UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

THE INFLUENCE OF ENGINEERING COMPETITION TEAM PARTICIPATION ON COLLEGE STUDENTS' LEADERSHIP DEVELOPMENT

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

Degree of

DOCTOR OF PHILOSOPHY

By

KIMBERLY GRAVES WOLFINBARGER
Norman, Oklahoma
2015

Downloaded from SHAREOK. Persistent Handle URL: https://hdl.handle.net/11244/14594

THE INFLUENCE OF ENGINEERING COMPETITION TEAM PARTICIPATION ON COLLEGE STUDENTS' LEADERSHIP DEVELOPMENT

A DISSERTATION APPROVED FOR THE
SCHOOL OF INDUSTRIAL AND SYSTEMS ENGINEERING

BY

_____
Dr. Randa L. Shehab, Chair

_____
Dr. Janet K. Allen

_____
Dr. Eric A. Day

_____
Dr. Suleyman Karabuk

_____
Dr. Deborah A. Trytten

_____
Dr. Susan E. Walden

© Copyright by KIMBERLY GRAVES WOLFINBARGER 2015
All Rights Reserved.

To my father, Sam Graves, a storyteller among storytellers,

to my mother, Ann Culligan Graves,

who taught me that “normal” is the average of everybody’s differences,

and to Kate, Rob, & Mike Wolfinbarger,

who encouraged me every day.

Acknowledgements

Although only one person will be listed as the author of this work, it does take a village to write a dissertation. I am most grateful to the competition team members who so generously shared their stories with me. My doctoral committee provided excellent critiques. Their challenging questions and attention to detail made this a better book. Dr. Randa Shehab, my advisor and friend, deserves special recognition. Many conclusions were reached as we wrestled with the data over coffee at Michelangelo's.

Robert Hughes and the College of Engineering provided early funding for my doctoral studies through the Hughes Centennial Fellowship. The School of Industrial & Systems Engineering directly funded most of the expenses associated with the research. My employers, the School of Industrial & Systems Engineering and the College of Engineering, have provided substantial financial support throughout graduate school. I especially appreciate Dr. Tom Landers, for showing such confidence in me, and Dr. John Antonio, for allowing me time and space to write during the work day.

Students in the College, particularly the members of the Industrial & Systems Engineering Leadership Program, have helped me put my ideas about leadership into practice. My colleagues make coming to work fun every day, and I have learned much from their wisdom. It is a privilege to be part of the OU Engineering family.

Finally, I would like to thank my own family, who have been a constant source of encouragement. Rob, Kate, and Mike, you have heard me say "Not now, I'm working on the dissertation" for the last time! I love you.

