scientist. All engineers are not reserved but their work habits and course of education are often spent autonomously [30]. Gathering multiple engineers who have limited experience working with a team dynamic will turn into a struggle for communication and team cohesiveness. This problem and other possible occurrences are documented throughout the course of this case study.

Within academic settings, groups are formed to accomplish tasks which cannot be completed by one person. Teams are formed in classrooms to increase exposure to a team atmosphere, gauge teamwork effectiveness, and bolster social interaction and contributions to work inside and outside of the classroom [52]. By following ABET requirements “to function on multidisciplinary teams” [53], student classroom experiences have shown a positive reflection on interpersonal skills and clarity of educational goals [54]. Cooperative learning is a structured approach which is intended to improve the students’ understanding of the course topics, and teamwork skills [55,56,57].

However, the inner workings of a team are not developed with an evident leader or chemistry. Therefore, teams which have no clear leader are cooperating together, free

from added responsibility and stress of accountability. An undergraduate senior design team is evaluated under this type of environment to determine if leaders emerge within the process, whether leadership style is developed, and if the overall goal can be accomplished. Three tools were used to triangulate the information gathered: ethnographic data of leadership performed, questionnaire about their leadership skills and teammates' opinions, and interview questions.

4.1 Case Study Description

This case study is staged within an undergraduate senior level course at Clemson University. The senior engineering design course works with outside sponsors to provide design problems within industry for the undergraduate senior students to solve in one semester or four months. This group of four students worked with an automotive company to solve the crimping system for the rear hatch of their sports utility vehicles. Each student was a senior mechanical engineering major at Clemson University and they all did not know each other before the start of the project. The crimping system or tool needs to fix the seal on the frame of the rear hatch within 120 seconds since their current system is insufficient for placing on the assembly line.

The group was accompanied by a graduate student coach to help them progress through the design process where necessary. As the graduate coach, the research was able to have a close viewpoint of experiencing the fruition of leadership in the group once per week. The goal of this case study is to examine the group dynamic closely during their weekly meeting and determine task and interpersonal leadership traits as they deliberate on the project.

4.2 Hypotheses of Interest

In Chapter Four, the main hypothesis is explored through interviewing and questionnaire given to each team member. The responses from those two data collection methods are cross-referenced to the ethnographic study and determine whether the team members recognize the leaders within the group. This part of the research will make the team members' recognition explicit. It is expected that the group will identify one team member who they see as a leader, and all three methods of data collection can verify this assertion.

The first two sub-hypotheses are also evaluated in this chapter. The values found within the ethnographic study supplies the identification of task and interpersonal qualities within the team members. Each team member identified as a leader from the initial hypothesis must display high values in task and interpersonal leadership types. In the second sub-hypothesis, all data collection methods are used to determine if non-leaders exhibit leadership traits. The ethnographic data has each team member's accumulation of leadership traits. Therefore, team members may show a period of time where they show similar values in the ethnographic study to the leaders which are established in the group.

The last sub-hypothesis will be proven because of duration of time which the group is moving forth with the project. A four month project is a short amount of time for a project. However, major occurrences from the initial direction instituted or personalities interacting within the group can pose a leadership change in the group. If this happened, the ethnographic data should show either a large decrease with the initial

followers or increase in the leaders. The interviewing questions also provide an opportunity for the students to express when and how the change occurred.

4.3 Case Study Protocol

Before the explanations of these case studies begin, there is also a nomenclature used in Chapter Four: and Chapter Five: to identify the questionnaire, interview questions, and students used in each case study. For example, Question 6 from the interview in the first case study in Chapter Four is known as C1I6 and Question 3 from the second case study in the questionnaire is C2Q3. Table 4.1 shows how the interview questions and questionnaire will be coded and Table 4.2 shows how the students are coded in both case studies.

Table 4.1: Interview and Questionnaire Coding for Case Studies

	Interview Questions		Questionnaire Questions	
	Case Study 1 (Ch. 4)	Case Study 2 (Ch. 5)	Case Study 1 (Ch. 4)	Case Study 2 (Ch. 5)
Question 1	C1I1	C2I1	C1Q1	C2Q1
Question 2	C1I2	C2I2	C1Q2	C2Q2
Question 3	C1I3	C2I3	C1Q3	C2Q3
Question 4	C1I4	C2I4	C1Q4	C2Q4
Question 5	C1I5	C2I5	C1Q5	C2Q5
Question 6	C1I6	C2I6	C1Q6	C2Q6
Question 7	-	C2I7	C1Q7	C2Q7
Question 8	-	C2I8	C1Q8	C2Q8
Question 9	-	C2I9	-	-
Question 10	-	C2I10	-	-
Question 11	-	C2I11	-	-
Question 12	-	C2I12	-	-
Question 13	-	C2I13	-	-
Question 14	-	C2I14	-	-
Question 15	-	C2I15	-	-
Question 16	-	C2I16	-	-
Question 17	-	C2I17	-	-
Question 18	-	C2I18	-	-
Question 19	-	C2I19	-	-
Question 20	-	C2I20	-	-
Question 21	-	C2I21	-	-
Question 22	-	C2I22	-	-
Question 23	-	C2I23	-	-
Question 24	-	C2I24	-	-
Question 25	-	C2I25	-	-
Question 26	-	C2I26	-	-
Question 27	-	C2I27	-	-
Question 28	-	C2I28	-	-

Table 4.2: Coding for Students in Both Case Studies

Students	Case Study 1 (Ch. 4)	Case Study 2 (Ch. 5)
Student 1	Alex	Eric
Student 2	Barry	Fred
Student 3	Carol	Grace
Student 4	Dave	Hank
Student 5	-	Irene

4.3.1 Ethnographic Study

The case study will proceed with three phases of implementation. All of the phases are used to encompass the goal of the first hypothesis. The first step of the case study is to quantify the leadership of the individual teammates of the group. By using the traits of the task and interpersonal oriented leadership styles as categories, the students can be evaluated through those items. Therefore, Table 4.3 was set up to take a tally of each student during their meetings. The data was collected in weekly meetings where the delegation of tasks took place. They also left the meeting each week with what each team member needed to do for the next week. The data taken from Table 8 will show how many times each student exhibits those qualities.

Table 4.3 Ethnographic Data Collection Table

Date:		Alex	Barry	Carol	Dave
Interpersonally Oriented	Idealized Influence				
	Inspirational Motivation				
	Individualized Consideration				
Task Oriented	Work Completion				
	Delegation of Tasks				
	Individualism				
Description					

4.3.2 Questionnaire

The second portion of the case study is the leadership questionnaire. This leadership questionnaire asks questions in the realm of leadership for a team atmosphere. There are two portions which are examined through the questionnaire. The first portion is their recognition of leadership within the group and the second is whether they have a

good understanding of what leadership is. The understanding of leadership is shown through basic questions about the differences between task and interpersonally oriented leadership and whether they or their team members are a certain type of leader in the group. The questionnaire has three questions to determine their knowledge and application of leadership. These questions are:

- Do you know the difference between task-oriented and interpersonally oriented leadership style? (1 – Strongly Disagree and 10 – Strongly Agree)
- Please place these words under what you consider which style (Task or Interpersonal):
- Words to choose from – Delegate, Consideration, Motivation, Individualism, Influential, Completion, Organization, and Morale
- What type of leadership do you consider yourself? (1 – Task, 3 – Both, 5 – Interpersonal)

These questions in addition to the ethnographic study will provide results of whether the students' and researcher's understand the definitions of leadership. The remaining four questions in the questionnaire explicitly ask who the leaders were in the beginning and end of the project and what leadership types were those members. The purpose of these questions is to determine their recognition of leadership in their surroundings. It is important for team members to understand who the leader within a group. The possible confusion caused by roles within a team can divide the team and prohibit the progress of accomplishing the main task. Questions to address these issues are:

- Do you believe there was a clear leader(s) at the beginning of the project?
- Were there any leaders which arose throughout the project?
 - If so, who (can be more than one)?
 - When did he/she/they arise?
- Do you think others within the group have seen you as a leader?
- Looking back at the experience, would you be more of a leader or follower?
- As far as leadership is concerned, rate yourself from 1 to 10: (1 – Strongly Disagree and 10 – Strongly Agree)
- What type of leadership do you consider yourself? (1 – Task, 3 – Both, 5 – Interpersonal)
- How confident are you in that leadership type? Rate strength of confidence: (1 – Strongly Disagree and 10 – Strongly Agree)

4.3.3 Interviewing

The next segment of the case study is the interviewing of the team members. These questions are comprised of behavioral, and leadership issues which are developed throughout the course of the study. Their answers should coincide with the data found from the table as well. If the answers from the questionnaire and ethnographic study do not equate, then the interview answers will clear any confusion between the data gathered. The interview questions for this case study are:

1. Do you think there will be problems later on by having no established leader?

2. A majority of seniors like to fall back as far as leadership, even if they were leaders before, have you seen that and feel that way yourself?
3. What have you done to help the direction of the group?
4. Did you utilize the advisors advice? Did you notice if anyone used it as well and if not, did you remind them about it?
5. Do you think you are a task or interpersonally oriented leader?
6. How did the end of the project turn out?

4.4 Triangulation of Data

Data triangulation is the tracking of how the data relates to each other. The mapping of data is important because without a sensible path of data collection, the data evaluated is incomplete. The use of multiple methods is used as a method of double checking results found by each method. The use of one method presents the data as opinionated material which needs more facts to relieve this notion. The addition of more methods provides additional confidence to the results. The path of data collection is a combination of methods which leads to the creation of patterns within the case study. This combination is also critical to the way in which the results are found within the case study. These combinations are mapped within Table 4.4 and Table 4.5 provided in Sections 4.4.1 and 4.4.2 respectively.

4.4.1 Intra-Method Triangulation

Triangulation within each of the data collection methods provides double checking of issues which need to be addressed and solved. This is accomplished by

asking similar questions in different ways. The repetition of those questions is multiple points of view for surrounding a particular issue. Another way to triangulate information within a data collection method is to ask the same question to multiple people. The multiple answers given from multiple people are compared and added to the rest of data found.

There is little intra-method triangulation in the ethnographic study and interview questions. The most triangulation within a data collection method in Chapter Four is in the leadership questionnaire. There are questions in the questionnaire which are being asked in different ways and these relationships are seen in Table 4.4. The first group of questions is related to the knowledge of knowing two types of leadership. C1Q3 asks how confident do the students understand the difference between task and interpersonal oriented leadership. C1Q4 asks each student to match associating words with each leadership type. Their confidence in C1Q3 has to match with how well they respond to C1Q4. If their confidence in each leadership type is 1, then they are expected not match all 4 pairs.

Table 4.4 Intra-Method Triangulation of Leadership Questionnaire

	C1Q1	C1Q2	C1Q3	C1Q4	C1Q5	C1Q6	C1Q7	C1Q8
C1Q1	-	X						
C1Q2	X	-			X	X	X	X
C1Q3			-	X				X
C1Q4			X	-				X
C1Q5		X			-	X		
C1Q6		X			X	-		
C1Q7		X					-	X
C1Q8		X	X	X			X	-

More triangulation is seen in questions which deal with leadership existing in the group. The first two questions, C1Q1 and C1Q2, ask if there was a leader in the beginning of the project and whether one arose during the extent of the project. This triangulation exists between both the questions and the people answering the questions. In general, these two questions ask whether a leader existed during the project but at different points of time within the project. Then by asking multiple people, triangulation determines who those leaders were in the project.

C1Q5 and C1Q6 triangulate one another by asking what they perceive their leadership as, then what their confidence is on a 1 to 10 scale. C1Q5 requires the students to think about their perception from other students. C1Q7 and C1Q8 triangulates in the same manner, yet by asking what they believe to be their leadership type. C1Q2 is related to these questions because if they have identified team members or themselves as leaders, then that effect they way these four questions are answered.

4.4.2 Inter-Method Triangulation

The triangulation between data collection methods is the primary method for finding patterns within a case study. Table 4.5 shows the mapping between the leadership questionnaire and the interview questions. C1I5 is the only question pertaining to leadership types. Therefore, it triangulates with C1Q3 through C1Q8. The inter-method triangulation of C1I5 extends to C1Q5 through C1Q8 because their confidence and perception of their leadership type also depends on what they answered for C1I5. C1I2 asks whether the students have seen anyone withdrawing from leadership in the group. This relates to all of the questions about leadership and confidence in the

questionnaire which are C1Q5 through C1Q8. Lastly, answers from C1I1 could point out leaders and non-leaders within the group. So, C1I1 is triangulated with C1Q1 and C1Q2.

Table 4.5 Inter-Method Triangulation of Interview and Questionnaire

	C1Q1	C1Q2	C1Q3	C1Q4	C1Q5	C1Q6	C1Q7	C1Q8
C1I1	X	X						
C1I2					X	X	X	X
C1I3								
C1I4								
C1I5			X	X	X	X	X	X
C1I6								

4.5 Results

The data gathered is analyzed thoroughly to get a broad perspective of what occurred within the group. The tools from the protocol will be used to interpret the proceeding of the ME 402 Senior Engineering Design Project and the students' ability to show leadership within four months. First, the chronological data has given values to the times where each student has exhibited leadership. Next, the questionnaire will be examined to verify what each student thought of their teammates and themselves. Then, the interviews will be the last piece which will connect everything together. Once the last part of the protocol is added, the data is triangulated and exposes the inconsistency within the previous data.

4.5.1 Ethnographic Study Analysis

The ethnographic study was evaluated on a weekly basis and given an increment within each category when the students show a characteristic of leadership. Overall, the group shows an increase of leadership throughout the project. There is a clear difference

between the leadership shown when they have started and towards the end of the project. Figure 4.1 shows the amount of leadership given by the group, as a whole, which is a 38% increase after the midpoint of the project. At the midpoint in the project, they all know each other and are more comfortable in everyone's ability. Another observation is the total of interpersonal and task oriented traits exhibited by all of the group members. Everyone combined to denote 100 times task-oriented traits are shown and 76 times for interpersonally-oriented qualities. In the first 4 weeks of the project, the students were balanced in using task leadership 26 times and interpersonal leadership 24 times. In Figure 4.2 and Figure 4.3, these graphs show each trend described above.

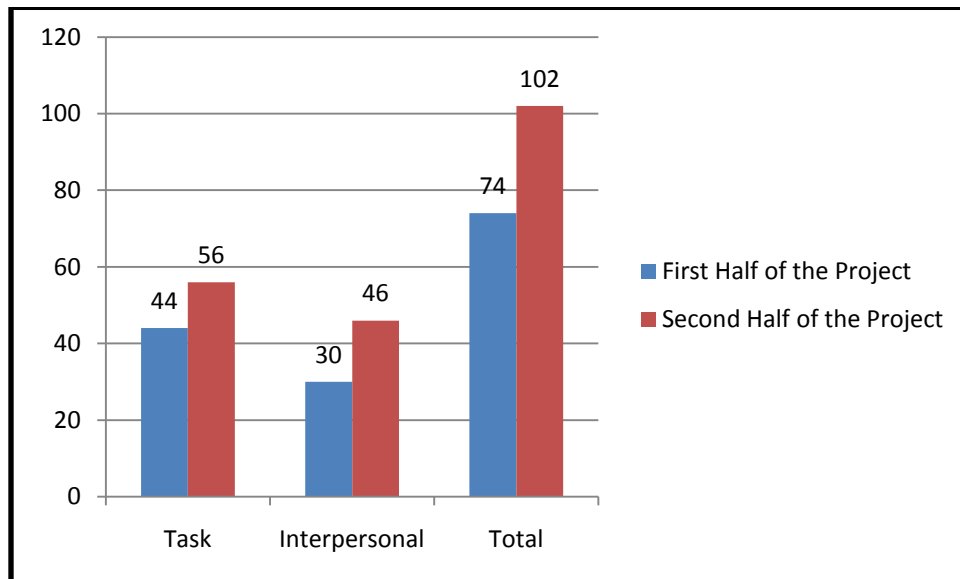


Figure 4.1: First and Second Half Leadership Values

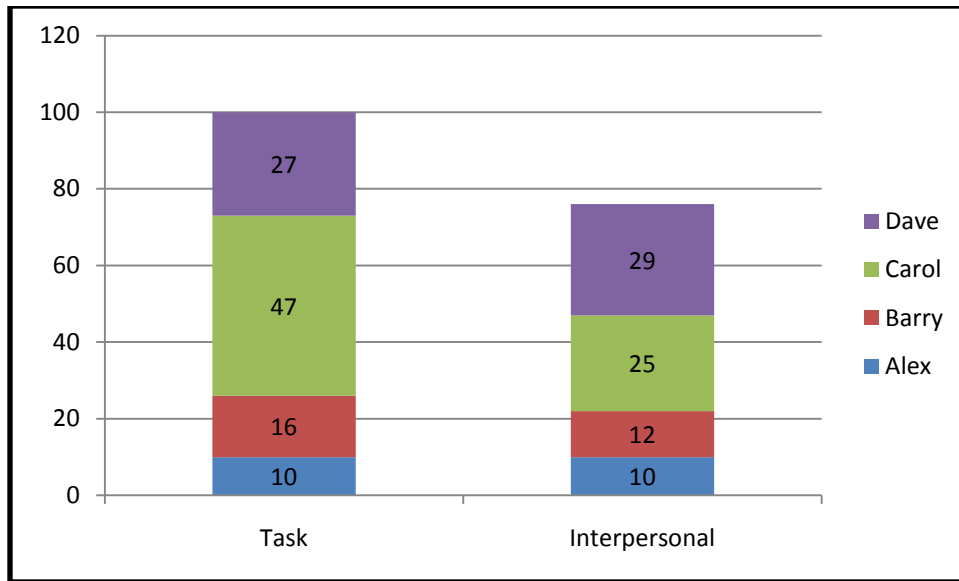


Figure 4.2: Task and Interpersonal Leadership by Students

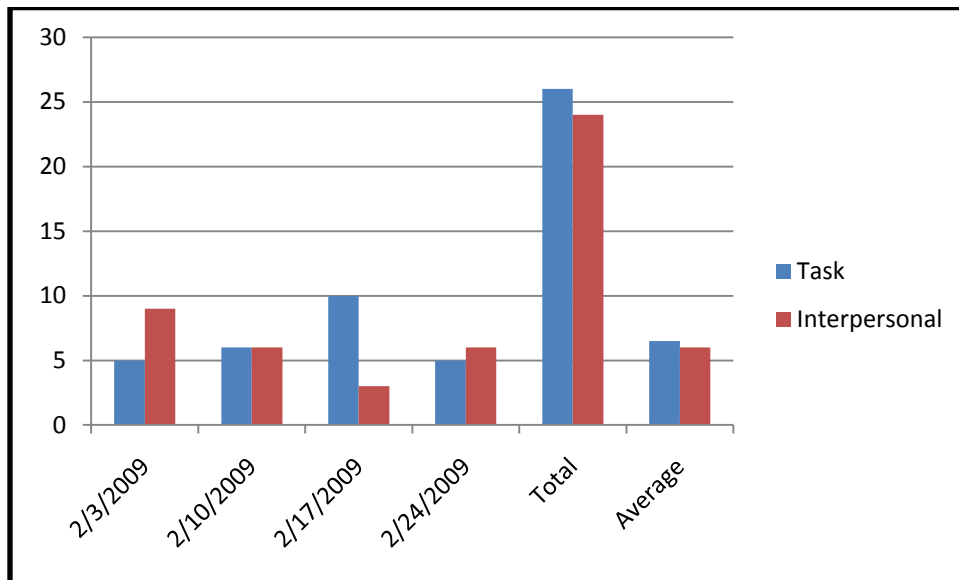


Figure 4.3: Leadership Values for the First Four Weeks

The individual statistics on the students is where the bigger picture is filled in more and a majority of the statistics is found in Appendix B. Alex has a maximum of showing leadership 4 times throughout the whole year on 3/31/2009. However, Carol

shows leadership a maximum of characteristics 10 times during the last two weeks of the project. Barry and Dave show similar qualities 5 and 7 times, respectively.

Alex does have the lowest showing of leadership qualities and Carol has the most throughout the whole project which is also seen in Figure 4.2. One interesting fact about Alex is that he/she did not exhibit any leadership at one point in the project (3/11/09). Barry demonstrated leadership 8 additional times than Alex. Barry also shows 4 more leadership traits within task orientation than in the interpersonal style. By showing a little less than half of leadership traits in three weeks after the midpoint, Figure 4.4 shows that Barry only displayed 1 or 2 leadership traits the rest of the weeks.

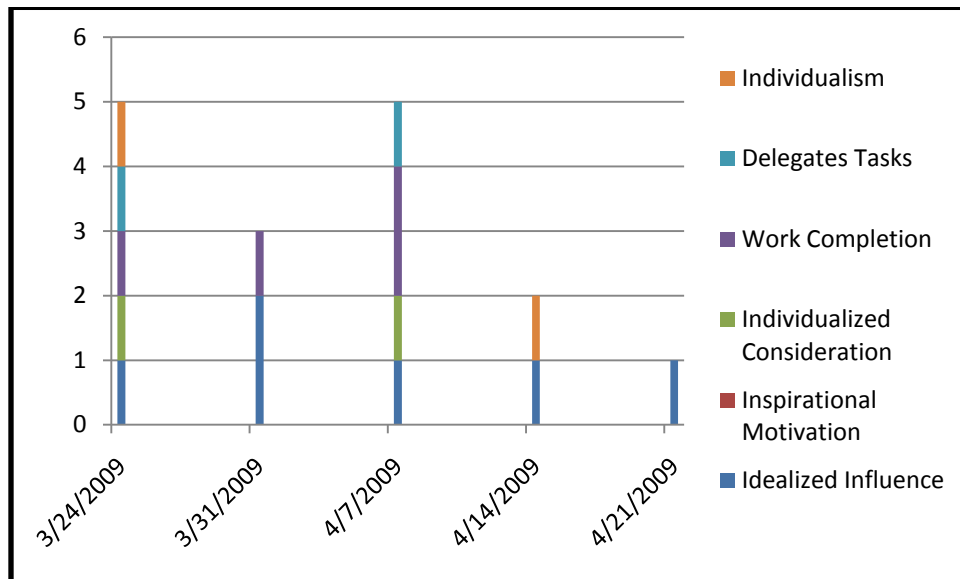


Figure 4.4: Last Five Weeks for Barry

On the other hand, Carol has shown a total of 72 occurrences of leadership within the course of the project. The majority of leadership is shown for Carol is within the task oriented leadership style. Carol has approximately double the amount of leadership traits within the task-oriented sector before the next student (25). At the midpoint of the

project, Figure 4.5 displays that Carol increased the amount of leadership exhibited by 48%. Throughout the project, Carol delegated work and checked if work was complete the most. Dave did not show the most leadership but came in a close second with 57 occurrences. However through the entirety of the project, Dave showed the most consistency. Even though this student peaked at 7, Dave illustrated leadership early in the project with 6 times in the first week and 5 times in weeks 3 and 4. The total amount of leadership shown by Dave in each style is only skewed by 3 towards the interpersonal side which is shown in Figure 4.6.

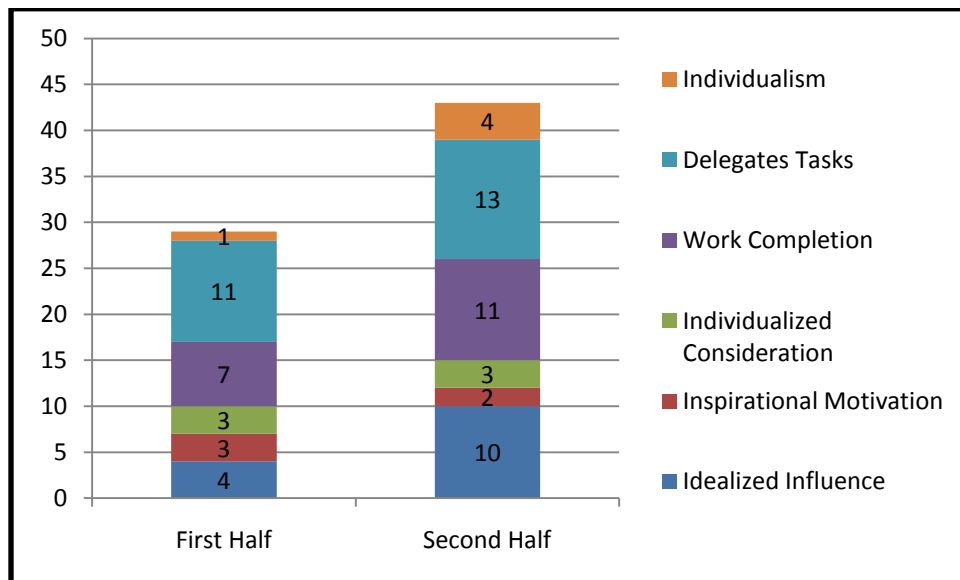


Figure 4.5: Carol's Leadership by First and Second Halves

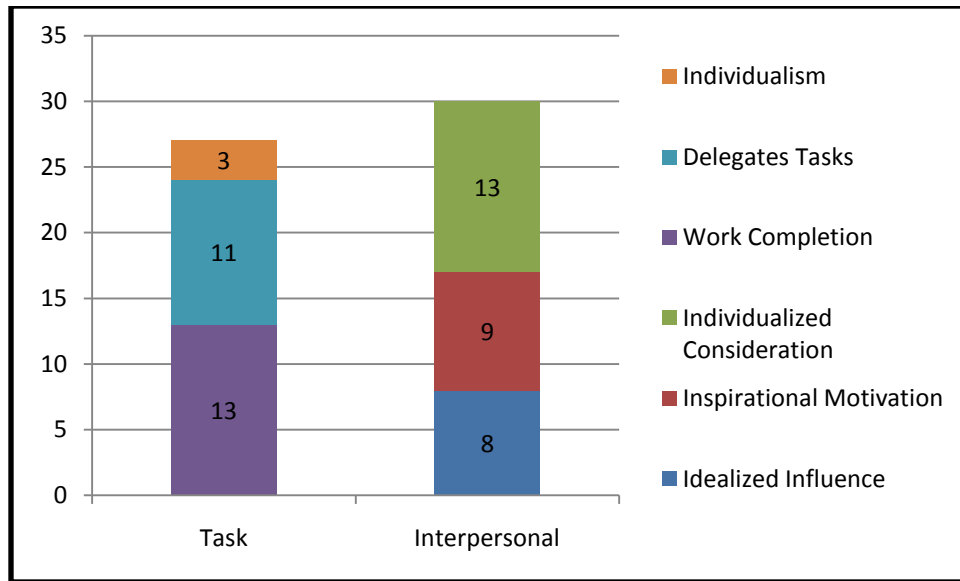


Figure 4.6: Task and Interpersonal Leadership of Dave

Through the ethnographic study, leadership is revealed in different ways. This data was taken from weekly meetings where the team members assigned tasks for next week. The teams met one or two times more the last three weeks of the project for testing. So during those meetings, someone else could have stepped up in those meetings. Therefore, Carol and Dave were the leaders at the weekly meetings. They have exhibited over double the amount of leadership qualities within the group. Carol is more of a task oriented leader and Dave is a balanced leader that shows slightly more occurrences of interpersonally oriented qualities. In the next section, the questionnaire will help determine if these statements are true.

4.5.2 Leadership Questionnaire Analysis

The leadership questionnaire revealed similar results to the ethnographic analysis. The figures below show the collection of answers given by the students. In C1Q1 and

C1Q2, it was definite that there were no leaders in the beginning of the project and leaders arose during the course of the project. For the last parts of C1Q2 (Figure 4.7 and Figure 4.8), the leaders arrived at many different points of the project but Carol was seen the most as a leader. Dave was seen as the leader three times and Barry voted on himself.

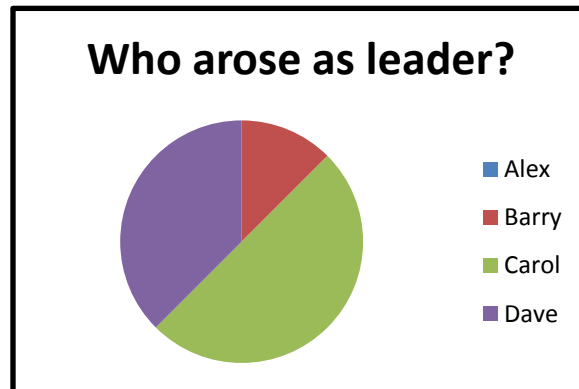


Figure 4.7: Question 2a

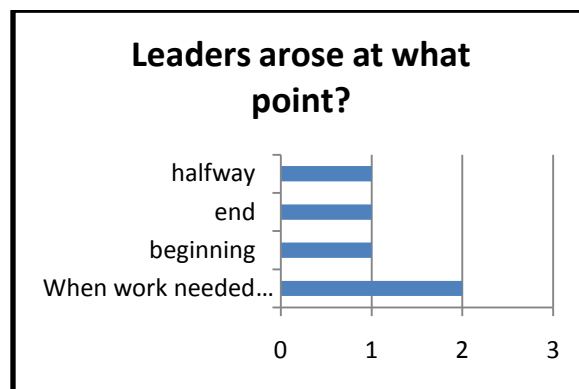


Figure 4.8: Question 2b

The next two questions, C1Q5 and C1Q6, pertain to what each student thinks the group's perception of them is. C1Q5 simply asks whether the group thinks they are a leader and every student answered yes. In C1Q6 (Figure 4.9 and Figure 4.10), each part of the question is aimed to support the previous question. The first part of the question determines what their confidence of C1Q5. Then, the next part asks what type of leader

they are seen as to the group. Alex and Barry recorded a score of 5 and 6 respectively, and Carol and Dave only scored a little higher with an 8 and 7. As far as leadership types seen by the group, Alex and Barry written down 2, which means that they are task-oriented with a little bit of interpersonal-oriented style. Carol responded with a 3, as in both leadership styles and Dave wrote down that he is seen as a 4 (interpersonal with a little task-oriented).



Figure 4.9: Question 6a

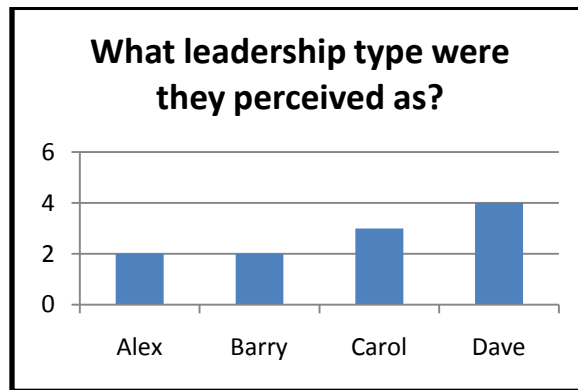


Figure 4.10: Question 6b

C1Q7 and C1Q8 evaluate the students' thoughts of themselves in leadership roles within the group. C1Q7 asks first if they think they are a leader or a follower. This is a different way of asking if they are a leader and asking them to circle yes or no. Then, the last question rates themselves as leaders, asks what type of leader they are and their

confidence. In Figure 4.11, the only team member who considered being a follower was Alex. Then, Figure 4.12 shows every student's confidence including Alex as the team member with the lowest confidence of a 6. Carol and Dave gave themselves a 7 and Barry rated himself an 8.

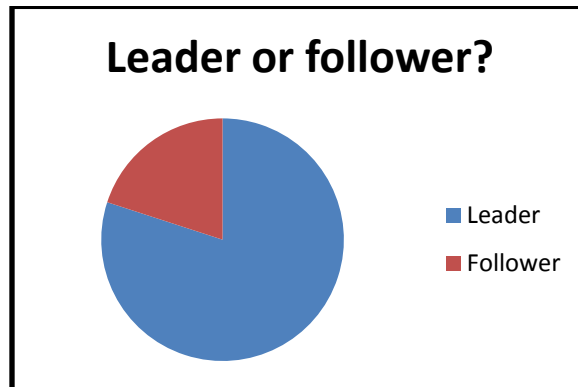


Figure 4.11: Question 7

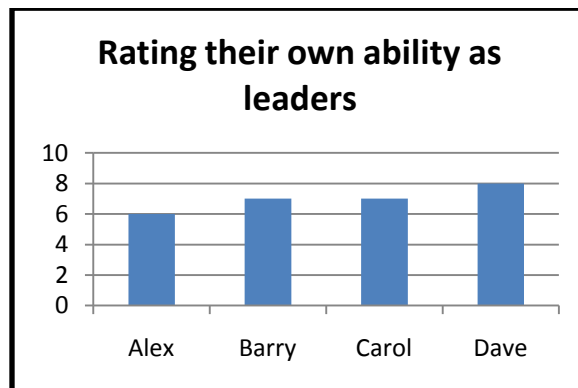


Figure 4.12: Question 8

In Figure 4.13, the second part to C1Q8 reveals what each student believes their leadership style truly is. Previously, C1Q6 asked whether they believed that others saw them as leaders. Therefore, Alex knew what role which he undertaken in the group dynamic by answering C1Q7 as a follower. By examining the rest of the students, Figure 4.14 shows the confidence each student's response to their leadership type. Dave

answered with the highest confidence with a 9. Alex and Barry have a confidence of 5 in their leadership type, which is higher than Carol's response of 4.

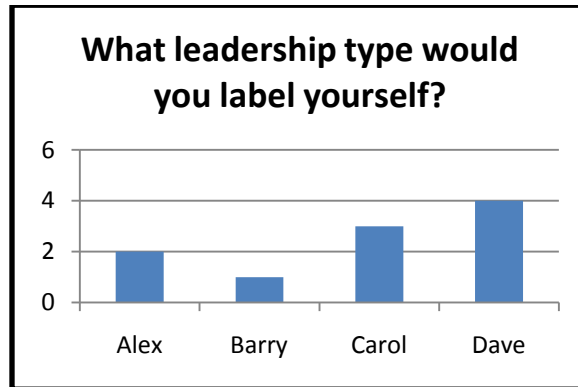


Figure 4.13: Question 8a

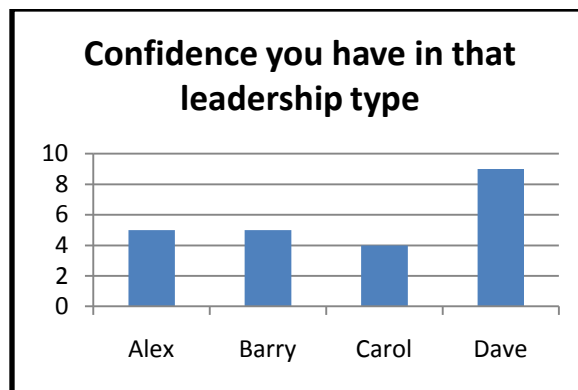


Figure 4.14: Question 8b

Lastly, Figure 4.15 and Figure 4.16 show C1Q3 and C1Q4 which inquire the students' knowledge of leadership itself. The third question asks about their confidence level of task and interpersonal types of leadership. Then, the fourth question offers a matching of words relative to each type of leadership. Task-oriented leadership was associated with the words delegate, completion, organization, and individualism. The interpersonally-oriented traits are morale, motivation, influential, and consideration. From these questions only Alex was not as confident as the others with knowing the

difference between the two styles and scored a 4. Alex and Carol answered only one pair of words wrong while Barry and Dave answered all correctly.

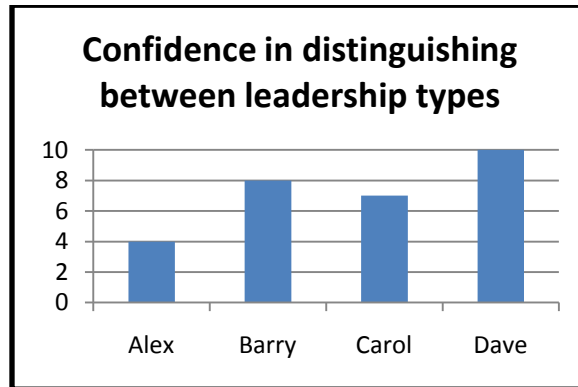


Figure 4.15: Question 3

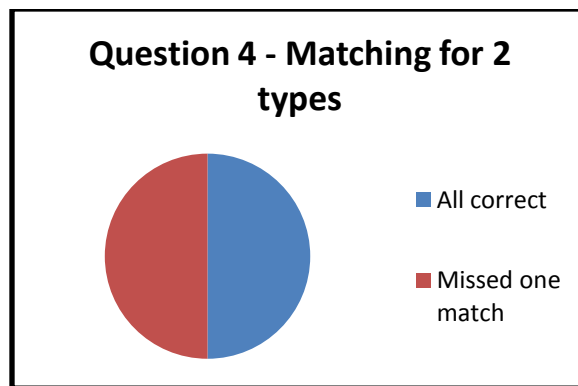


Figure 4.16: Question 4

4.5.3 Ethnographic Data v. Questionnaire Comparisons

Within these two types of data collection, the ethnographic and questionnaire data has shown some validation of the conclusions drawn from the previous section. Carol and Dave have much more occurrences of leadership than Alex and Barry. By Dave having the most consistent data, he/she had an impact on the team from the first day and Carol was not that far behind. At Week 5, the two students were even with occurrences. Then after that week, Carol always had at least two more times where he/she showed

leadership. In the questionnaire, Carol and Dave appeared 4 and 3 times respectively, as leaders of the engineering group. However, Barry showed up once but he is a clear follower. Even though Barry was voted once as a leader, yet even Alex did not vote for Barry as a leader. This means that Barry believed that he was more of a leader than Dave, which is wrong.

Alex was the only group member with a low confidence level about the subject and answered one match wrong. The questionnaire has an error because the word individualism is used to describe both styles. This is one portion of the questionnaire which is modified in Chapter Five. However, individualism by itself is known as a task-oriented quality and individual consideration is known as an interpersonal-oriented trait. In C1Q5 and C1Q6, every member saw themselves as some type of leader with respect to the other group members.

According to the questionnaire data, Carol and Dave were slightly correct about how they were viewed as leaders. They each chose 2 and 4 out of 5 respectively, as their leadership types. By looking at the ethnographic data, Carol is correct and Dave is incorrect about their evaluations of themselves. Dave has a balanced count of task and interpersonal traits and Carol has double the amount of task traits than interpersonal. Therefore, Carol's leadership style is currently task oriented and Dave's leadership style is balanced between interpersonal and task oriented.

There are two abnormal statistics from the last two questions within the questionnaire and the ethnographic data which are the confidence and ability levels of Barry and Dave. In Part A of C1Q8, Barry rated himself an 8 out of 10, as far as his/her

ability of being a leader. This coincides with Barry's previous answer in the second question of whether group members arose to become leaders. Barry strongly thinks he was a leader for this group but the data showed otherwise. For the confidence level of leadership type, Barry's was low with Alex and surprisingly Carol. Carol showed the most leadership and more than Alex and Barry combined, yet his/her confidence score was below their score. Dave wrote down an 8 and it is illustrated from the consistency of the student's data.

From the second method of data collection, these interpretations are drawn up to this point:

- Carol has shown the most leadership overall within the weekly meetings through accumulating more task leadership than Dave and Barry combined.
- Dave has shown the second most leadership overall through the weekly meetings and has the most interpersonally oriented type of leadership in the group.
- Alex and Barry accumulated the least amount of leadership through the weekly meetings. In C1Q7, Alex indicated he/she is a follower but Barry marked leader.
- Barry answered C1Q7 as being a leader, but there is a gap in the amount of leadership shown in the weekly meetings. Barry also responded to Part A of C1Q8 with a confidence of 8, which is higher than Carol and Dave responses of 7.

- Dave has a balanced amount of leadership between task and interpersonal, yet has a high confidence of being more of an interpersonally oriented type of leader.
- Carol exhibits more leadership with the task oriented type, and responded as a task oriented leader with a slight use of interpersonally oriented leadership (2) in Part B of C1Q8. Yet, the confidence marked in Part C of C1Q8 is lower than Alex and Barry.

4.5.4 Interview Questions

During the middle of the project, interviewing commenced to find out what each group member was thinking individually. These answers should be able to help complete the full picture of what happened in the group in terms of leadership. By being a more informal questionnaire, the questions asked are similar. However, the questions can be elaborated on top of their answers. One of the keys to take away from these questions is the answers given about Carol. Alex has shown the most characteristics of a follower but has some good insight to the leadership of the group. Alex mentions that Barry is “a tad laid back.” Also, Dave said that Barry has been “waiting for someone to assign tasks to him.” Carol’s statements agree with that statement about Alex and Barry as well.

Another interesting question is on the view of complacency as seniors. Carol and Dave are highly motivated by their responses to lead. Dave says that “he wants to get good grades and gain the most out of each class.” Dave also understands that he may be less of a leader sometimes because of “classes that cause me (him) not to do work sometimes.” The rest of the questions which were asked are consistent with the

questionnaire given at the end of the project. Every student's leadership style rating in the questionnaire matches with the responses given in the interview questions.

4.6 Conclusions

By using the interview questions as the third source of analysis, the picture of what occurred during the four months is clear. Leaders are defined within the study by the interview answers given from Carol and Dave. Leaders are defined within the study by the ethnographic study and interview answers given from Carol and Dave. Carol and Dave have the most scores of leadership in the ethnographic study. Carol had the most task oriented leadership scores with 49 and Dave had the most interpersonally oriented scores with 29.