Table of Contents

Acknowledgements iv

List of Tables x

List of Figures xi

Abstract xii

Chapter 1: Introduction, Research Question, and Motivation 1

1.1 An Overview of Collegiate Engineering Competitions 3

1.2 The Formula SAE Collegiate Design Series 5

1.3 The ASCE National Concrete Canoe Competition 6

1.4 Motivation 7

Chapter 2: A Review of the Literature 9

2.1 Leadership Theories: A Brief History 9

2.1.1 Behavioral Theories 11

2.1.2 Contingency Theories 12

2.1.3 Leader-Member Exchange 13

2.1.4 Transformational Leadership 13

2.1.5 Functional Leadership 16

2.1.6 Collectivistic Leadership 17

2.2 Teams, Teamwork, & Team Leadership 21

2.2.1 Social Network Theory 21

2.2.2 Characteristics of Effective Teams 25

2.2.3 Team Leadership Theories 28

2.2.4 Team Leadership Research 36

2.2.5 Shared Leadership in Teams 41

2.3 Models of Leader(ship) Development 44

2.4 Leadership Development in College 53

2.4.1 Predictors of Student Leadership Emergence and Effectiveness 53

2.4.2 Engineering Students' Understanding of Leadership 55

2.4.3 Formal Programs of Leadership Development within Engineering Education 58

2.4.4 Reported Behaviors & Attributes of Project Teams and Team Leaders 60

2.4.5 Observed Behaviors & Attributes of Project Teams and Team Leaders 60

2.5 Engineering Competition Team Participation & Leadership Development 63

2.5.1 Faculty Perceptions of Competition Benefits 63

2.5.2 Student Perceptions of Competition Benefits 64

Chapter 3: Method 66

3.1 An Overview of the Teams 71

3.1.1 The Jets 71

3.1.2 The Sharks 72

3.2 Approach 73

3.2.1 Phase 1: The Team Environment and Social Network Questionnaire 74

3.2.2 Phase 2: The Interview 77

Chapter 4: Questionnaire Results 85

4.1 Participants 85

4.2 Data Reduction and Analysis 86

4.3 Internal Team Environment and Coaching 86

4.4 Social Network Measures: The Jets 88

4.4.1 Team-Level Measures 88

4.4.2 Individual-Level Measures 89

4.5 Social Network Measures: The Sharks 91

4.5.1 Team-Level Measures 91

4.5.2 Individual-Level Measures 92

4.6 Discussion 93

4.6.1 Internal Team Environment 93

4.6.2 Team Social Network Measures 94

4.6.3 Individual Social Network Measures 95

4.6.4 Core-Group Social Network Measures 96

4.6.5 Limitations 100

4.6.6 Conclusion 100

Chapter 5: What Behaviors and Characteristics Do Engineering Competition Team Members Associate with Leadership? 102

5.1 Background 103

5.2 Method 104

5.2.1 Participants 105

5.2.2 The Interview 106

5.2.3 Researcher Bias 107

5.2.4 Trustworthiness 107

5.2.5 Coding 108

5.3 What is Leadership? 109

5.4 What Makes a Leader? 112

5.5 Discussion 127

5.6 Conclusion 131

Chapter 6: The Influence of Engineering Competition Team Participation on Students' Leadership Identity Development 133

6.1 Method 136

6.2 General Findings 138

6.3 Profiles in Leadership Identity Development 142

6.3.1 The Scout 144

6.3.2 The Coordinator 146

6.3.3 The Collaborator 148

6.3.4 The Liaison 150

6.3.5 The Reluctant Leader 154

6.3.6 The Big Man 159

6.4 Discussion 163

6.4.1 Individual Differences 163

6.4.2 Team-Level Differences 167

6.5 Conclusion 173

Chapter 7: Conclusion 175

7.1 Addressing the Research Questions 175

7.2 How Can Institutions Improve the Leadership Development Opportunities for Students via the Engineering Competition Team Experience? 186

7.3 Concluding Remarks 188

References 190

Appendix: Data Collection Instruments 204

Social Network Questionnaire 205

Preliminary Questionnaire for ECT Leadership Interview Participants 208

Interview Protocol A: Returning Members 210

Interview Protocol B: New Members 212

List of Tables

Table 3.1. Statements regarding dimensions of internal team environment and coaching 75

Table 3.2. Teamwork within the engineering competition team 78

Table 3.3. Individual perceptions of leadership and teamwork 79

Table 3.4. Leadership development within the team 79

Table 3.5. Individual contributions to the team 80

Table 4.1. Internal team environment ratings 88

Table 4.2. Team-level social network measures 89

Table 4.3. Jets core group social network measures 91

Table 4.4. Sharks core group social network measures 93

Table 5.1. Definitions of behavioral categories 114

Table 5.2. Behavioral categories and frequency of mentions, by team 115

List of Figures

Figure 2.1.The Team Leadership Cycle 31

Figure 2.2. The Team Leadership Framework 33

Figure 2.3a. The Leadership Identity Development Model, Stages 1–3 48

Figure 2.3b. The Leadership Identity Development Model, Stages 4–6 49

Figure 4.1. Core-group influence sociograms 98

Figure 4.2. Core-group leadership sociograms 98

Figure 6.1. Leadership identity development stages of engineering competition team members 143

Figure 7.1. Core-group influence sociograms (reproduced from Page 98) 180

Figure 7.2. Core-group influence sociograms (reproduced from Page 98) 180

Abstract

Engineering competition teams are promoted as incubators for the development of leadership among college students, yet we know little about how leadership actually develops within the teams. This descriptive, instrumental case study of two engineering competition teams at a public university in the United States explored the influence of team participation on the leadership development of engineering students. The mixed-methods design included questionnaires and semi-structured interviews. During the first phase, members of the teams answered a questionnaire regarding the internal team environment, listed personally influential team members, and rated each listed member on personal influence and the extent to which the team relied on that member for leadership. Following the method of Carson et al. (2007), the social network measure of density was used to evaluate the level of shared leadership within each team. Individual-level social network measures were calculated to estimate the amount and type of influence exercised by individual team members, and to select candidates for the interviews. In the second phase, fourteen team members participated in individual recorded semi-structured interviews exploring the team experience and their own individual leadership development journeys. Interview transcripts were coded using both structured and inductive coding procedures.