As for the interview, Carol seen herself "in a position to lead" and "noticed the lack of leadership." Dave named Alex as a student which did not take any initiative and Barry as "half and half." Alex and Barry did not notice anyone lacking in leadership ability. These statements are proven by the ethnographic study showing Carol and Dave with the most occurrences of leadership and the questionnaire revealing Carol and Dave's confidence in being a leader. Barry is not indicated as a leader through the questionnaire because of the interview and amount of leadership shown in the ethnographic study. These conclusions justify the main hypothesis.

For the first sub-hypothesis, there have been two leaders to evaluate, Carol and Dave. Carol exhibited task oriented leadership a slight showing of interpersonal traits but answered in the interview as "in between" task and interpersonal. Dave has shown a close balance of task and interpersonal traits but in the interview states that the student is

an interpersonal type and “the morale (person) all the way.” The answers to C1I5 matches the results found in C1Q5 through C1Q8, which refers to the identification and confidence of leadership types. Therefore, there is one student which perceives and another which has exhibited task and interpersonally oriented traits. However from the ethnographic study, the more dominate type shown is task oriented leadership. Dave is a balanced leader but shows a small amount more on the interpersonal domain. Therefore, the sub-hypothesis is disproven because there are only high values of task oriented leadership shown.

Alex and Barry are classified as the non-leaders within this group and have a combined amount of 26 task and 22 interpersonal leadership traits. This is compared to Dave’s 27 occurrences of task leadership and Carol’s 25 occurrences of interpersonal leadership. However, there is a small amount of evidence which suggests that Barry has some leadership capabilities. Barry answered that he arose as a leader in C1Q2, C1Q7, and said that he “definitely noticed the effort of contribution versus leadership.” In the ethnographic study, Barry showed the third most occurrences of leadership in the group. Since the ethnographic study was only during the weekly meetings, these details suggest that Barry may have increased leadership during the embodiment stage. Figure 4.4 shows the first three weeks after the break (3/17/09), where Barry showed the second most leadership. Barry also answered C1I2 – C1I3 and C1Q5 – C1Q8 as if he was a leader as well. Barry helped the direction of the group by “pushing a design for the pneumatic piston” and “moving the direction of prototyping for the group.” Therefore, Barry has shown leadership traits but is classified as a non-leader.

The last sub-hypothesis suggests that leaders will remain the same once they are established. Part B in C1Q2 asks when the leaders arose in the project but not if anyone has changed during that duration. C1I1 and C1I2 also displayed no discussion of a leader changing or depreciating in their ability to lead. Then, ethnographic study shows Carol and Dave either remaining at a steady rate of leadership or increasing towards the end of the project. Therefore, the last sub-hypothesis is proven to be correct and in Chapter Five, another engineering design group is examined to evaluate the hypotheses and determine similar patterns in the research.

CHAPTER FIVE: ENDURANCE TESTING DEVICE CASE STUDY

The second case study is conducted on a yearlong design project in which a lunar wheel endurance testing device was designed and built. This endurance testing device is for a government funded project which is testing the long-term capabilities of the Lunar TWEEL [58]. The Lunar TWEEL is a non-pneumatic wheel which is designed to send into outer space with a lunar rover. This project as a whole is collaborative with the Jet Propulsion Laboratory, and Michelin.

This project is testing the design of the Lunar TWEEL because the pneumatic wheels previously used in outer space had a small life expectancy. The Lunar TWEEL is expected to traverse the circumference of the moon or at least 10,000 km [59,58]. The accomplishment of this goal is predicated on the success of this device. The Creative Inquiry team that will be evaluated in this case study designed and built this device. The endurance testing device was built by a machining group on an off-site campus warehouse. The testing and analysis portion of the project was passed to a new group of individuals who joined the Creative Inquiry group.

The design team consists of five undergraduate students in the Mechanical Engineering Department at Clemson University. These undergraduate students are a part of the Creative Inquiry group, which is a voluntary opportunity for undergraduates to gain more experience with team projects in their respective fields. Unlike the case study of Chapter Four, the students have graduate students and a professor who works above

them. Therefore, the direction of the project comes from the professor in charge of the project and not the students themselves.

Throughout this study, readers will learn about the team dynamic which existed over the year of this project. The case study will identify leadership development within the team through an interview, two written surveys which are a questionnaire and evaluation, and documentation analysis.

5.1 Hypotheses of Interest

Similar to Chapter Four, the main hypothesis and all three sub-hypotheses are being studied in this chapter. The leaders of the group will be identified through all four methods of data collection. Since there is not an ethnographic study for this case study, the interview is the primary data collection method used to determine the dynamic of the group. Then, the questionnaire, evaluation sheet, and documentation analysis provides support to answers given in the interview. After each method is evaluated in the case study, the results should anticipate at least two clear leaders established in the group.

The first sub-hypothesis is answered through the evaluation sheet. The evaluation sheet has the ratings for transactional and transformational leadership traits. Also, the students perform a self-evaluation to compare against the ratings given by the other group members. The values between the established leaders and followers should have a clear distinction against each other. In the interview, there are questions which can support the findings of the evaluation sheet and help determine if the values translate to leadership capabilities.

The second sub-hypothesis suggests that non-leaders may exhibit leadership traits. Once the non-leaders are established, all four data collection methods are used to reveal whether they show indications of leadership ability. Each data collection method will not be used as a whole but several instances within each method such as having more documentation than other team members, scoring higher than established leaders in several traits, or descriptive answers from the interviews. Any or a combination of those supporting factors can implicate if the non-leaders exhibited leadership traits. However in this case study, there were clear indications of who led and followed. Therefore, this sub-hypothesis is not expected to follow Chapter Four and not have any non-leader show leadership activity.

For this particular project being evaluated over a year, there should be change within the group of who takes the initiative. There are a multitude of factors which can produce the changing of leaders in the group and one factor is the transition to a new semester. Students in engineering have demanding school schedules and the addition of classes could cause previous leaders to step back from the leadership role. The time period of a year offers more chance of change happening, so this change is expected to occur contrasting from Chapter Four.

5.2 Case Study Protocol

5.2.1 Interviewing

A set of questions were developed to ask the students in the Lunar TWEEL Project. These questions are more detailed and ask the students where the responsibility is located in the group. Responsibilities such as reports, meeting updates, and organizing

tasks and operations are instances where students have showcased their willingness to participate. The evidence which is captured by interviewing is statements which cannot be found by asking short answer questions or evaluation sheets. This method provides an opportunity for the team members to explain their answers to the initial questions.

Through the participation in the interview, each student also has the opportunity to display initiative to accomplish tasks. Therefore, these questions intend to dissect who is doing the necessary work, how the communication exists within the group, and if the team members recognize who are the leaders. Interviewing the group also fills in the voids of the previous data collection methods. Since the other sets of data provide short answers or numerical values, the details derived from the interviewing will help justify those figures. The interview transcript is located in Appendix E and the questions given to each team member are in Table 5.1.

Table 5.1: Chapter Five Interview Questions

Interview Question Number	Interview Question
1	What was your role for the construction of the MGR?
2	Were there any specific parts that you had ownership of throughout the entirety of the construction?
3	What design collaboration skills did you contribute to help the construction of the project?
4	Do you have any experience with group projects before the start of this construction?
5	How often did you record documentation?
6	What was prescribed to you of how much documentation to record?
7	Has there been a team member who took the initiative with creating documentation?
8	Who was the one to combine sections of the reports for the project?
9	How much did you contribute to reports?
10	Who proactively called you to work on MGR objectives?
11	Who proactively e-mailed you to work on MGR objectives?
12	Who proactively texted you to work on MGR objectives?
13	Who did you call to work on MGR objectives?
14	Do you think you are a task or interpersonally oriented leader?
15	Have you noticed anyone not taking initiative in the group?
16	Have you seen teammates unmotivated to lead and/or felt that way yourself?

17	Was there a clear structure or hierarchy within the group dynamic?
18	Was the construction completed successfully?
19	What have you done to help the direction of the group?
20	How much flexibility was involved in making decisions?
21	Were you able to innovate on problems and products being investigated?
22	Did you take ownership and responsibility over the project?
23	Was there a certain level of performance standard set?
24	Looking back at the school year during the project, were there any occurrences of emotional distress or elation?
25	How well did you manage your emotions during last year?
26	What was the motivation for you to work on this project?
27	Was there any strong indication that someone did or did not know their emotions?
28	Aside from communication, how were your relationships with others in the group?

5.2.2 Questionnaire

The questionnaire used for this case study is the same one used for the case study in Chapter Four. The eight questions gauge the confidence of their leadership type and how well they know leadership. However, there is one change which was needed to correct the wrongfulness of one of the questions and the next paragraph shows that change in C2Q4. C2Q4 states: Please place these words under what you consider which style. There are eight words to choose from and the students pair the words with task or interpersonally oriented leadership. There is one word which is replaced from *individualism* to *contingent reward*. Individualized consideration is a trait for transformational or interpersonally oriented leadership. Therefore, individualism is changed to contingent reward to correct the mistake of having two similar traits.

The Chapter Five Leadership Questionnaire consists of:

1. Do you believe there was a clear leader(s) at the beginning of the project?
2. Were there any leaders which arose throughout the project?
 - a. If so, who (can be more than one)?
 - b. When did he/she/they arise?

3. Do you know the difference between task-oriented and interpersonally oriented leadership style? (1 – Strongly Disagree and 10 – Strongly Agree)
4. Please place these words under what you consider which style: Words to choose from – Delegate, Consideration, Motivation, Contingent Reward, Influential, Completion, Organization, and Morale
5. Do you think others within the group have seen you as a leader?
6. If so, in what respect?
 - a. Rate strength of confidence: (1–Strongly Disagree and 10–Strongly Agree)
 - b. From 1 to 5, rate what style they would see you as (1–Task, 3–Both, 5–Interpersonal):
7. Looking back at the experience, would you be more of a leader or follower?
8. As far as leadership is concerned, rate yourself from 1 to 10: (1 – Strongly Disagree and 10 – Strongly Agree)
 - a. What types of leadership to you consider yourself? (1 – Task, 3 – Both, 5 – Interpersonal):
 - b. How confident are you in that leadership type? Rate strength of confidence: (1 – Strongly Disagree and 10 – Strongly Agree)

5.2.3 Evaluation Sheet

The first method of determining the leadership and the styles of leadership in the group is through an evaluation sheet, which is shown in Table 5.2. This evaluation sheet

has categories of transactional and transformational leadership, and climatic conditions which were explained in Sections 2.1 and 2.2 of Chapter Two. Transactional leadership traits consist of idealized influence, individualized consideration, motivation, and intellectual stimulation. Transformational leadership traits include contingent reward, management-by-exception (passive and active), and laissez-faire leadership. Lastly, the climatic conditions are self-awareness, self-regulation, empathy, social skills, and social awareness. The definitions of these leadership traits were given to each team member and are shown in Table 5.3. Each of the students evaluated the team on these conditions and also themselves. Then, the averaged values will be compared against their self-evaluations to determine how accurately each student recognized their leadership qualities throughout the project.

Table 5.2: Chapter Five Evaluation Sheet

	Eric	Fred	Grace	Hank	Irene
Idealized Influence					
Intellectual Stimulation					
Individualized Consideration					
Inspirational Motivation					
Contingent Reward					
Management-by-exception active					
Management-by-exception passive					
Laissez-faire					
Self-Awareness					
Self-Regulation (Management)					
Empathy					
Social Skills					
Social					

Awareness					
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Table 5.3: Definitions of Leadership Traits in Evaluation Sheet

Leadership Traits	Definitions
Idealized Influence	Instilling pride and gaining respect and trust with high ethical behavior
Intellectual Stimulation	Challenging decisions, assumptions, and ideas which team member offers
Individualized Consideration	Attending to each team member's individual needs
Inspirational Motivation	Expressing an inspiring vision and communicating optimism to the team
Contingent Reward	Providing a reward in exchange for a mutual goal
Management-by-Exception Active	Being proactive to any standards not met
Management-by-Exception Passive	Intervening when standards are not met
Laissez-faire	Avoiding responsibility and decision making
Self-Awareness	Aware of one's own personality
Self-Regulation (Management)	Bringing order or uniformity to oneself
Empathy	Understanding feelings experienced by others
Social Skills	Skills facilitating interaction and communication with others
Social Awareness	Aware or conscious of people in your surroundings

The evaluation sheet was only given out once at the end of the project's term.

They were disseminated to each student unaided and one handout of the definitions and evaluation sheet were given together. One evaluation at the end gives an overall synopsis of what each team member exhibited throughout the entire project. This form of data collection was created to provide a type of examination of leadership types amongst the group. Since the ethnographic study was not done with this group, another form of data collection was needed to show the two types of leadership for the team members. Therefore, the evaluation and self-evaluation of each leadership characteristic found in transactional and transformational leadership is compared by each student numerically.

5.3 Triangulation of Data

Triangulation is where various data collection methods are used to provide multiple and different positions of similar information. These stances assure that the weaknesses of one method are protected by using other methods where that method is weak. In case study research, each method has a weakness and the hypotheses need to be proven through the justification of those methods. So the triangulation of these methods is critical to the confirmation of the hypotheses. There are two types of triangulation, intra- and inter-method triangulation. Intra-method triangulation uses the method itself to triangulate information and inter-method triangulation uses multiple methods to verify assertions made by the case study.

5.3.1 Intra-Method Triangulation

Within the questionnaire, the relationships established in Chapter Four remain true in Chapter Five. Table 5.4 reiterates the correlating questions in the questionnaire where each 'X' resembles a positive relationship. There are only two questions which ask about the students' knowledge of the leadership types which are questions 3 and 4. Questions C2Q1-C2Q2, C2Q5-C2Q6, and C2Q7-C2Q8 are all paired together and the latter question is a follow-up to the first question asked. C2Q2 and C2Q8 are connected to each other and multiple questions.

Table 5.4: Intra-Method Triangulation of Leadership Questionnaire

	C2Q1	C2Q2	C2Q3	C2Q4	C2Q5	C2Q6	C2Q7	C2Q8
C2Q1	-	X						
C2Q2	X	-			X	X	X	X
C2Q3			-	X				X
C2Q4			X	-				X
C2Q5		X			-	X		
C2Q6		X			X	-		
C2Q7		X					-	X
C2Q8		X	X	X			X	-

C2Q5 through C2Q8 are influenced by C2Q2 because the team members are exposed to the idea of leadership arising throughout the project. So, C2Q5 through C2Q8 are based upon their understanding of leadership within the group dynamic. C2Q8 is related to C2Q2 because their confidence could depend on how they answered that question. C2Q3 and C2Q4 are also related to C2Q8 because their understanding of leadership types allows them to answer those questions.

5.3.2 Inter-Method Triangulation

Through inter-method triangulation, the interviewing and questionnaire are compared to examine information across each data collection method. In Table 5.5, these two methods are compared by the questions asked in each method and each 'X' resembles a positive relationship. C2I1 is similar to C2Q1 and C2Q2 by gauging the thoughts of the team members in respect to their initial roles on the team. Then, C2I2 and C2I3 ask more specifically of how they contributed to the group. C2I4 asks about how much experience they have encountered before the start of the project. This question relates to C2Q1 because this could have influenced whether they were an initial leader of the group.

Table 5.5: Inter-Method Triangulation of Interviewing and Questionnaire

	C2Q1	C2Q2	C2Q3	C2Q4	C2Q5	C2Q6	C2Q7	C2Q8
C2I1	X	X						
C2I2								
C2I3								
C2I4	X							
C2I5		X					X	X
C2I6		X					X	X
C2I7		X					X	X
C2I8		X					X	X
C2I9		X					X	X
C2I10		X					X	X
C2I11		X					X	X
C2I12		X					X	X
C2I13		X					X	X
C2I14			X	X				
C2I15		X						
C2I16		X						
C2I17	X	X						
C2I18								
C2I19								
C2I20								
C2I21								
C2I22								
C2I23								
C2I24								
C2I25								
C2I26								
C2I27								
C2I28								

C2I5 through C2I13 correspond to C2Q2, C2Q7, and C2Q8 because the qualities that are being interrogated are related to the amount of leadership a group member demonstrates. C2Q3 and C2Q4 are relative to the team members' knowledge of leadership and C2I14 asks the same question. C2I15 and C2I16 questions ask if the team member has notice anyone not taking initiative or unmotivated to lead. The individuals mentioned in these two questions should not be seen as a leader in C2Q2. Lastly, C2I17 asks if there is a clear hierarchy in the group and C2Q1 and C2Q2 combine to show who are the initial leaders and joined as leaders later on during the project.

5.4 Case Study Results

The results are derived from triangulating the data collected through the case study protocol. The order in which the data will be analyzed is first with the interview questions. The interview questions are detailed and provide a foundation how the progression of the project operated throughout the year. So any additional data will either support or contradict what has been evaluated. The inter-method triangulation helps the evaluation of the interviews through the relationships found in the previous section.

The first two questions in the questionnaire assist C2I1 and C2I17. These questions are about the leadership which exists in the group. C2Q2, C2Q7, and C2Q8 provide assistance to C2I5 through C2I13 and C2Q2, C2Q5, and C2Q6 provide assistance to C2I15 and C2I16. These questions give more detailed explanations to what each student has done in the duration of the project and relates to their confidence in being leader. The confidence of their responses is shown in the questionnaires, in addition to what specific types of leadership can be compared to their other responses. Finally, the evaluations are the final portion to the case study which supports the notion of task and interpersonal leadership within the team members.

5.4.1 Interview Analysis

There are strong indications of the team members' leadership within the group through the questions asked which are stated explicitly throughout the interview. Through an interview, details are explained further about the questions asked. Therefore, the details help the triangulation with the other two data collection methods. The first set

of questions analyzed is about each team member's roles and responsibilities, and thoughts on other members of the group. Then, the next set of questions considers the climatic conditions which occurred during the extent of the project. Lastly, tentative inferences are made of the leadership and leadership types from the interviewing which are subject to change depending on the questionnaire and evaluation sheet analysis.

5.4.1.1 Roles and Responsibilities

The first question in reference to roles and responsibilities was C2I4 which asked to the students was, "What was your role for the construction of the Lunar TWEEL Project?" Table 5.6 provides a summary as other aspects are highlighted within this question. Hank was the only team member to state, "definitely a team member," which was one major implication from C2I4. The other four team members stated that they were both team members and leaders of the group. Therefore, Hank's leadership needs to be proven in another way throughout this case study. C2I4 asks whether any of the students have any group project experience prior or during the project. Each student had at least two group projects before starting the Lunar TWEEL Project. Eric's experience was over 10 years and had more responsibility over deliverables and money for those projects. Eric's projects included airplane parts for Boeing where "contracts were about 1.5 to 2 million dollars," and "drawings for BMW in the remodel group and designing tools for the X6, X5, and Z4." Eric's experience clearly was the most out of the group.

Table 5.6: Summary of Question 4

Student	Number of Projects	Number of People in Projects	Amount of Money Spent within Projects
Eric	50+	2-20	\$1000-2M
Fred	2	2, 4	\$26-28
Grace	5-6	3-4	\$0
Hank	2	3, 5	\$100
Irene	3	3-7	\$100

C2I5 to C2I9 ask about what the students recorded and contributed to the project which is summarized in Table 5.7. C2I5 and C2I6 ask how often documentation was recorded and what was required of the students to document. Eric, Fred, and Irene said they recorded documentation either from “week to week,” “every week,” or “once a week.” There was a meeting held once per week to update the group on progress and assignments were given before the end of each meeting. Therefore, each team member was required to have done their work every week and give an update. Hank says that work was recorded “bi-weekly” and Grace says “just once.” Therefore, these two students did not generate more work than Eric, Fred, and Irene.

Table 5.7: Responses to C2I5 to C2I8

Student	Documentation Frequency	Required Documentation	Students Starting Documentation	Students Combining Documentation
Eric	Weekly	One page report at the end of term	Irene	Irene
Fred	Weekly	Semester and Individual Reports	Fred and Irene	Irene
Grace	Once	Midterm and Final Report	Irene	Irene
Hank	Bi-Weekly	Concept Design Report	Irene	Grad Student
Irene	Weekly	Budget and Weekly Report	Fred, Grace, Irene	Irene

The inference of one possible leader comes with C2I7, which asks if there has been a team member who took the initiative to create documentation. The entire group stated that Irene “kept a pretty good record of everything from the meetings” and done “all of the organization.” However, Fred said that “Irene and I put together the major

reports” and Grace said “sometimes it would be me writing with her.” So Fred and Grace think that they deserve some credit but unanimously Irene took the initiative and spearheaded recording the team’s continuous progress.

Conversely, C2I15 and C2I16, seen in Table 5.8, ask whether the students have noticed any of their team members not taking initiative or seen any unmotivated individuals. Eric, Fred, Grace, and Irene all said that Hank did not take any initiative while on the project. Eric believes that Hank did not “help with the construction of it (carousel) at all.” Fred said that “it seemed like the project was not a priority to him.” Fred and Irene commented on a task about fencing given to Hank. They both stated that the task was minor and handed over to Fred for completion. Therefore, Hank’s unwillingness to complete work is becoming a consistent theme throughout the interview questions.

Table 5.8: Responses to C2I15 and C2I16

Student	Students w/o Initiative	Students w/o Motivation
Eric	Hank	Hank
Fred	Hank	Grace and Hank
Grace	Hank	Fred and Hank
Hank	-	-
C2S5	Hank	Hank

5.4.1.2 Climatic Conditions

The first climatic condition which showed differences within the team members was responsibility. C2I22 asks if the team members have taken ownership over the project. Grace and Hank did not take ownership over the project and for different reasons. Grace had another “major project to take care of and other classes to consider” and Hank “never felt that it was (his) project.” On the other hand, Eric called ownership

“making sure that the parts (he) was responsible for matched the designs” and Fred “invested time and effort into the project” and says “if that means seeing the project through completion.” From this question, only Eric and Fred clearly understand what it means to take ownership while Grace and Hank knowingly did not attempt to take responsibility.

Table 5.9 shows the next climate asked the team members about standards in C2I23. Fred and Irene say the standard were initially set high but “ended up as a medium” and “towards the end of the project the performance went down.” Eric provides a similar statement and states there was a standard set “initially, but there may not have been a document outlining a work statement.” The work statement outlines what each student would be in charge of implementing. Grace and Hank stated how they think there were standards set but Eric, Fred, and Irene were more accurate in their depictions of performance standards.

Table 5.9: Summary of Interview Question 23

Student	Question 23 Responses
Eric	“I would say that there was not one.”
Fred	“I think initially was high, but then it ended up as a medium”
Grace	“In the beginning, definitely no... There are probably standards now.”
Hank	“Usually Dr. Summers, when we had objectives and tasks set, he made sure that we stayed on task and that everything was correct.”
Irene	“I think the expected performance effort was to turn in something every week and towards the end of the project the performance went down.”

The group managed their emotions well and there was only one occurrence of a team member’s emotions affecting work performance. Irene “had a relationship with Fred at the beginning of the year.” Irene definitely thinks “it affected (her) motivation to do things for the project.” After Fred and Irene broke away from their relationship, Fred

“mainly worked with Eric and Grace after that point.” Fred, on the other hand, did not mention this relationship during the interview at all. During C2I25, Fred mentions that he/she “can usually set aside the emotional issues and deal with them later,” and was not “sure if everyone can do that.” Irene’s emotional state was altered during this project by this relationship and caused a separation during group work. For relationships within the group dynamic, everyone worked well together. C2I28 asks how these relationships were within the group and every student had positive statements.

5.4.1.3 Leadership Types

C2I14 asks the students whether they think they are a task or interpersonally oriented leaders and their answers are shown in Table 5.10. Eric, Fred, and Grace state that they are task oriented individuals and Eric and Fred feel that they “build relationships while doing the tasks” or “certain situations deem it necessary to talk a little.” This reiterates how much they concentrate on the task rather than building the relationships within the group. Hank chosen to be an interpersonally oriented leader and Irene “likes organization and getting things done” but “leans on task or interpersonal style” depending on different situations.

Table 5.10: Summary of Leadership Types

Student	Leadership Types from C2I14
Eric	Task
Fred	Task
Grace	Task
Hank	Interpersonal
Irene	Task and Interpersonal

5.4.1.4 Interviewing Synopsis

From the questions asked about roles and responsibilities, climatic conditions and leadership types, there are several tentative conclusions which can be made. The first conclusion is that Grace and Hank are not leaders of this group. These two students are not mentioned in a positive manner or neglected altogether. Hank was mentioned in C2I15 and C2I16 as the team member who did not take any initiative to complete work.

Conversely, Eric, Fred and Irene are leaders which exuded initiative and knowledge of what happened operationally throughout the group. They each show instances of leadership in different questions throughout the interview. Eric has tremendous amount of experience with engineering group projects and this is supported through multiple questions. In addition to Eric's experience stated in C2I4, Eric also talked about a work statement to outline the list of objectives to complete for the group and the importance of verifying the final product from the original design in C2I23. Irene was revealed to be the organizer of information and documentation for the group. This aspect occurred during the design portion of the project and at weekly meetings all year. Fred is similar to Eric with leading the team with tasks and confirming the completion of the project. Therefore, the leadership types of these three students need to be confirmed in the next two sections.

5.4.2 Leadership Questionnaire Analysis

The leadership questionnaire is a written survey which inquires the confidence of each student's leadership type and recognition of their own leadership. The analysis of

this data will justify the conclusions made in the previous section or create new conjectures which will need to be proven with the last method of data collection.

5.4.2.1 Leadership Types within the Group

Throughout the process of this case study, the students have been hearing the terms task and interpersonally oriented, transformational, and transactional leadership. C2Q3 and C2Q4 ask the students how confidently they know the difference between task and interpersonally oriented leadership. C2Q4 tests their confidence by placing words relating to each type under each category. These words are delegate, consideration, motivation, contingent reward, influential, completion, organization, and morale. From Chapter Four, individualism and consideration were the same characteristic, so individualism is replaced with contingent reward.

From the results shown in Figure 5.1 and Figure 5.2, all group members acknowledge that they at least have a confidence of 7 and one student missed a matching pair. Eric was the only member to be highly confident with a value of 10, following Fred and Hank with a value of 8. Next, C2Q4 is the word matching question with the eight words defined under task or interpersonally oriented leadership. Eric, Fred, Grace, and Irene matched them correctly and Hank missed one match, confusing morale and organization. Therefore, this is one indication from the questionnaire of Hank's possible inability to lead.

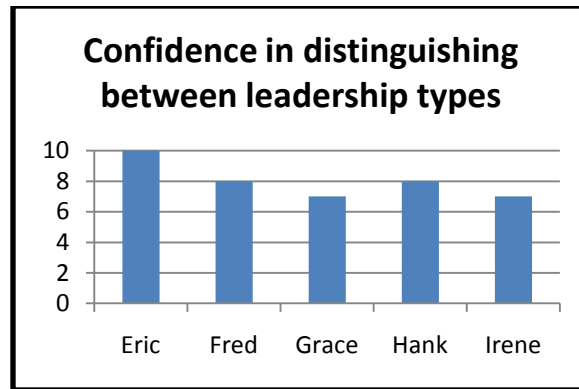


Figure 5.1 Question 3

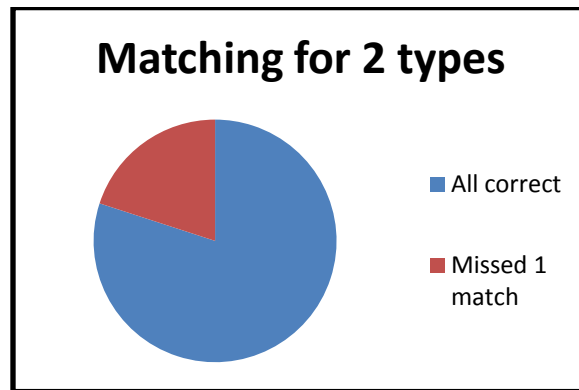


Figure 5.2: Question 4

C2Q5 asks if they think other students within the group perceived themselves as leaders of the group. C2Q5 asks how confident they are in their response and what type is they perceived as. Eric, Fred, Hank, and Irene all believed that others thought they were leaders of the group. Hank was the only student to indicate being recognized as an interpersonally oriented leader and Eric indicated a response of 2 (task leadership with slight interpersonal skills). The values of 2 and 4 for this question means that they are either a task oriented leader with minimal interpersonal skills or an interpersonally oriented leader with minimal task skills. Figure 5.3 and Figure 5.4 provide the data given from C2Q5 and C2Q6.

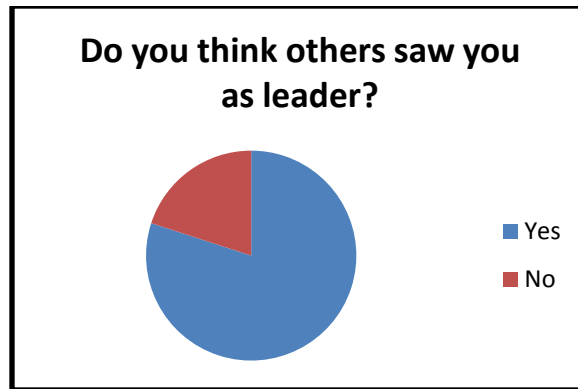


Figure 5.3: Question 5

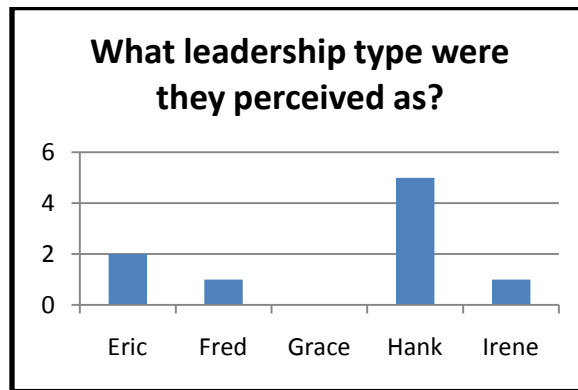


Figure 5.4: Question 6b

The last question concerning leadership types is C2Q8, which asks for a quick self-evaluation of what leadership they are and what confidence they have in that ability. In part A of C2Q8, or Figure 5.5, Eric, Fred and Hank remained consistent with values of 2, 1, and 5 respectively, from C2Q6. Irene was the only team member to change the value of leadership from 1 to 3. Irene's perception of leadership is the most contrasting from where Irene's perception of the group.

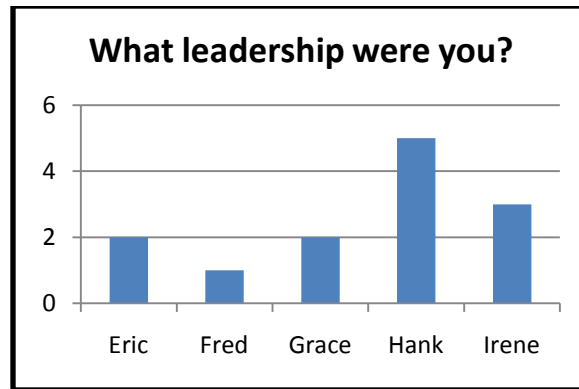


Figure 5.5: Question 8a

5.4.2.2 Confidence in Leadership Ability

In addition to the questions regarding leadership types, there were also questions asking the team members how confident they are with the leadership types selected. For C2Q6, the confidence of the team members varied to determine whether they thought other team members considered them to be leaders. Figure 5.6 shows two team members rating their confidence as a 6 and the other two team members give an 8 and 9. One of those team members to give a value of 6 was Hank, which from a previous question missed matching a pair of words in C2Q4. Eric and Fred provide the values of 8 and 9 respectively and in Part B for C2Q8, each show equal or greater confidence in their own ability as leaders.

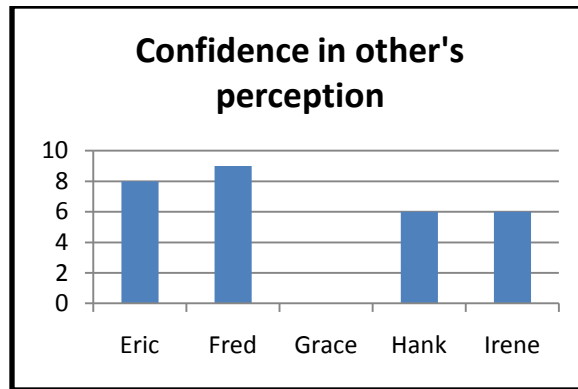


Figure 5.6: Question 6a

Figure 5.7 displays where the team members were confident in their leadership types. Eric and Fred remain to exceed their team in confident with values of 8 and 10. Eric is consistent with the confidence value, even though Eric has a breadth of experience with group projects. Hank and Irene increased their confidence to 7. However, Irene has clearly shown more characteristics as a leader throughout this case study.



Figure 5.7: Question 8b

5.4.2.3 Leadership Questionnaire Synopsis

Through the leadership questionnaire, Eric and Fred have shown that they know the difference between the two leadership styles, have knowledge of what their styles are, and exude high confidence in their ability to lead. They both also recognize that they are

task oriented leaders and this notion is verified through C2I14. Another pattern which is recognized throughout the questionnaire is the inability for Hank to lead throughout the project. Hank missed one of the matching pairs in C2Q4 and was perceived as an interpersonal oriented leader. The idea that Hank is an interpersonal leader is false because during the interview, each member of the group said in C2I15 and C2I16 that Hank was unmotivated to lead and displayed no initiative.

Irene showed leadership through the interview, yet in the questionnaire demonstrated a timid and modest nature by answering C2Q6 as a 6. Eric also did not have as much as confidence that would come from a seasoned engineer who has worked for 10 years, which is stated in C2I4. Fred has only done two group projects before starting the Lunar TWEEL Project but rates the confidence of leadership as a value of 10 instead of an 8. However, Eric answered C1I1 as being both a team leader and member.

In C2Q2, shown in Figure 5.8, two team members have chosen Eric as a leader which arose during the project. Irene has also shown to be a leader in the first half of the project with organizing information from meetings and writing reports. However, Irene's confidence is one of the lower values through two questions as 6 and 7. C2Q2 shows that one team member has chosen Irene as a leader and C2I5 – C2I13 have shown many instances of recording documentation and communication between team members. Table 5.11, Table 5.12, and Table 5.13 shows the team members frequency of calling, e-mailing, and texting one another.

Table 5.11: Frequency of Calling Each Team Member

	Eric's Response	Fred's Response	Grace's Response	Hank's Response	Irene's Response
Eric	-	2/wk	2/wk	N/A	N/A
Fred	2-3/wk	-	N/A	N/A	4-5/wk
Grace	2-3/wk	N/A	-	N/A	1/biwk
Hank	N/A	N/A	N/A	-	N/A
Irene	2-3/wk	3/wk	2/wk	N/A	-

Table 5.12: Frequency of E-Mailing Each Team Member

	Eric's Response	Fred's Response	Grace's Response	Hank's Response	Irene's Response
Eric	-	3/wk	2-3/wk	N/A	1/biwk
Fred	N/A	-	N/A	N/A	1/wk
Grace	N/A	N/A	-	N/A	N/A
Hank	N/A	N/A	N/A	-	N/A
Irene	N/A	1/wk	2-3/wk	N/A	-

Table 5.13: Frequency of Texting Each Team Member

	Eric's Response	Fred's Response	Grace's Response	Hank's Response	Irene's Response
Eric	-	2/wk	12/wk	N/A	N/A
Fred	3-4/wk	-	N/A	N/A	2-3/wk
Grace	3-4/wk	N/A	-	2/wk	N/A
Hank	N/A	N/A	N/A	-	N/A
Irene	3-4/wk	1/wk	12/wk	N/A	-

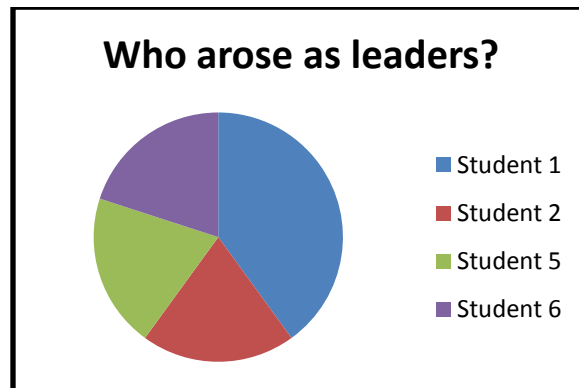


Figure 5.8: Question 2a

Table 5.10 also helps C2Q7 and C2Q8 correlating who was more proactive in communication towards who was a leader or non-leader. Figure 5.9 shows three team members as followers, Fred, Hank, and Irene. Irene is one of those team members because Eric and Fred stepped up in the second half of the project as leaders. Previously, Irene has shown her dedication in C2I5 – C2I13,

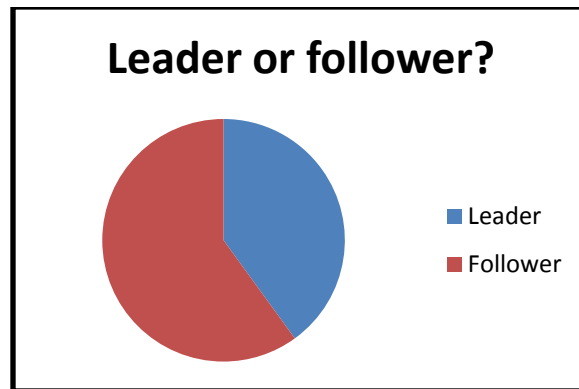


Figure 5.9: Question 7

5.4.3 Lunar TWEEL Project Evaluation Sheet

The evaluation sheet is another method for self-evaluation and evaluating the team on a number of traits relating to transactional, transformational, and emotional characteristics. These evaluations are located in Appendix E. The values within the tables range from 1 (highest) to 5 (lowest) and the characteristic of laissez faire leadership is a negative term which means to avoid responsibility. Therefore, a high ranking within that trait means illustrating a high amount of irresponsibility. The students were asked to self-evaluate themselves to determine if they are being perceived correctly. The descriptions of each trait were given to the team members and those

descriptions are in Table 5.14. Those values of self-evaluation are in parenthesis with the averaged values from the other four members are in Table 5.15.

Table 5.14: Descriptions of Leadership Traits in the Evaluation Sheets

Leadership Trait	Descriptions
Idealized Influence	Instilling pride and gaining respect and trust through high ethical behavior
Intellectual Stimulation	When the leader challenges the decisions, takes risks and solicits the team members' ideas
Individualized Consideration	Where the leader attends to the team members' individual needs
Inspirational Motivation	Inspiring and communicating optimism to the team members
Contigent Reward	Providing rewards in exchange for mutually agreed upon goals
MbE Active	Taking proactive action for any deviation of the rules
MbE Passive	Being reactive when rules are not followed
Laissez faire	Avoiding responsibility and making decisions
Self Awareness	To be aware of one's own personality
Self Regulation	To bring order or uniformity to oneself
Empathy	To understand the feelings another experiences
Social Skills	The ability to communicate and interact with people
Social Awareness	To be aware of societies or people in your surroundings

Table 5.15: Evaluation Sheets with Averaged Values

	Eric	Fred	Grace	Hank	Irene
Idealized Influence	2.25 (2)	3 (2)	2 (3)	4.25 (2)	1.75 (1)
Intellectual Stimulation	3 (2)	3.5 (2)	2 (5)	4.25 (2)	2.5 (3)
Individualized Consideration	2.25 (2)	3 (1)	2.25 (3)	4.5 (2)	1.75 (1)
Inspirational Motivation	2.25 (1)	2.5 (3)	2.25 (4)	4.5 (2)	2.5 (2)
Contigent Reward	2.75 (3)	3.25 (3)	2.75 (3)	4 (2)	2.75 (3)
MbE Active	3 (1)	3 (1)	2.5 (5)	4.25 (3)	2.75 (3)
MbE Passive	2.75 (2)	3 (2)	2.25 (5)	3.75 (2)	2.5 (3)
Laissez faire	3.75 (5)	3.75 (5)	4 (3)	1.5 (4)	3.75 (4)
Self Awareness	1.75 (2)	2 (2)	1.75 (2)	3.5 (1)	1.75 (2)
Self Regulation	2.25 (3)	2.25 (1)	2.25 (3)	4 (2)	2 (3)
Empathy	2.75 (2)	3 (4)	1.75 (2)	2.75 (1)	1.5 (2)
Social Skills	2 (1)	2 (1)	1.25 (3)	3.25 (1)	1.5 (2)
Social Awareness	1.75 (1)	2 (1)	1.25 (3)	2.75 (1)	1.25 (2)

From the evaluations, Irene has proven to be a more balanced leader within the group. Irene has the first or second highest score in each category and higher scores within the transformational traits. Grace also has a similar trend of having the first or second highest score in every leadership trait. However, Irene's self evaluation is more accurate to the perception of the group. Therefore, Irene realizes each characteristic of leadership the best out of the entire team. Eric and Fred were ranked between 1.75 and 3 for the five traits of emotions, and their self-evaluations were also accurate within the emotional traits. Eric and Fred defined themselves as task oriented leaders, yet they are able to distinguish their emotional state. Conversely, Hank is ranked the lowest in each leadership trait and is the least accurate comparing to the self-evaluation.

5.5 Conclusions

From using the three methods of data collection within the second case study, there have been conclusions drawn from the hypotheses. The main hypothesis, clearly determining the leadership within the use of a case study, holds true. Through the interview, Eric, Fred, and Irene were identified as potential leaders of the group. Each of these students was classified as dominantly task oriented leaders. Irene organized information and combined all sections of the reports during the first half of the project. Eric and Fred pushed the final concept and organized the construction of the device during the second half of the project. Eric and Fred showed high confidence values in C2Q6 and C2Q8. Irene had the lowest and second lowest confidence in C2Q6 and C2Q8. However, additional evidence from the interview, evaluation sheet, C2Q2, and

C2Q4 show that Irene is one of the leaders from the group. Therefore, Eric, Fred, and Irene are defined as the leaders from this case study.