Most team members' definitions of leadership aligned with an individualistic, hierarchical view. A few team members' definitions indicated an understanding of the nonpositional and collectivistic aspects of leadership. Further analysis revealed that team members understood leadership from a functional perspective. Team members strongly associated five categories of behavior with leadership: Ideal Behavior,

Individual Consideration, Project Management, Technical Competence, and Communication. Other leadership behaviors, including Collaboration, Training & Mentoring, Problem-Solving, Motivating Others, Delegation, and Boundary-Spanning, were less consistently recognized, and some behaviors were valued more highly within one team than the other. ECT participation helped students further their technical, relational, and project-management skills. The interviews also revealed considerable room for improvement. Team members struggled to manage their projects, failed to document important information, and overemphasized ideal behavior as the key to project success. The team members interviewed exhibited the full range of collegiate leadership identities described by the Leadership Identity Development (LID) model (Komives et al., 2005, 2006). Positional leadership role experience (within ECT or other organizations) did not positively predict a student's level of leadership identity development. Students' leadership development was enhanced through prolonged and immersive participation in the engineering competition team. The degree of leadership development experienced by team members was moderated by project complexity, team culture, and team practices. With one exception, members of the team with the greater leadership density and the more complex project occupied higher stages on the LID model. The complex project provided greater opportunities for team members to collaborate. Although the results show that ECT participation can have a positive contribution on students' leadership development, the benefits should not be assumed. In order to help students develop as leaders, institutions must approach leadership development intentionally.

Chapter 1

Introduction, Research Question, & Motivation

Experiential learning is a key component of modern engineering education. Engineering competition teams are one of the many manifestations of experiential learning. Teams of students, usually undergraduates, design and build a vehicle, structure, robot, or machine and compete with other teams on a regional, national, and sometimes international level. Typically, the teams also raise funds and manage the budget for their project.

The competition team experience is advertised to have many benefits, including the opportunity to develop skills in design, manufacturing, project management, financial management, and teamwork (see, for example, Barry et al., 2013; Hillebrand, 2013). Competition teams are also promoted as incubators for the development of leadership and associated skills (American Society of Civil Engineers, 2013a, 2013b; Wankat, 2005; Sulzbach, 2007), yet we know almost nothing about how leaders and leadership actually develop within these teams.

This project is a case study of the two largest engineering competition teams (ECT) at a large public university in the central United States, conducted during a single competition year (which roughly coincides with the academic year). This study seeks to describe the leadership development at the individual level in order to provide a basis for exploring team-level leadership development. Results from this research may be useful in designing a formal program of leadership training, development, and assessment for competition team members and, by extension, the larger engineering student body.

Colleges offer a variety of competitive and noncompetitive teaming experiences. Although sports teams are the most widely recognized form of intercollegiate competition, opportunities exist for students to compete in a variety of nonathletic venues as well, such as debate, marching band, business-plan development, software hackathons, ballroom dancing, and even *a capella* singing. Noncompetitive teams exist within student organizations, course-related project groups, and peer support and mentoring groups.

Engineering competition teams differ from other collegiate teams in important ways. As a team advisor said, "These competitions are one of the few opportunities for the students to get real hands-on experience constructing something. Being able to conceive, design, fabricate, construct an object, and see it perform in action is an invaluable experience for young engineers" (Wankat, 2005, p. 346). In addition, ECT participants often must raise funds, manage a budget, develop a team work schedule, work with administrators and sponsors to obtain resources, and train less-experienced team members. Few other collegiate competition experiences provide the opportunity to develop such a range of leadership-related skills. For example, athletic teams offer competition and teamwork, but the coaches set the requirements and design most of the strategy, while paid staff handle the logistics and administration. The team captain may assist the coach with "establishing team norms and schedules," but otherwise the captain's role is that of liaison, communicator, motivator, and exemplar (Dupuis, Bloom, Loughead, 2006). Marching band is similar: Section leaders are selected by the band directors primarily on the basis of musicianship and work ethic, and their leadership functions consist primarily of communication and motivation (Dannason, 2007).