Instead of an ethnographic study, the first sub-hypothesis is proven with the evaluation sheet. The evaluation sheet was given to each team member who rated the other individuals and also a self-evaluation. This method has produced that Irene and Grace are the best performers in transformational and transactional leadership. Through the case study, Irene has been identified as a leader, yet Grace is identified as a non-leader. Grace has shown traits of a non-leader because for C2Q7 follower was selected, Fred believed he/she did not show any initiative and Grace was not selected as one of the leaders in C2Q2. Even though there are not as many negative marks for Grace, there are is no supporting data to infer that Grace is a leader on this team. Therefore, the evaluation sheet is not a proven method which can determine whether a leader can be identified by high scores in task and interpersonal traits.

Nevertheless, Grace has shown leadership traits while being considered a non-leader. Even though Fred mentioned Grace as not being motivated in C2I16, Grace was referred by Irene in C2I7 as the team member which led in sub-groups and writing weekly reports. In the evaluation sheet, Grace had the first or second highest scores in the group in every category. These values were higher than Eric and Fred's evaluation scores. Grace was one of the four students which matched all four pairs of task and interpersonally oriented words in C2Q4. All of these occurrences are examples of Grace illustrating leadership while being classified as a non-leader and proves the second hypothesis is true.

The last sub-hypothesis of the case study is whether the leaders will remain stable throughout the duration of the project. Contrary to the previous case study, this sub-hypothesis is disproven. Eric, Fred, and Irene have been proven as leaders within this case study; however there are instances where the change of leadership is stated. In C2I22, Irene stated that most of the effort was given “at the beginning of the project than towards the end.” Then in C2I6 through C2I8, it is evident that Irene was responsible for all the documentation and budgeting. In C2I19, C2S1 and Fred said they “helped with setting the direction with construction” and “pushed the project from the conceptual phase to the embodiment and detailed design.” The construction of the device occurred after the midpoint of the project. Also, in C2I19, C2I21, and C2I22 has more evidence of Eric and Fred being mainly invested in the construction aspect of the project. These instances display that change was present within the leadership roles of the design team.

CHAPTER SIX: CROSS-CASE ANALYSIS

Chapter Four: and Chapter Five: conducted two case studies to determine the leadership characteristics seen within engineering design project groups. In both of these chapters, the data collection methods which were used are found in Table 3.2. The combination of methods used in each case study derived conclusions which have proven or disproven the hypotheses stated in Chapter Two:.. Therefore, this chapter will compare each of the case studies and discover patterns between them.

The patterns are first established by the hypotheses and their role within the case study. Clearly identifying the leaders within each group is the main hypothesis and this is found by the inter- and intra-method triangulation implemented in both chapters. Next, the first sub-hypothesis states that leaders established in those groups have high values of task and interpersonally oriented leadership. This sub-hypothesis is accomplished by the ethnographic study in Chapter Four: and the evaluation sheet in Chapter Five:..

The next sub-hypothesis asserts that non-leaders exhibit leadership traits. Evidence from all data collection methods assists with the verification of this statement. Lastly, the third hypothesis states that the leaders will remain stable throughout the duration of the engineering design project once they are established as leaders. In order to confirm this sub-hypothesis, the data collection method of interviewing is used in both case studies to determine proof of this assertion.

6.1 Comparison of the Main Hypothesis

Chapter Four: and Chapter Five: case studies defined two students as leaders within the engineering design projects. Carol and Dave were identified as the two leaders within the four person group. Through the ethnographic study, each student exhibited at least double the values seen from Alex and Barry. Carol showed the most task oriented leadership and Dave showed the most interpersonally oriented leadership. In the questionnaire, Dave's confidence was high in his ability while Carol was modest a substantially lower value. However, Carol was named the leader which arose throughout the project more than Dave. Then, the interview was the last data collection method evaluated and C1I2 and C1I3 helped clarify inferences made from the previous methods. These two questions showed Carol and Dave had leadership roles and identified unmotivated individuals.

Eric, Fred, and Irene were recognized as leaders for the case study conducted in Chapter Five: . The evidence of their leadership began in the interview process where several questions illustrated roles and responsibilities, climatic conditions, and leadership types. Eric and Fred were concentrated on completing the construction, while Irene showed how her role as an organizer was critical to the group. In the leadership questionnaire, Fred showed high values in confidence of his leadership ability and thoughts of how the other group members perceived him. Eric and Irene were modest in their confidence but answered C2Q4 correctly and Eric was chosen twice as a leader which arose as a leader. Then, the evaluation sheet showed that Irene has the highest or second highest rating among the team members and the most accurate self-evaluation.

Therefore, both case studies have identified clear leadership within both engineering design projects.

Through these two case studies, leaders were established in different ways and each is shown in Table 6.1. Even though there were different combinations of data collection methods to identify the leaders, there were different methods which contributed to the proof of this hypothesis. In Chapter Four:, the ethnographic study and questionnaire were the most influential data collection methods to determine the leadership within the case study. The ethnographic study numerically displayed the leadership and the questionnaire showed the confidence and recognition of leadership knowledge within the team. On the other hand, the interview questions were the most influential data collection method in Chapter Five:.. The questions were detailed by outlining each team member’s work experience, leadership types, recognition of leadership, and viewpoint of surroundings while working with the group. Each sub-hypothesis has a combination of data collection methods which helped proved them the most. So, the next three sections will compare the two case study results and explain which methods were used to obtain those results.

Table 6.1: Summary of Leaders Found in Both Case Studies

Students	Leadership Styles	Main Data Collection Method
Carol	Task	Ethnographic Study
Dave	Balanced	Ethnographic Study
Eric	Task	Interview
Fred	Task	Interview
Irene	Balanced	Interview

6.2 Comparison of Sub-Hypothesis 1

The goal of the first sub-hypothesis was to monitor whether there was a balanced leader which exhibited task and interpersonally oriented leadership. There was a single instance within both case studies where this occurred. Chapter Four: showed Dave as a student which had a balanced ability of both task and interpersonal types of leadership. This student perceived himself as a 4 within the questionnaire, which means that he favors more interpersonally than task oriented skills. In the interview, Dave says that he was the “morale guy” and kept a “positive attitude.” Although in Chapter Five:, Irene showed balance in the beginning of the project and she perceived herself as a task oriented leader.

These two were identified as balanced leaders through different data collection methods. Dave in the first case study was proven as a balanced leader from the ethnographic study. This method showed Dave having a value of 29 in interpersonal traits and 27 in task oriented traits. This data, with the addition to the answers from the questionnaire and interview, proves that Dave was a balanced leader. However, Chapter Five: used an evaluation sheet to determine the amount of task and interpersonally oriented skills shown by the team members. Irene had a well balanced evaluation but also an accurate self-evaluation shown in Table 5.15. Additionally in the interview, Irene says that “it depends on the situation of whether to lean on task or interpersonal styles.”

Through Bass’ [60] research, it has been demonstrated that transformational or interpersonal leaders are more successful than task oriented leaders. However in these

case studies for engineering design teams, students were dominant as task oriented leadership. In Chapter Four:, Carol displayed about 50% more task oriented leadership in the ethnographic study. There were two students in Chapter Five: which showed task oriented leadership. This is evident in the interview and leadership questionnaire. Eric and Fred talked about their efforts in the second half of the design in the interview and answered that they are task oriented in multiple questions in the leadership questionnaire. This data was triangulated with the evaluation sheet, however an ethnographic study could have numerically displayed the performances of these two task oriented leaders.

6.3 Comparison of Sub-Hypothesis 2

Sub-hypothesis 2 states that non-leaders are also capable of demonstrating leadership qualities. The research was able to obtain one student from each case study who exhibited leadership traits while being labeled a non-leader. Barry in Chapter Four: showed instances of leadership within the case study. There was three day span where Barry had 13 out of the 28 times leadership was recorded and in C2I3, he “(pushed) a design for the pneumatic piston” and “(moved) the direction of prototyping for the group. Figure 6.1 provides a view of 3/24/09 where Barry had as much leadership as Dave.

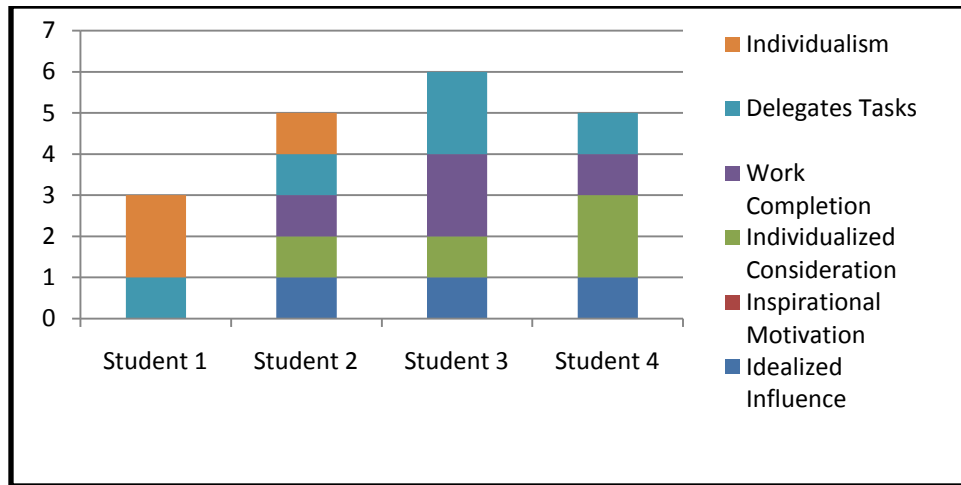


Figure 6.1: Chapter Four: Leadership Shown on 3/24/09

In Chapter Five:, Grace exhibited leadership but was not considered a leader with the group. In C2I7, Irene said if they were in sub-groups or writing weekly reports, Student 2 was a leader during those periods of time. The evaluation sheet also showed Grace as a team member with the highest or second highest scores similar to Irene. Table 5.15 displays both Grace and Irene’s averaged scores.

For both case studies, these two students received little negative reviews or no acknowledgement of leadership from their peers. In the leadership questionnaires in both studies, each student perceived themselves as task oriented leaders. One major similarity between the students is the role they contributed in their respective teams. Barry showed more task oriented leadership in the ethnographic study and concentrated on the design and prototyping. Grace claims she put 25% into the reports in C2I9 and C2I19 talks about “working a lot on the concept design paper and helping Irene with the weekly reports.” Therefore, non-leaders achieve the ability of showing leadership traits in

engineering design projects and are mainly the students concentrating on completing tasks to finish the project.

6.4 Comparison of Sub-Hypothesis 3

Identifying leadership is the main goal of this research, and the third sub-hypothesis intends to determine whether leadership remains stable once leaders are established. Chapter Four: used the interview and leadership questionnaire to verify if this sub-hypothesis is true. From the interview, there was no indication that leaders changed during the project. C1I1 asked if having no established leader affected their group and every student had positive remarks. Then, C1I6 asked about the end of the project and there was a positive reaction from all four students as well. C1Q2 revealed who became leaders of the group and when this occurred. Since Carol was chosen four times and Dave was selected three times, these two students must have been consistent leaders with the group. Throughout the case study, Carol and Dave were leaders simultaneously and not consecutively.

However in Chapter Five:, leadership changed at the midpoint of the project. Eric, Fred, and Irene were established as leaders in the second case study, yet they accentuated different roles within the group. Eric and Fred talked about the construction of the design project extensively through the interview. The construction portion of the project occurred at the end of the project. Irene showed that her efforts towards documentation and producing reports occurred during the conceptual stage. Since the conceptual stage is towards the beginning of the design phase, her leadership is inferred

as at the beginning of the project. Therefore, the second case study has caused the last sub-hypothesis to be disproven.

6.5 Conclusions

The cross-case comparisons of the hypotheses have shown that all of them except the last hypothesis are proven to be true. By comparing each of the case studies and data collection methods, the hypotheses were able to be proved. In addition to the comparison of the results, the hypotheses have determined which data collection methods were instrumental to the derivation of the results. These data collection methods obtained the data needed to conclude if the hypotheses are true and understanding which methods are needed creates the exact case study for this research. The results and order of data collection methods for each hypothesis is stated in bulleted form below to illustrate the execution of discovering leadership in engineering design project teams.

The main hypothesis has yielded these results:

- At least two leaders have been identified by both case studies
 - Carol and Dave in Chapter Four:
 - Eric, Fred, and Irene in Chapter Five:
- One student from each case study has been identified as clearly a non-leader
 - Alex in Chapter Four:
 - Hank in Chapter Five:
- Three data collection methods were used to determine the leaders with the case studies

- Ethnographic Study and Interview in Chapter Four:
- A more detailed interview and questionnaire in Chapter Five:

Sub-hypothesis 1 has determined these results:

- One student in each case study showed both task and interpersonally oriented leadership
 - Dave in Chapter Four:
 - Irene in Chapter Five:
- However, task oriented leadership existed within the engineering design project groups as well
 - Carol, who also showed more overall leadership in the ethnographic study conducted in Chapter Four:
 - Eric and Fred showed task leadership in Chapter Five:
- Different data collection methods were used in each chapter to obtain these results
 - Chapter Four: used an ethnographic study to tabulated the leadership occurred
 - Chapter Five: used an evaluation sheet to represent the leadership exhibited
 - Ethnographic study provided more visualization of which types of leadership occurred periodically

Proving the verification of non-leaders in engineering design project teams showed:

- One student in each case study identified as a non-leader displaying leadership traits
 - Barry in Chapter Four:
 - Grace in Chapter Five:
- Each student were defined as task oriented leaders
 - Barry had four more task leadership skills shown within the ethnographic study and indicated task leadership in the interview and questionnaire
 - Grace denoted task leadership in the interview and questionnaire

Sub-hypothesis 3 is the only hypothesis to be disproven by these results:

- Chapter Four: did not determine a change in leadership
 - Carol and Dave led simultaneously
- Change in leadership occurred in Chapter Five:
 - Irene led through documentation and writing reports in the beginning of the project
 - Eric and Fred led during the construction phase, which transpired at the second half of the project

The data collection methods recommended for obtaining the leadership within engineering design project teams are:

- Ethnographic Study
- Interviewing
- Leadership Questionnaire

CHAPTER SEVEN: CONCLUSIONS

Through the first six chapters of this research, leadership has been established to be used within engineering project teams. Chapter One: and Chapter Two: introduced the issues of leadership in engineering design teams and types of leadership encountered in research. One purpose of this research is to determine what types of leadership, task and transactional or interpersonal and transformational. Chapter Three: explained the use and types of case studies in research. Chapter Four: and Chapter Five: provided the protocols and results of two case studies proving the four hypotheses stated in Chapter Two:.

The cross case analysis in Chapter Six: has shown that task or transactional leadership is needed in engineering groups for the group to function and complete the project. This is apparent because of the technical skills needed for completing an engineering project. Transactional leadership involves technical skills, contingent reward, management-by-exception, and laissez-faire leadership. Therefore, these characteristics have to be implemented to engage an engineering team and provide assistance to complete objectives. From the second hypotheses, task oriented and balanced leaders were shown in both case studies.

From the ethnographic study in Chapter Four and the interviewing which occurred in Chapter Five, transformational or interpersonally oriented leadership is shown within engineering projects as well. However, the degree at which these skills are required to have for leaders is low. Dave was the only student who exhibited the most of this style in Chapter Four: and Chapter Five: results derived Irene as the balanced leader

within the group. Both students who exhibited interpersonally oriented leadership were also leaders in their respective groups. In addition to the existence and types of leadership, this research is verified through non-leadership displaying leadership attributes, whether leadership changed throughout the duration of each engineering design project, and defining the data collection methods that are implemented to identify the leadership in future groups.

7.1 Development of Leadership

Through the examination of Chapter Six:, the research questions presented in Chapter One: have been answered. The answers of these questions conclude whether the research has provided new information about leadership in engineering design teams.

The first two questions are:

- Can leadership be clearly identified in engineering design project teams?
- How will leadership be identified in engineering design project teams?

The main hypothesis has answered the first question. Leadership was identified through the use of case studies, which illustrated at least two leaders in Chapter Four: and Chapter Five:. These case studies used data collection methods which triangulated data for identifying the leaders of the group and their respective leadership types.

The next three research questions expound upon the previous two questions about what specifically was found as leadership types within the engineering design project teams. These three research questions are:

- What leadership types are found students within engineering project teams?

- What leadership traits are contributed by the undergraduate students from the leadership types shown in engineering project groups?
- What is the reasoning behind the leadership types seen within engineering project groups?

Sub-hypotheses 1 answered the first question and the research has determined that task oriented leaders are dominant in engineering design teams and balanced (task and interpersonally oriented) leaders are identified in this type of group as well.

However, the more evident traits seen within each chapter were different. In Chapter Four:, there was an emphasis on the delegation of tasks, completing tasks, and influencing others to do their work. Chapter Five: inserted emotional intelligence traits in addition to transformational and transactional traits for the evaluation sheets. The emotional intelligence traits were all in the top five scored traits, which were social awareness, social skills, self-awareness, empathy, and self-regulation. The traits exhibited in Chapter Four: are common among engineering students because the path which engineers receive their education requires them to be autonomous [30]. However, emotional intelligence being ranked higher in Chapter Five: occurred because of the relationships which existed in this group before they started the project.

7.2 Multiple Degrees of Transactional Leadership

A high degree of transactional leadership is seen by Eric and Fred in the Lunar TWEEL study. These two individuals viewed their leadership through completing tasks and helping others with the project. However, their leadership started halfway through the project when they organized the construction of the testing device. These two

students were also highly confident in their transactional leadership types which are shown in the interview and questionnaires. Carol's transactional leadership was high in the ME 402 project as well. However, this student's confidence in leadership was lower by having a score of a six. Another reason for the low confidence could be modesty or the presence of Dave as a leader within the group. Dave's leadership was balanced and Carol's role shifted from the forefront to a secondary leadership position.

Irene's leadership in the Lunar TWEEL case study existed at the design phase of the project, yet it was only visible during reports or at weekly meetings. The reports and final design came towards the end of the design phase and at the midpoint of the project. This is where Eric and Fred took over and Irene's transactional leadership which occurred became diminutive. Dave's balanced leadership and vibrant personality caused his transactional leadership to be exerted less through the extent of the ME 402 project. The mixture of transactional and transformational leadership worked well with Carol's highly transactional style of leadership. Consequently, the amount of transactional leadership shown in each project varied which was revealed to be evident in different manners.

7.3 Future Work

The research developed has presented results which can be examined further and opportunities to expand upon what has occurred. The results have shown that transactional leadership is present within both engineering group projects heavily. However, transformational leadership is not as important in these engineering groups. Transformational leadership can be examined further within engineering project groups

to determine how much is found. The discovery of limited transformational leadership and overall leadership could have directly been an effect of how the case studies were executed.

The case studies completed through this research were assembled at different periods of time. The prescribed data collection methods in Chapter Six: should be implemented in future case studies to prove future hypotheses. This order of methods will also answer the remaining research questions, which are:

- Is case study research the correct method to conduct this research?
- What data collection methods are needed to complete each case study?
- What data collection methods are needed specifically for identifying leadership in engineering design project teams?

An ethnographic study immerses the researcher in the subjects' surroundings. This will provide accurate data of what leadership is exhibited by all members of the group in question. A detailed interview, such as the one administered in Chapter Five:, will supply specific information regarding the group and their performance. Then, the leadership questionnaire completes the triangulation of information with leadership knowledge and confidence ratings. This protocol is made specifically for students in engineering design projects, but what about engineering students in other subject matters. Other data collection methods mentioned in Teegavarapu and Summers' [49] research has yet to be used. Participatory research, cultural inventory, demographic study, standardized tests, or structural tests have not been used to determine the leadership within engineering design project groups and could yield more plausible results.

For example, what is the leadership ability of an engineering student in an entrepreneurial or marketing project? The approach of the engineering student could be different because their knowledge in those areas is diminished. However, the engineering student may treat group projects the same in any subject area and continue to produce the same amount of leadership. The students who participated in these case studies may act differently in other projects as well. So, research on several students traversing through multiple projects could be beneficial because of the reasoning and perceptions of what caused the possible changes in leadership. Motivation and climate, personalities, and subject knowledge are all possible reasons to affect the consistency of leadership shown in multiple projects.

Instead of following students through multiple projects, what about following multiple leadership types through engineering design projects? The ability to detect leadership types is one path of research, however to determine the right combination of leadership types to have successful projects is another path. Teachers in engineering at multiple campuses have either mini or semester long projects which account of a certain percentage of the students' grades. Therefore, does the success of these projects depend on a certain combination of task and interpersonally oriented leaders and non-leaders? The correct combination may only work a large percentage, yet the success rate of the best combination of leadership types in engineering design projects will occur once the students are placed within groups tailored for optimal performance.

The correct combination for an aerodynamics course project may not be the same for a heat transfer course project. So, are different combinations of leadership types

needed for different courses? More research into leadership types and styles could produce small tests to administer to students before the teacher assigns the students to their respective groups. This data could be useful to determine whether students are ready for graduate school or employment as well. The development of leadership styles and corresponding qualities with a longitudinal case study could determine the future of students in industry or graduate level studies.

Clearly identifying leadership within engineering design teams has applicability to other areas of research such as engineering education, team building and management, and concurrent engineering. This research is not limited to the leadership types which were examined. The defining of leadership styles and management traits could also help the development of engineering course groups, and identifying future graduate students or industry employees. More avenues can be discovered by implementing these possible directives and enhance the leadership exhibited throughout engineering design.

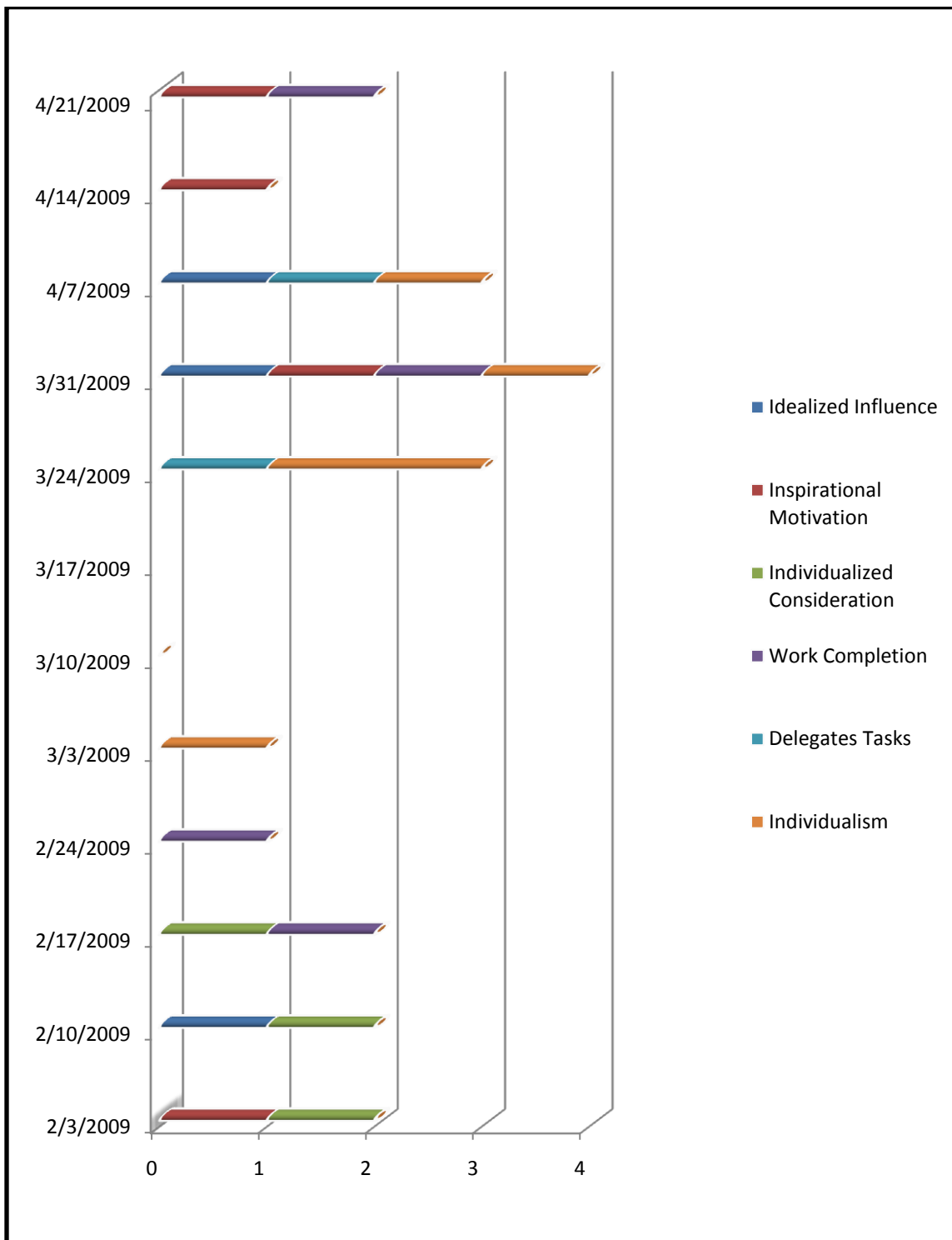
APPENDICES

Appendix A: Ethnographic Study

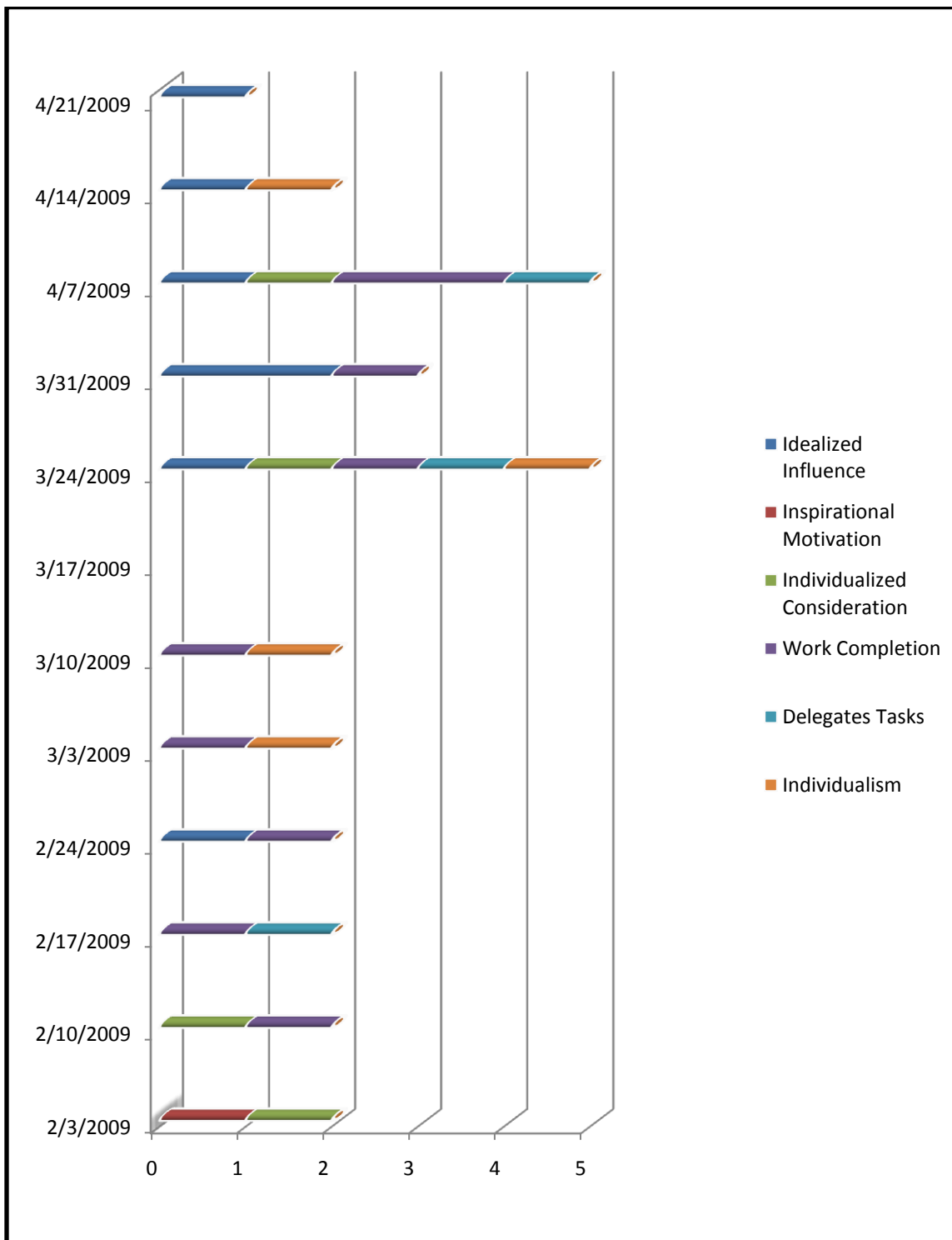
The ethnographic study was conducted by a tally of leadership traits where each individual was monitored through the extent of the project. There were three leadership traits in both types of leadership. Task-oriented leadership consisted of work completion (purple), delegating tasks (teal), and individualism (orange). Interpersonally-oriented leadership consisted of idealized influence (blue), inspirational motivation (red), and individualized consideration (green). When these characteristics were seen in each team member at their weekly meetings, the specific trait was marked and accumulated.

Each graph in this appendix has the total amount of leadership shown in each team member. The graph starts at the bottom (2/3/2009) and travels upward to the last scheduled weekly meeting (4/21/2009). The legend on the right starts with the three interpersonally-oriented traits and ends with the task-oriented traits. Alex and Barry's graphs are in increments of one because they did not show as much leadership as Carol and Dave. Carol and Dave's graphs are in increments of two. Therefore when reading the graph and going from trait to trait, there may be multiple tallies within each trait. The week of 3/17/2009 will not have any leadership tallies because that was spring break for all students.

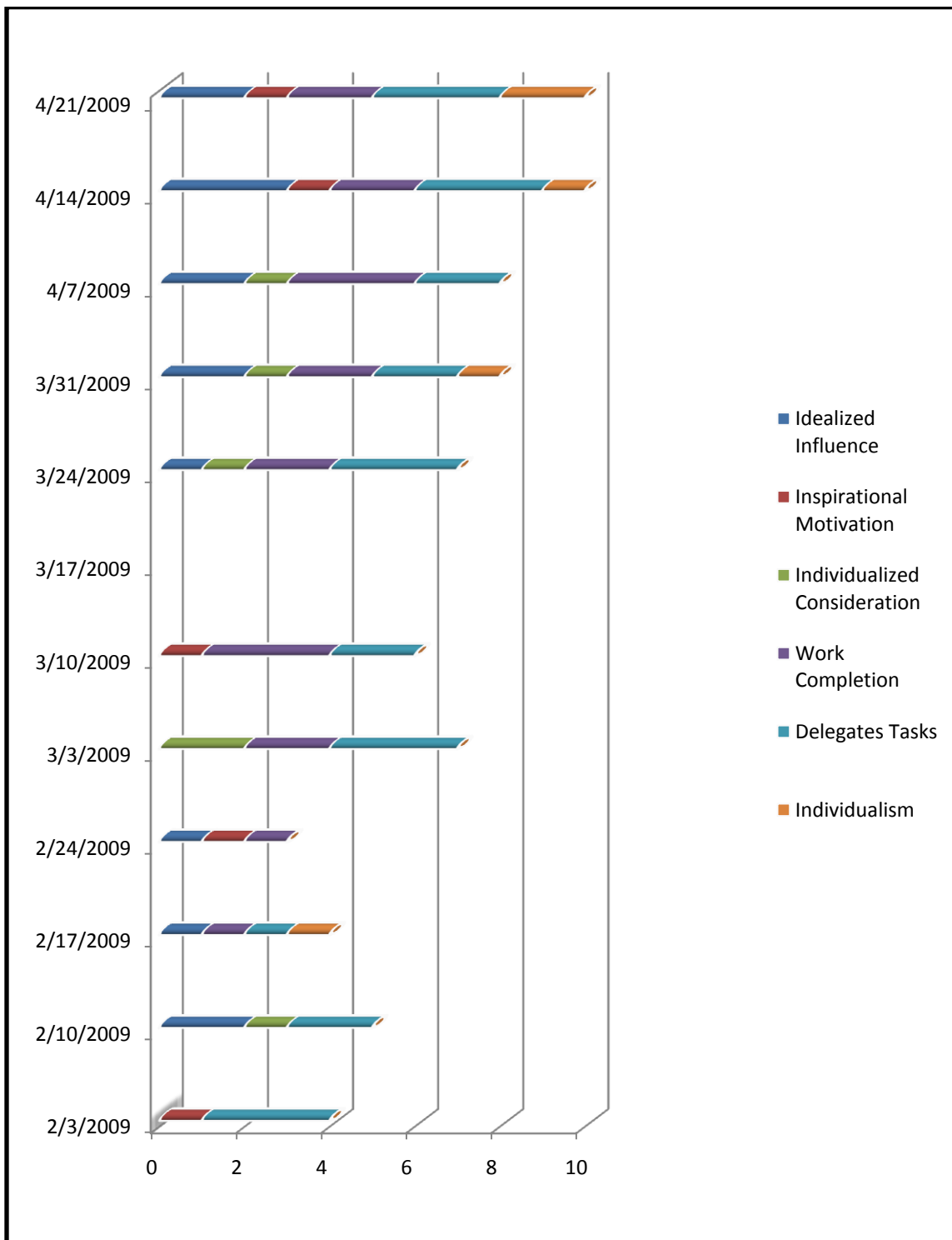
Alex's Ethnographic Data



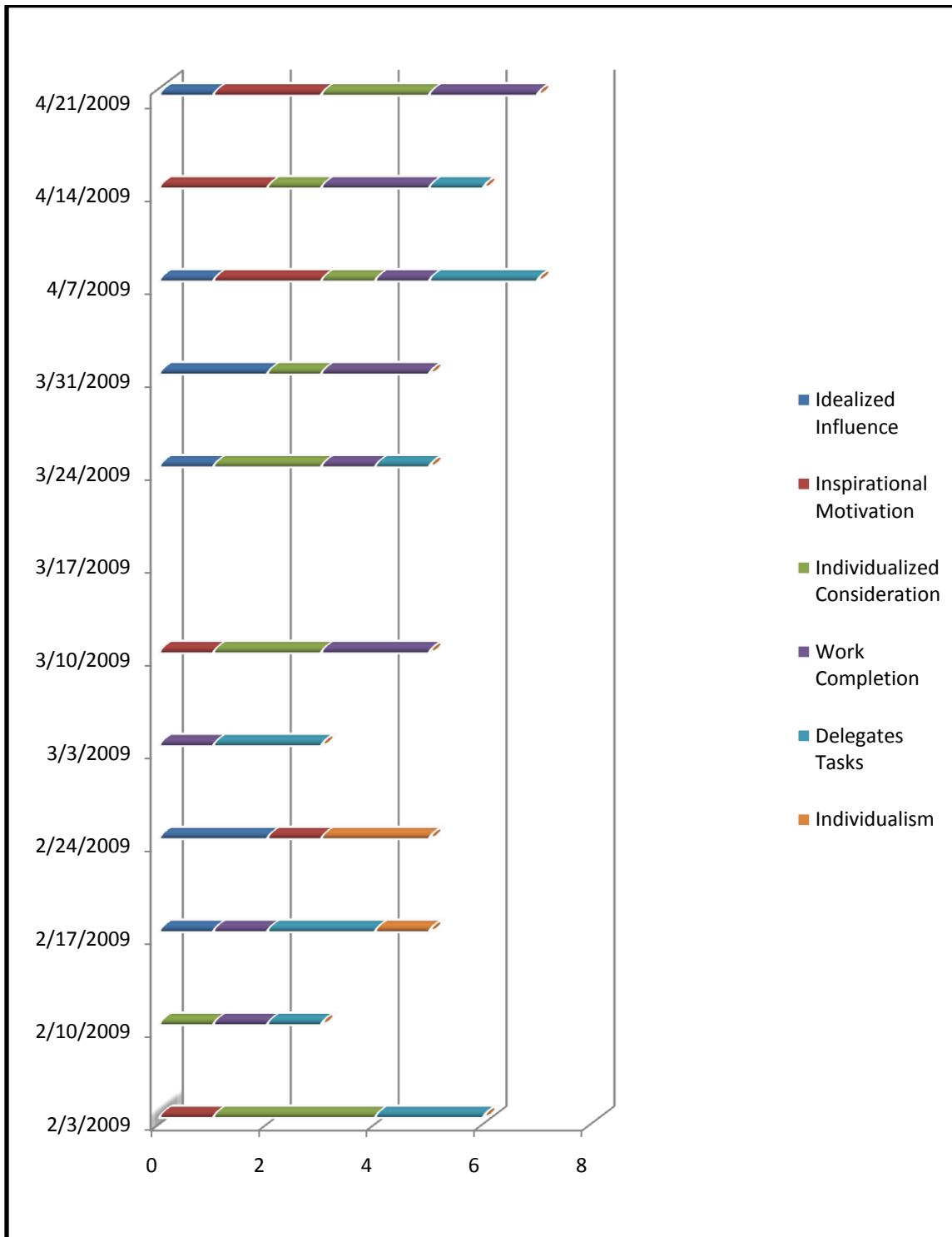
Barry's Ethnographic Data



Carol's Ethnographic Data



Dave's Ethnographic Data



Appendix B: Chapter Four Leadership Questionnaire

In Appendix B, each team member's questionnaire responses are individually recorded the first case study. This is a resource where readers can look at the responses of individuals instead of collectively looking at each question. Those results are found in Chapter Four. The questionnaire consists of eight questions which each student answered without the help of their team members. These questionnaires were administered at the end of the project.

For each question, the answers are underlined next to the corresponding question. The exception to this statement is C1Q4. C1Q4 is the question which asks to match the leadership traits to their appropriate leadership type. The leadership types are underlined and underneath are the leadership traits which they have responded with. The correct answers are left alone and the wrong answers have a strikethrough response.

Alex's Leadership Questionnaire

1. Do you believe there was a clear leader(s) at the beginning of the project?

Yes

No

2. Were there any leaders which arose throughout the project?

Yes

No

a. If so, who (can be more than one)? Carol and Dave

b. When did he/she/they arise? When work needed to get done

3. Do you know the difference between task-oriented and interpersonally oriented leadership style? (1 – Strongly Disagree and 10 – Strongly Agree): 4

4. Please place these words under what you consider which style: Words to choose from – Delegate, Consideration, Motivation, Individualism, Influential, Completion, Organization, and Morale

Task-Oriented

Interpersonally-Oriented

Delegate

Consideration

Completion

Motivation

Organization

~~Individualism~~

Morale

Influential

5. Do you think others within the group have seen you as a leader?

Yes

No

6. If so, in what respect?

a. Rate strength of confidence (1–Strongly Disagree and 10–Strongly Agree): 5

b. From 1 to 5, rate what style they would see you as (1–Task, 3–Both, 5–
Interpersonal): 2

7. Looking back at the experience, would you be more of a leader or follower? Follower

8. As far as leadership is concerned, rate yourself from 1 to 10 (1 – Strongly Disagree
and 10 – Strongly Agree): 6

a. What types of leadership to you consider yourself? (1 – Task, 3 – Both, 5
– Interpersonal): 2

b. How confident are you in that leadership type? Rate strength of
confidence (1 – Strongly Disagree and 10 – Strongly Agree): 5

Barry's Leadership Questionnaire

1. Do you believe there was a clear leader(s) at the beginning of the project?

Yes

No

2. Were there any leaders which arose throughout the project?

Yes

No

a. If so, who (can be more than one)? Carol and I

b. When did he/she/they arise? Carol, at the beginning and I, at the end

3. Do you know the difference between task-oriented and interpersonally oriented leadership style? (1 – Strongly Disagree and 10 – Strongly Agree): 8

4. Please place these words under what you consider which style: Words to choose from – Delegate, Consideration, Motivation, Individualism, Influential, Completion, Organization, and Morale

Task-Oriented

Interpersonally-Oriented

Delegate

Consideration

Completion

Motivation

Organization

Morale

Individualism

Influential

5. Do you think others within the group have seen you as a leader?

Yes

No

6. If so, in what respect?

a. Rate strength of confidence (1–Strongly Disagree and 10–Strongly Agree): 6

b. From 1 to 5, rate what style they would see you as (1–Task, 3–Both, 5–
Interpersonal): 2

7. Looking back at the experience, would you be more of a leader or follower? Leader

8. As far as leadership is concerned, rate yourself from 1 to 10 (1 – Strongly Disagree
and 10 – Strongly Agree): 8

a. What types of leadership to you consider yourself? (1 – Task, 3 – Both, 5
– Interpersonal): 1

b. How confident are you in that leadership type? Rate strength of
confidence (1 – Strongly Disagree and 10 – Strongly Agree): 5

Carol's Leadership Questionnaire

1. Do you believe there was a clear leader(s) at the beginning of the project?

Yes

No

2. Were there any leaders which arose throughout the project?

Yes

No

a. If so, who (can be more than one)? Dave and I

b. When did he/she/they arise? When work needed to get done

3. Do you know the difference between task-oriented and interpersonally oriented leadership style? (1 – Strongly Disagree and 10 – Strongly Agree): 7

4. Please place these words under what you consider which style: Words to choose from – Delegate, Consideration, Motivation, Individualism, Influential, Completion, Organization, and Morale

Task-Oriented

Interpersonally-Oriented

Delegate

Consideration

Completion

Morale

Organization

~~Individualism~~

~~Motivation~~

Influential

5. Do you think others within the group have seen you as a leader?

Yes

No

6. If so, in what respect?

a. Rate strength of confidence (1–Strongly Disagree and 10–Strongly Agree): 8

b. From 1 to 5, rate what style they would see you as (1–Task, 3–Both, 5–
Interpersonal): 3

7. Looking back at the experience, would you be more of a leader or follower? Leader

8. As far as leadership is concerned, rate yourself from 1 to 10 (1 – Strongly Disagree
and 10 – Strongly Agree): 7

a. What types of leadership to you consider yourself? (1 – Task, 3 – Both, 5
– Interpersonal): 3

b. How confident are you in that leadership type? Rate strength of
confidence (1 – Strongly Disagree and 10 – Strongly Agree): 4

Dave's Leadership Questionnaire

1. Do you believe there was a clear leader(s) at the beginning of the project?

Yes

No

2. Were there any leaders which arose throughout the project?

Yes

No

a. If so, who (can be more than one)? Carol and I

b. When did he/she/they arise? Halfway

3. Do you know the difference between task-oriented and interpersonally oriented leadership style? (1 – Strongly Disagree and 10 – Strongly Agree): 10

4. Please place these words under what you consider which style: Words to choose from – Delegate, Consideration, Motivation, Individualism, Influential, Completion, Organization, and Morale

Task-Oriented

Interpersonally-Oriented

Delegate

Consideration

Completion

Motivation

Organization

Morale

Individualism

Influential

5. Do you think others within the group have seen you as a leader?

Yes

No

6. If so, in what respect?

a. Rate strength of confidence (1–Strongly Disagree and 10–Strongly Agree): 7

b. From 1 to 5, rate what style they would see you as (1–Task, 3–Both, 5–
Interpersonal): 4

7. Looking back at the experience, would you be more of a leader or follower? Leader

8. As far as leadership is concerned, rate yourself from 1 to 10 (1 – Strongly Disagree
and 10 – Strongly Agree): 7

a. What types of leadership to you consider yourself? (1 – Task, 3 – Both, 5
– Interpersonal): 4

b. How confident are you in that leadership type? Rate strength of
confidence (1 – Strongly Disagree and 10 – Strongly Agree): 9

Appendix C: Chapter Four Interview Transcript

Six questions were asked to the design team in Chapter Four for an interview and their responses are within this appendix. The interviews were conducted individually and clarification of the question was given, if it was needed. The transcript consists of the question, then each of the student's responses below the given question. The answers are given in alphabetical order by the arbitrary names given to each student. Each question will be answered by Alex, Barry, Carol, and Dave every time.

1. Do you think there will be problems later on by having no established leader?

Alex: Everything is going fine. Maybe we can talk about it when it gets more intense, but for now everything is ok.

Barry: No, not really. It's still early and the group is functioning well without a clear leader.

Carol: So far I think everything has gone really well. Everybody in the group gets along great and we've been making steady progress.

Dave: Well everything is fine. It is moving a little slow but once everything is defined the ball will start rolling.

2. A majority of seniors like to fall back as far as leadership, even if they were leaders before, have you seen that and feel that way yourself?

Alex: Yes, but I haven't seen anything horrible happen because of it. My past experience in successful groups allows my contributions to be ok.

Barry: Yes, I definitely noticed the effort of contribution versus leadership.

Carol: I find myself in a position to lead and I have noticed the lack of leadership.

Dave: Yep, I've seen it. However, I want to get good grades and gain the most out of each class. Alex is one and Barry is half and half.

3. What have you done to help the direction of the group?

Alex: I've initialized the designs for the pneumatic hammer.

Barry: I've been pushing a design for the pneumatic piston and I feel that I'm moving the direction of prototyping for the group.

Carol: Set deliverables and tasks for each meeting.

Dave: I get the deliverables done and I'm the communication guy. I try to keep all of the information organized and standardize the e-mails. I try to also keep a positive attitude and at level ground.

4. Did you utilize the advisors advice? Did you notice if anyone used it as well and if not, did you remind them about it?

Alex: We use what the advisors give us but at the last minute. Therefore, we are telling each other before the presentation what they have talked about last week, every week.

Barry: I definitely use the advisors advice. Since the piston was the focus a couple times, I've just been trying to finish the code and design parameters.

Carol: Yea, I think we do all the time. That hurts us as well because we wait on them to tell us if we are doing good or not. Not a great thing to do.

Dave: We used their advice all the time but it was always crunch time when we used it. So we'll just talk about what is needed an hour before its time to present. Crazy stuff.

5. Do you think you are a task or interpersonally oriented leader?

Alex: I'm more task-oriented than interpersonal.

Barry: I feel I'm more task-oriented than interpersonal.

Carol: In between. I don't want to give tasks all the time but someone has to do it.

Dave: Interpersonal and the morale guy all the way.

6. How did the end of the project turn out?

Alex: It was cool. The attachment to the crimper worked great at the plant and the company was impressed by every team's designs.

Barry: The project turned out great, better than what I expected.

Carol: Awesome! Our prototype worked and it was cool to see the other designs that were made.

Dave: It was great man. Every group's crimper worked and had different types of attachments. Really cool.

Appendix D: Chapter Five Leadership Questionnaires

Appendix D contains five leadership questionnaires of each team member in the second case study. The questionnaires are similar to the ones found in Appendix B except for the fourth question. C2Q4 was corrected during the second case study because one word caused confusion. The word *individualism* was replaced with *contingent reward* to clarify the difference between the task and interpersonally-oriented traits. All answers found within each questionnaire are underlined with the exception of C2Q4. C2Q4 answers are correct if the words are left alone and are incorrect if the word has a strikethrough response.

Eric's Leadership Questionnaire

1. Do you believe there was a clear leader(s) at the beginning of the project?

Yes

No

2. Were there any leaders which arose throughout the project?

Yes

No

a. If so, who (can be more than one)? Grad Student

b. When did he/she/they arise? In the beginning, when he started grad school

3. Do you know the difference between task-oriented and interpersonally oriented leadership style? (1 – Strongly Disagree and 10 – Strongly Agree): 10

4. Please place these words under what you consider which style: Words to choose from – Delegate, Consideration, Motivation, Contingent Reward, Influential, Completion, Organization, and Morale

Task-Oriented

Interpersonally-Oriented

Delegate

Motivation

Contingent Reward

Consideration

Completion

Influential

Organization

Morale

5. Do you think others within the group have seen you as a leader?

Yes

No

6. If so, in what respect?

a. Rate strength of confidence (1–Strongly Disagree and 10–Strongly Agree): 8

b. From 1 to 5, rate what style they would see you as (1–Task, 3–Both, 5–
Interpersonal): 2

7. Looking back at the experience, would you be more of a leader or follower? Leader

8. As far as leadership is concerned, rate yourself from 1 to 10 (1 – Strongly Disagree
and 10 – Strongly Agree): 8

a. What types of leadership to you consider yourself? (1 – Task, 3 – Both, 5
– Interpersonal): 2

b. How confident are you in that leadership type? Rate strength of
confidence (1 – Strongly Disagree and 10 – Strongly Agree): 8

Fred's Leadership Questionnaire

1. Do you believe there was a clear leader(s) at the beginning of the project?

Yes

No

2. Were there any leaders which arose throughout the project?

Yes

No

a. If so, who (can be more than one)? Eric and Fred

b. When did he/she/they arise? A few weeks after the start of the project

3. Do you know the difference between task-oriented and interpersonally oriented leadership style? (1 – Strongly Disagree and 10 – Strongly Agree): 8

4. Please place these words under what you consider which style: Words to choose from – Delegate, Consideration, Motivation, Contingent Reward, Influential, Completion, Organization, and Morale

Task-Oriented

Interpersonally-Oriented

Delegate

Consideration

Organization

Morale

Completion

Motivation

Contingent Reward

Influential

5. Do you think others within the group have seen you as a leader?

Yes

No

6. If so, in what respect?

a. Rate strength of confidence (1–Strongly Disagree and 10–Strongly Agree): 9

b. From 1 to 5, rate what style they would see you as (1–Task, 3–Both, 5–
Interpersonal): 1

7. Looking back at the experience, would you be more of a leader or follower? Leader

8. As far as leadership is concerned, rate yourself from 1 to 10 (1 – Strongly Disagree
and 10 – Strongly Agree): 8

a. What types of leadership to you consider yourself? (1 – Task, 3 – Both, 5
– Interpersonal): 1

b. How confident are you in that leadership type? Rate strength of
confidence (1 – Strongly Disagree and 10 – Strongly Agree): 10

Grace's Leadership Questionnaire

1. Do you believe there was a clear leader(s) at the beginning of the project?

Yes

No

2. Were there any leaders which arose throughout the project?

Yes

No

a. If so, who (can be more than one)? Eric and Irene

b. When did he/she/they arise? Ben, at the midpoint and Sam, in the beginning

3. Do you know the difference between task-oriented and interpersonally oriented leadership style? (1 – Strongly Disagree and 10 – Strongly Agree): 7

4. Please place these words under what you consider which style: Words to choose from – Delegate, Consideration, Motivation, Contingent Reward, Influential, Completion, Organization, and Morale

Task-Oriented

Interpersonally-Oriented

Delegate

Consideration

Contingent Reward

Motivation

Completion

Influential

Organization

Morale

5. Do you think others within the group have seen you as a leader?

Yes

No

6. If so, in what respect?

- a. Rate strength of confidence (1–Strongly Disagree and 10–Strongly Agree): N/A
 - b. From 1 to 5, rate what style they would see you as (1–Task, 3–Both, 5–Interpersonal): N/A
7. Looking back at the experience, would you be more of a leader or follower? Follower
8. As far as leadership is concerned, rate yourself from 1 to 10 (1 – Strongly Disagree and 10 – Strongly Agree): 5
- a. What types of leadership to you consider yourself? (1 – Task, 3 – Both, 5 – Interpersonal): 2
 - b. How confident are you in that leadership type? Rate strength of confidence (1 – Strongly Disagree and 10 – Strongly Agree): 4

Hank's Leadership Questionnaire

1. Do you believe there was a clear leader(s) at the beginning of the project?

Yes

No

2. Were there any leaders which arose throughout the project?

Yes

No

a. If so, who (can be more than one)? N/A

b. When did he/she/they arise? N/A

3. Do you know the difference between task-oriented and interpersonally oriented leadership style? (1 – Strongly Disagree and 10 – Strongly Agree): 8

4. Please place these words under what you consider which style: Words to choose from – Delegate, Consideration, Motivation, Contingent Reward, Influential, Completion, Organization, and Morale

Task-Oriented

Interpersonally-Oriented

Delegate

Consideration

Completion

Motivation

~~Morale~~

Influential

Contingent Reward

~~Organization~~

5. Do you think others within the group have seen you as a leader?

Yes

No

6. If so, in what respect?

a. Rate strength of confidence (1–Strongly Disagree and 10–Strongly Agree): 6

b. From 1 to 5, rate what style they would see you as (1–Task, 3–Both, 5–
Interpersonal): 5

7. Looking back at the experience, would you be more of a leader or follower? Follower

8. As far as leadership is concerned, rate yourself from 1 to 10 (1 – Strongly Disagree
and 10 – Strongly Agree): 7

a. What types of leadership to you consider yourself? (1 – Task, 3 – Both, 5
– Interpersonal): 5

b. How confident are you in that leadership type? Rate strength of
confidence (1 – Strongly Disagree and 10 – Strongly Agree): 7

Irene's Leadership Questionnaire

1. Do you believe there was a clear leader(s) at the beginning of the project?

Yes

No

2. Were there any leaders which arose throughout the project?

Yes

No

a. If so, who (can be more than one)? N/A

b. When did he/she/they arise? N/A

3. Do you know the difference between task-oriented and interpersonally oriented leadership style? (1 – Strongly Disagree and 10 – Strongly Agree): 7

4. Please place these words under what you consider which style: Words to choose from – Delegate, Consideration, Motivation, Contingent Reward, Influential, Completion, Organization, and Morale

Task-Oriented

Interpersonally-Oriented

Delegate

Consideration

Contingent Reward

Motivation

Completion

Influential

Organization

Morale

5. Do you think others within the group have seen you as a leader?

Yes

No

6. If so, in what respect?

a. Rate strength of confidence (1–Strongly Disagree and 10–Strongly Agree): 6

b. From 1 to 5, rate what style they would see you as (1–Task, 3–Both, 5–
Interpersonal): 1

7. Looking back at the experience, would you be more of a leader or follower? Follower

8. As far as leadership is concerned, rate yourself from 1 to 10 (1 – Strongly Disagree
and 10 – Strongly Agree): 6

a. What types of leadership to you consider yourself? (1 – Task, 3 – Both, 5
– Interpersonal): 3

b. How confident are you in that leadership type? Rate strength of
confidence (1 – Strongly Disagree and 10 – Strongly Agree): 7

Appendix E: Chapter Five Interview Transcript

The interview conducted in Chapter Five included 28 questions. These questions were given to the five group members individually. Some interview questions and answers are long, but the answers of each team member are still divided by their name. Some answers by individuals are given in paragraph form and they are separated by indentations. The answers are given in alphabetical order by the arbitrary names given to each member of the group.

1. What was your role for the construction of the MGR?

Eric: Both. As team leader, I orchestrated some of the trips to the shop and got a game plan together for the construction. First, we started with putting up the cables and making everything easier for everybody else. As team member, I cut the cables and hung the cables too. I did things myself, set examples and wanted everyone to contribute as well. So I helped in both ways.

Fred: I feel like I was both. Outside of meetings, I coordinated things with MTS and spent a lot of time with them. In the meetings, everyone fell back to the role of team member.

Grace: Both. We were given certain aspects of the project to be in charge of and we had to answer to Dr. Summers.

Hank: Definitely a team member.

Irene: Both. I'm a member when I contribute to finding parts and etc. I'm a leader when I get things organized for the group.

2. Were there any specific parts that you had ownership of throughout the entirety of the construction?

Eric: On the center shaft, I helped with the analysis on buckling. Then, I sized the cables for the length of the shaft. I also helped with the turntable bearing on the top of the shaft. I did the drawings for MTS on the shaft and the mounting on the bottom. They actually did the assembly. Then with the cables, I helped size the cables, tensioners, clamping pieces, and helped them install all of the pieces. As for the fixture, I helped do the

framework drawings, size the bars for the a-arms, and designed the plate the motor goes on.

Fred: I was assigned to the center column with David while he was here. The cables to the MGR were solely my responsibility. I picked up the casters and I was with MTS when they dropped off the trough sections and helped calculate the sections.

Grace: I did the center shaft and I guess the casters.

Hank: I helped with the buckling analysis over the center column and the overall design of the MGR.

Irene: Casters, Trough and Cables.

3. What design collaboration skills did you contribute to help the construction of the project?

Eric: I've had about 6 or 7 years of SolidWorks experience that I contributed to the project, where I used that experience for industry projects because I have a part time job. I was able to help others do some SolidWorks analysis and draw pictures in SolidWorks. I also did calculations for sizing things.

Fred: I was the one who wanted to go with the design of floating the MGR above the ground. Also, there was a design about the treadmill for the sand as well.

Grace: We did stuff like brainstorming and defining ideas to draw up.

Hank: I used brainstorming during the beginning of the project and coming up with ideas to make this thing. I tried to use as much 202 class skills as possible. I also used some

Strength of Materials coursework for picking materials for what I was working on as well.

Irene: Analysis and selection of the casters and fitting the budget.

4. Do you have any experience with group projects before the start of this construction?

Eric: Before the project, I have been doing part time and full time engineering work for about 10 years. This would be over 50 projects within that span. At times, there was only me and sometimes it got up to 20 people. So coming onto this project with the 6 or 8 people, it was something I was use to. Through the years, I've done drawings for BMW in the remodel group and designing tools for X6, X5 and Z4. Those teams ranged from 2 or 3 people up to 12. I've worked on projects with Boeing where contracts were about 1.5 to 2 million and down to individual project for companies that could be a 1000 dollar, short term project. I was contracted under a general tooling company for BMW and those projects were around 2 to 3 weeks. Some of those lasted 3 to 4 months as a long term project, and for the most part, they were shorter. A tool or fixture for a part for BMW usually only took a week to design, sizing and fabrication for 40 hours a week.

Fred: Before the project, I was part of a freshman engineering course where the objective was to build a car to go a given distance and stop at a target. It was only me and another person and we spent 20 dollars. We spent about 15-20 hours per week at a week's span on Clemson University's campus.

During the project, we built a toothpick bridge for Statics. There was 4 people on the team and only spent 6-8 dollars. I worked about 40 hours per week on the project and we met only once a week together. The goal was to build a bridge to a ratio of expense to loading. We got second place in initial strength.

Grace: I have a bunch of projects before I joined this group. There were about 5 or 6 that I did at my last school with 3 or 4 students in the group. There was no money associated with any of the school projects and they would last for about 2 months each. There were all Introduction to Engineering Design type classes. One project was that we had to build a soap box derby car and we had to design a helicopter.

Hank: Before the project, I had a Mechatronics class in Australia. There were 3 team members for 3-4 hours per week and with \$100. The study abroad lasted for a semester and it was held at the University of New Castle. The objective was to create a robot to drive itself with an infrared remote.

During the project, I was part of ME 401 at Clemson University. This was in the spring semester with 5 team members for 6 hours per week. There were two projects: The first was to distill rain water into drinking water which also meant we had to capture it. The next project was an automatic external defibrillator. It was suppose to instruct any user, and the chair could only be mechanical.

Irene: Initial brainstorming for the MGR which had 6-7 people and 0 dollars. We committed about 3-4 hours per week, one day a week for meetings for 6 weeks. LEGOs Construction was a visual aid for the intial concept. We also got together to make sure ideas were clear and come up with things that can be altered or changed. Then, we made

CAD drawings of the MGR concepts. This project was sponsored by Clemson University and NASA.

The Mini-Go-Round construction was also before the project with 3-4 people and 20 hours per week. There was only \$50 spent in the course of 8 weeks and this was also at Clemson University. This included the Annulus testing as a Eureka student.

During the project, there was a General Engineering project which was about 8 weeks with 4 people. 50 dollars was spent and only 5 hours per week was needed to complete the project. The project was to create a musical instrument with different pitches and notes.

5. How often did you record documentation?

Eric: Because of the week to week meetings, there were week to week deliverables. Whatever we were working on got updated on a weekly basis and that was pretty consistent. Then, there was a final drawing or model for the center column and there was a whole semester before you even got that.

Fred: I would say every week. I took notes from meetings and at least once a month I updated a report. Also, I made copies of printouts.

Grace: Just once, to write everything up and turn it in at the end.

Hank: I only recorded information bi-weekly.

Irene: Once a week and it consisted of meeting notes, progress reports, and budgeting.

6. What was prescribed to you of how much documentation to record?

Eric: I don't think we were really required to do any work. I think we were required to do a one page report at the end of the semester. I don't recall having to do anything and we did prepare for the meetings.

Fred: Semester reports, individual project reports, and it could vary as far as time but with occurrence.

Grace: No, just a final report and maybe sometimes a midterm report.

Hank: Just at the initial concept design phase.

Irene: Anything to do with the budget and a weekly progress report was expected.

7. Has there been a team member who took the initiative with creating documentation?

Eric: Irene was the one to write everything down and keep a pretty good record of everything from the meetings.

Fred: Irene and I put together major reports like the design review paper.

Grace: For this project, it would be Irene Sometimes it would be me writing with her but as far as organizing, Irene did all of the organization.

Hank: Irene definitely

Irene: It varied within each subgroup when we split up into different pairings. When there were subgroups, it was either Grace or Fred. When we were at meetings, it was me and for weekly reports, it was Grace.

8. Who was the one to combine sections of the reports for the project?

Eric: Same as Question 7.

Fred: Same as Question 7.

Grace: Same as Question 7.

Hank: It was Gary who combined all of the reports. Irene mainly distributed who did what.

Irene: I was the one to compile reports and Fred helped with the flow and organization. When one report was due, me and Fred stayed up until 5 am the day it was due. Everyone sent their part to me and they were late too.

9. How much did you contribute to reports?

Eric: Usually I contributed drawings, some analysis and things.

Fred: I had the conclusion to the report; me and Irene had the Introduction. I worked on the flow of the paper by taking reports from before and combining them. If it didn't make sense to me, then it won't to anyone else.

Grace: Less than Irene but more than the rest of the group. I think Irene put in about 40%-50%, so I would be at 25%.

Hank: Not a lot, only about 10%.

Irene: The casters portion of the paper, if anything.

10. Who proactively called you to work on MGR objectives?

Eric: Fred and I communicated a lot during the construction of the project. We called each other a lot to put it together. Me, Irene and Grace worked on the design portion

together and we met on a week to week basis. It was about half and half with the year. During the design phase, we would talk 2-3 times a week.

Fred: Irene called me for projects 3 times a week. It was really quick and we mostly talked about the project in general. Eric called me for drawings and specifications around 2 times a week. Calls from Eric lasted around 10-15 minutes at a time.

Grace: Usually it was Irene or Eric was the one who would call me. It would be about organizing people or writing documents. Then, also for technical work as well. They would call me about a couple times a week.

Hank: Nobody really called me. The most communication I saw was in meetings that were every week.

Irene: Fred, Gary, and occasionally Grace. Fred called about 4-5 times a week for 20 minutes each time about the cables, casters, and trough. Gary called once a week for 10 minutes each time about getting updates on how the project is progressing. Grace called biweekly for about 10 minutes each time about the groomer.

11. Who proactively e-mailed you to work on MGR objectives?

Eric: I operated less through email and more through text and calling. Email was rare and it was only for sending documents for reports like CAD drawings.

Fred: Gary contacted me by email to make sure work was getting done. This was once and on a biweekly rate. Eric also contacted me by email about drawings, specifications, and MTS orders three times a week. Then, Irene sent me Word documents for reports about once a week.

Grace: The same people, Irene and Eric for about 2-3 times a week. The papers were done by e-mail but also the design work. This led to e-mails about the construction too.

Hank: Whoever sent mass emails, I think that was Dr. Summers. They were only about once a week and it was about updates on construction. There were also reminders about who was responsible for what at meetings.

Irene: Fred, Gary, and Eric. Fred e-mailed me once a week about ordering information for the cables, casters and trough. Gary e-mailed me once a week about updates. Eric e-mailed me biweekly about ordering information for parts and model numbers.

12. Who proactively texted you to work on MGR objectives?

Eric: Through the beginning of the year, the same people who were texting was 3-4 times a week.

Fred: Gary was the main one to contact me by texting. Texting is the best way to get in contact with me. He just asked quickly if things were done or what was needed for the project. This was for about six times a week. He also verified aspects of papers and made sure equations were correct. Eric texted me about two times a week to see when we were going to be able to work on construction. Irene contacted me about once a week about setting up times to meet.

Grace: Again, it was just Eric and Irene. We definitely texted a lot more than any other type of communication. I would say it was about a dozen times a week.

Hank: Grace texted me about twice per week and that was to remind me of what objectives were due.

Irene: Fred and Gary were the only ones to text me. Fred texted me about 2-3 times a week for a combination of reminders and deadlines. Gary texted me once a week about updates.

13. Who did you call to work on MGR objectives?

Eric: Same as Question 10.

Fred: Same as Question 10.

Grace: Hank and I called him to remind him about the meetings. I would call him about two times a week.

Hank: Nobody.

Irene: The same people from Question 10, Fred, Gary and Grace.

14. Do you think you are a task or interpersonally oriented leader? (Task: Concerned with accomplishing work, Interpersonal: Concerned with building relationships)

Eric: I'm more concerned with accomplishing the task and building the relationships while doing the tasks. I feel that I lean more towards the task edge of the spectrum.

Fred: I would say task oriented. Since I have a busy schedule, certain situations deem it necessary to talk a little. It's mostly because I'm a busy guy.

Grace: Probably task.

Hank: Interpersonal

Irene: Both, I like organization and getting things done but motivation is the key to accomplishing the goal. It depends on the situation of whether to lean on task or interpersonal style.

15. Have you noticed anyone not taking initiative in the group?

Eric: I noticed that Hank didn't take a lot of initiative and I don't think he helped with the construction of it at all. For the design, the work was spread out and you couldn't tell who was doing what. But out of that, he was one that I saw that wasn't doing much.

Fred: Hank For him, it seemed like the project wasn't a priority to him. Last year, he was assigned to figure out the fencing and it didn't get done until I was assigned to do it.

Grace: Yeah, it was mostly Hank. It wasn't a big problem but he was the type where you have to give him a specific task.

Hank: No, I've never felt there was a dire need to get work done but no one was neglecting work either.

Irene: Hank, he showed up at maybe half of the meetings, gave effort when he got a specific task but was inefficient to complete it. It only took Fred one week to complete the fencing where Hank didn't even complete it.

16. Have you seen teammates unmotivated to lead and/or felt that way yourself?

Eric: It wasn't a pressured environment, so that was good to work in but you can also stack. Everyone had classes and that work took precedence over the work in this project. For a lot of teammates, it wasn't necessarily motivation but it could have been

overwhelming for them with classes as well. I would say Hank was unmotivated and that's about it.

Fred: Hank and Grace had a lot of stuff going on too. I noticed three people stepping up more to help move the project forward.

Grace: Hank was not motivated to lead and Fred didn't want to step and lead as well. He was willing to put in the work put when it was time for someone to lead, he stepped back. You could definitely count on him to get tasks done.

Hank: Nope.

Irene: Sometimes I was stressed about classwork or external duties, then motivation decreased and work was pushed to the side. Again, Hank wasn't motivated at all to complete assignments.

17. Was there a clear structure or hierarchy within the group dynamic?

Eric: Initially there wasn't anybody because of David transitioning out and you just joined the group. At the beginning, there wasn't any real leadership. Then, there was Gary, Jeff, and another TA. Then, Gary helped out as a TA, gave support and we could ask questions to him as well. That automatically puts you in the leadership position.

Fred: The top 3 or 4 are clear, which are Dr. Summers, Gary, Jeff, and David was there too. With the group, there was no hierarchy and each brought a certain skill. So it was only a matter of making sure certain people were assigned the right things.

Grace: Not really. I don't think so.

Hank: Yes, there was a structure to the group. Dr. Summers understood the big picture and knew what we needed. Gary broke down the bigger tasks for everyone and delegated work for the team members. Then, everyone else was a part of the team.

Irene: Everyone reports to me. Then Dr. Summers and Gary delegated tasks to the students.

18. Was the construction completed successfully?

Eric: It's done but it wasn't completed on the timeline that was scheduled. I think there were quality checks for parts and construction from MTS. MTS was not able to efficiently complete the task and its like the real world because it's hard to get someone to rework something. You have to work around that and get the project where it needs to be. It was completed but not completed accurately.

Fred: Yes, I think it was and it's built. I felt like it went well. We got stuck in the concepts and the analysis took a long time but it's done.

Grace: I haven't seen it to know whether it was or not.

Hank: Yes it was successful, especially since I didn't think it would be constructed.

Irene: Yes, it runs and hasn't fallen apart or killed anybody.

19. What have you done to help the direction of the group?

Eric: I definitely helped a lot of people with visual design and SolidWorks. I also helped with setting the direction with construction stuff and having experience with doing welding and things like that. I helped with the motivation of getting that started.

Fred: I pushed the project from the conceptual phase to the embodiment and detailed design. When the conceptual was done, I helped others realize it was done. I also applied real-world applications and the PTO shaft is an example, which is used in other applications. I just thought of ideas that have been built and tried to use in our setup.

Grace: I helped with finishing up the final design. I worked a lot on the concept design paper and helping Irene with the weekly reports. I was really swamped in the second half of the project but participated in the construction as much as I could.

Hank: Help with the concepts and elimination of unnecessary ones. Then, picking the best concept to go forth and construct.

Irene: I tried to keep a collection of documents and keep organization of the budget and phone numbers.

20. How much flexibility was involved in making decisions?

Eric: I think there was a lot of flexibility in the project. I don't see anything that was hard to fix initially that could be changed later. But a lot of things were discussed during our meetings where we made primary decisions and then talk about, come back and change it again. I think there was a lot of flexibility, maybe more than what should have been. Maybe it should have been nailed down to three concepts, think about it for a week, come back, pick one and roll with it. So maybe it was too flexible.

Fred: Initially we had quite a bit of flexibility, but it proved that it couldn't happen because everyone was dragging their feet. Dr. Summers put specific deadlines on things

and then got rid of that flexibility to keep the project moving. This is because things kind of fell out for a while. So we took advantage of the flexibility and then put on a timeline.

Grace: The project was really flexible with making decisions. I remember having plenty of conversations about designing the Merry-Go-Round. They were long and mostly because we could do so many things. So it took us a while to make a decision.

Hank: I feel like we did a good little bit. It seemed like every time we had something to do; we asked what we could do in order to get it done. What do you think we should do? Everyone would pitch in with their ideas and we'll pick from them.

Irene: Overall, I think there was a good amount of flexibility because half of the time we didn't know what we needed (like the exact specifications). So it was more or less whatever worked the time.

21. Were you able to innovate on problems and products being investigated?

Eric: Yeah, I thought there were some problems with the motor structure and some conceptual things with the a-arms that were added. The failure of the bearing was another instance.

Fred: I felt like I was able to innovate a little, specifically for the tire and wheel fixture because we were able to use a PTO shaft. This is usually put on a tractor and it's not the first thing that you would think of using.

I would say we were able to innovate on small portions because we really didn't have the big picture in mind for what we wanted to accomplish and how we wanted to do

it. So you can change small portions like the PTO shaft and move the project along a little further. As long as we kept the big picture in mind, we could do so.

Grace: The same as the last question. There was freedom to innovate on the project. Since I was mostly around during the design, there were times we changed before and after the final decisions were made. I didn't see anything afterwards.

Hank: Yeah, I feel like a lot of the time, there was something that needed to be created, then we would come up with ways to do it. So that gave a lot of space for flexibility. We could innovate most of the time, anytime we needed to get the work done.

Irene: If you came up with a solution, it was fairly easy to understand if we were able to go with it. For the group, it was what's the main idea and got feedback so see if we can do it. I felt like I took ownership over a majority of the project. 75-80%. Not sure, but having multiple ideas

22. Did you take ownership and responsibility over the project?

Eric: I think certain aspects of the project. When you spend a lot of time designing something and then you start constructing, you want to make sure your construction of your final product is done. So in design meetings you were handed ownership over certain parts of it. Then you want your design to match your construction. So I took ownership into making sure that the parts I were responsible for matched the designs.

Fred: I definitely feel like I invested time and effort into the project. If that means seeing the project through completion, I would say I did so. Parts and contributions were my own but the project as whole, certainly.

Everyone took ownership of the project, but at varied levels. Everyone had the same invested interest in the project. Hank was the only one not to take real interest in the project and it wasn't that he didn't do what he was asked to do. It's just that his timeline was a lot longer than what the project would allow. Normally, I would help to make sure he was going along with what he was assigned for the project.

Grace: Not really, mostly because of school. I had a major project to take care of and other classes to consider. Since I was graduating, I wanted to finish strong and made sure I was graduating.

Hank: Probably not, because I've never felt that it was my project. I'm just helping out and being a part of it. I feel like the whole thing belonged to the professors. With everyone that I worked with on the papers and the project, I felt that we were all contributing. It wasn't like the 402 project where it was all on us, we don't have the final say on stuff.

Irene: I feel like I gave more effort at the beginning of the project than towards the end.

23. Was there a certain level of performance standard set?

Eric: I think initially, but there may not have been a document outlining a work statement. At work, we always did a proposal and then a work statement. Then as we work, we go off of the work statement and check things off. So I would say that there was not one.

Fred: I would say so. If you look at the people that were a part of our group, Eric was great with SolidWorks and Grace and Irene had experience with engineering calculations.

Then, the design and conceptual ideas is where I was excelling and I was able to excel with practical things. With that I would say that there was definitely a performance standard set for the group. I think initially was high, but then it ended up as a medium because we fell out part of the way through the project.

Grace: In the beginning, definitely no. The initial group was all girls and we got nothing done. I think it was more developed over time. There are probably standards now. When you came in, the roles were defined more and the expectations rose up.

Hank: Yeah, definitely. There were certain constraints and criteria that were set for the project, so as long as we were within that it was fine. They definitely were standards that could be met. Usually Dr. Summers, when we had objectives and tasks set, he made sure that we stayed on task and that everything was correct.

Irene: I think the expected performance effort was to turn in something every week and towards the end of the project the performance went down. Dr. Summers had an expectation to be met and it wasn't in the second half of the year. He has made it clear that improvement needs to be made every week. Everyone put the work on the back burner until the meeting or even not doing the work.

There was a transition between Dr. Summers or Gary leading which caused confusion.

24. Looking back at the school year during the project, were there any occurrences of emotional distress or elation?

Eric: No not that I know of.

Fred: Since last year there is the football season, and that's every weekend. Depending upon my exam schedule, some meetings were more productive than others. Those were some factors that planned out the entire week. Some meetings were 10 to 15 minutes because no one had exams. Getting the trough built up and overseeing the construction, then getting the device running with the first few couple tests. Getting to see the thing to run was a high point, and not seeing it fall over.

Grace: Nope, school is school and nothing big happened outside the group.

Hank: Not really, the only time was when I realized it was a day or so before the meeting and something was due.

Irene: There was some stress with dating Fred towards the beginning of the project. When we broke ties, it became hard to work on the project when it was just Dr. Summers, Gary and three others. After we broken ties, I was only working with 2 people and avoiding Fred.

25. How well did you manage your emotions during last year?

Eric: Yes, I think so. I am able to separate the emotions from school and work.

Fred: I think I managed my emotions pretty well. Emotions don't really affect how I get it done and when I get it done. There are not enough hours in the day and no matter what goes on, I still need to get stuff done. So I can usually set aside the emotional issues and deal with it later. I'm not sure if everyone can do that. I would say overall, emotions were not a huge factor for me not to get work done.

Grace: I managed them well. I didn't have any huge problems last year. I had a big burden with school and that's about it.

Hank: I really didn't have a problem last year emotionally. I'm assuming that everything went good.

Irene: I had a relationship with Fred at the beginning of that year. It affected my motivation to do things for the project. Yeah, there was a time during that stress where I told myself that it's over, I have work to do, and let's move on. I mainly worked with Grace and Eric after that point and working with Fred whenever it was necessary.

26. What was the motivation for you to work on this project?

Eric: Someone asked me to work with the group. I liked the idea of the project, especially from being on the Formula team. I also thought it was great to put on a resume, even though I really didn't need that. It was something to add to my work experience. Mainly, it was the project that I really wanted to work on, not for any other purposes. As a resume filler, it would have been nice but I was already offered a full time position.

Fred: A lot of people think it's an easy grade. I would say it's not as easy as someone would imagine it; there is a lot of work to be done. The specific thing that got me interested in it was the project itself. We were going to design, build, and test something. Doing all of those things and being able to put it on a resume and do a part of a project like that with NASA, it gets people's attention. Even if it's something out of my

curriculum, it's a unique thing that is one my resume. Ultimately, the interest of the project got me through the door but it's a resume builder now.

Grace: At first, it was to get experience because I was entering the last couple years of school. Then, the project kept getting interesting. First, it was the TWEEL and then the design of the Merry-Go-Round was crazy. So, I had to see it finished.

Hank: Initially I join the project because Grace was in the same class as me and she invited me to do it. Then after the first semester, the potential for it to become a technical elective was one thing that I saw as pretty cool. It wasn't the normal classwork or homework and it was out of that realm.

Irene: Originally, it was fun, interesting projects and it was a great way to meet professors with better relationships in the department. It was an extra grade, especially with engineering being hard as it is. It was also the experience of working with a team and being able to walk into an interview and saying that I have worked with teams.

It was great working with Grace, and it was fun to work with her when I had the chance. I never really worked with Eric, and it was fun working with Fred when it was good.

27. Was there any strong indication that someone did or did not know their emotions?

Eric: No, not anyone I can think of.

Fred: No, everyone was cool and knew each other.

Grace: Not really. I saw no problems in anyone.

Hank: No, not really. I got along with everybody pretty well. I feel like the group dynamic was pretty cool. Everyone was so outgoing.

Irene: People made a conscious effort to leave the personal things outside of the meeting.

28. Aside from communication, how were your relationships with others in the group?

Eric: They were all great. I met Fred through the group and hung out with him during working with the group. Most of it was work related but we still hung out. I knew Irene and Grace before the group. I hung out with them before and after.

Fred: We were assigned to work with people. Irene and I worked a lot together on parts of it. Eric and I collaborated on the design aspects. He would draw it up on SolidWorks and I would take it to MTS to see if it could be made. I didn't work a lot with Grace, and I didn't work at all with Hank. Then, I was with Gary and Dr. Summers for various approvals with stuff.

Grace: Relationships were good with everyone. I helped Hank to get on the project and I've known Irene and Eric way before the project began.

Hank: I hung out with Irene more often and especially with working on the project. I never really worked with Eric and he designed a lot of stuff.

Irene: Everything was cool. We worked well together and I go out with Grace all the time outside of the group.

Appendix F: Chapter Five Evaluation Sheets

Each team member in Chapter Five was given an evaluation sheet to complete. They each evaluated the other team members in the group and gave a self-evaluation. The values range from 1 (strongly agree) to 5 (strongly disagree). For laissez-faire leadership, the values will look backwards but it is in response to the meaning of the trait. Laissez-faire leadership is a negative leadership trait which means the leader avoids responsibility and decision making.

The first four leadership traits are transformational (interpersonal), then the next four are transactional (task), and the last five are emotional intelligence traits described in Chapter Two. For each evaluation sheet below, the self-evaluations are highlighted in red font. The averaged values are found within the text in Chapter Five and the evaluation sheets are shown in alphabetical order.

Eric's Evaluation Sheet

	Eric	Fred	Grace	Hank	Irene
Idealized Influence	2	2	2	3	2
Intellectual Stimulation	2	2	1	3	1
Individualized Consideration	2	2	2	4	2
Inspirational Motivation	1	2	2	3	1
Contingent Reward	3	3	3	3	3
MbE Active	1	1	2	3	1
MbE Passive	2	2	2	3	2
Laissez faire	5	4	4	3	4
Self Awareness	2	2	2	2	2
Self Regulation	3	2	2	4	2
Empathy	2	2	1	3	1
Social Skills	1	1	1	3	1
Social Awareness	1	1	1	2	1

Fred's Evaluation Sheet

	Eric	Fred	Grace	Hank	Irene
Idealized Influence	2	2	3	5	2
Intellectual Stimulation	2	2	2	4	2
Individualized Consideration	1	1	3	4	1
Inspirational Motivation	3	3	3	5	3
Contingent Reward	3	3	3	3	3
MbE Active	1	1	2	4	2
MbE Passive	2	2	2	3	1
Laissez faire	4	5	4	1	4
Self Awareness	2	2	2	5	2
Self Regulation	1	1	2	4	1
Empathy	3	4	2	1	2
Social Skills	1	1	1	2	1
Social Awareness	1	1	1	3	1

Grace's Evaluation Sheet

	Eric	Fred	Grace	Hank	Irene
Idealized Influence	2	4	3	4	2
Intellectual Stimulation	5	5	5	5	5
Individualized Consideration	3	4	3	5	3
Inspirational Motivation	1	3	4	5	4
Contingent Reward	3	4	3	5	3
MbE Active	5	5	5	5	5
MbE Passive	5	5	5	5	5
Laissez faire	4	4	3	1	3
Self Awareness	2	3	2	3	2
Self Regulation	3	3	3	4	3
Empathy	3	4	2	3	2
Social Skills	3	4	3	4	3
Social Awareness	3	4	3	3	2

Hank's Evaluation Sheet

	Eric	Fred	Grace	Hank	Irene
Idealized Influence	2	2	1	2	1
Intellectual Stimulation	2	3	2	2	2
Individualized Consideration	3	3	1	2	1
Inspirational Motivation	2	2	2	2	2
Contingent Reward	2	2	2	2	2
MbE Active	3	3	3	3	3
MbE Passive	1	3	2	2	2
Laissez faire	5	4	5	4	4
Self Awareness	1	1	1	1	1
Self Regulation	1	2	1	2	2
Empathy	2	3	1	1	1
Social Skills	1	1	1	1	1
Social Awareness	1	1	1	1	1

Irene's Evaluation Sheet

	Eric	Fred	Grace	Hank	Irene
Idealized Influence	3	4	2	5	1
Intellectual Stimulation	3	4	3	5	3
Individualized Consideration	2	3	3	5	1
Inspirational Motivation	3	3	2	5	2
Contingent Reward	3	4	3	5	3
MbE Active	3	3	3	5	3
MbE Passive	3	2	3	4	3
Laissez faire	2	3	3	1	4
Self Awareness	2	2	2	4	2
Self Regulation	4	2	4	4	3
Empathy	3	3	3	4	2
Social Skills	3	2	2	4	2
Social Awareness	2	2	2	3	2

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