Professional and service-oriented student associations provide opportunity for their student leaders to exercise leadership and management functions, but they typically lack the technical challenges that are the hallmark of engineering teams. And while class project teams can address complex technical problems, most lack the inherent motivating factor of a competition. A student who participates in a class project has no choice; students who join competition teams do so voluntarily, often with no tangible reward. The unique nature of engineering competitions makes these teams fruitful ground for the study of student leadership development.

1.1 An Overview of Collegiate Engineering Competitions

Collegiate engineering competitions began after the conclusion of the Second World War. In 1949, students at Purdue University organized an intramural Rube Goldberg competition, in which teams of engineers designed and built complex machines to perform a simple task (Rube Goldberg Inc., 2014). Civil engineering students at the University of Illinois and the University of California, Berkeley, organized the first Concrete Canoe competitions in the 1960s (ASCE, 2014). By the 1970s, professional organizations and corporations had begun to take notice of these competitions. The Society of Automotive Engineers organized the first Mini Baja off-road competition in 1976; this was followed by the Mini-Indy (the precursor of Formula SAE) in 1978. The American Society of Civil Engineers sponsored its first national Concrete Canoe competition in 1988; that same year, Rube Goldberg Inc. established the official National Rube Goldberg Machine Contest. The competition universe grew in the 1990s, with the addition of Design Build Fly (1996), Chem-E Car (1999), and

others. Today there are more than forty collegiate competitions in engineering and related fields (Wankat, 2005).

Although collegiate engineering competitions have existed for almost seven decades, empirical research regarding the competition team experience is limited. The most common theme among the research is perceived benefits of participation [e. g., Wankat, 2005; Barry, Meyer, Arnett, & Spittka, 2013; Sánchez-Alejo et al., 2010]. A few also explore factors associated with success (e. g., Wankat, 2005; Dolan et al., 2011; Zafft, Adams, & Matkin, 2009). The relationship between the culture of engineering teams and the inclusion of underrepresented students has been examined by Trytten, Pan, Foor, Shehab, & Walden (2015), Pan, Shehab, Foor, Trytten, & Walden (2015), Foor, Walden, Trytten, & Shehab (2013a & b), and Walden, Foor, Shehab, & Trytten (2013).

The teams examined for this study participate in national competitions. “The Jets” participate in the Formula SAE Collegiate Design Series, while “The Sharks” participate in the ASCE National Concrete Canoe Competition. The rules governing the competitions vary in complexity and scope. For example, competitions sponsored by the Society of Automotive Engineers require adherence to specific and extensive technical rules but set few restrictions on participation. In contrast, competitions sponsored by the American Society of Civil Engineers have detailed rules regarding team demographics.

1.2 The Formula SAE Collegiate Design Series

The Society of Automotive Engineers sponsors several collegiate engineering vehicle competitions. Students can design, build, and race snowmobiles, electric cars, off-road vehicles, and other machines. The Formula SAE internal-combustion (FSAE) engine competitions in Michigan & Lincoln are the largest: Approximately 3000 students participated in the two competitions in 2013 (SAE, 2014). Competitions are also held in several locations around the world, including Germany, Brazil, Japan, and the United Kingdom. The product is a small racecar similar in style to a Formula One machine. The vehicle is powered by a purchased motorcycle engine; all other vehicle systems are designed and/or built by the student team members. Each competition consists of several events. Teams earn points on the basis of design, the writing and presentation of a technical report, and, of course, race performance. The competitions are not hierarchical; participation in one competition is not dependent on success in previous competitions.

The 2014 Formula SAE rulebook (SAE International, 2014) contains 140 pages of detailed instructions regarding technical requirements, competition administration and judging, safety, vehicle marking, registration, and logistics. Team composition and individual participation requirements are covered in only a few paragraphs. Participants in F-SAE must be undergraduate or graduate students who are currently enrolled in their team's sponsoring university. [Recent graduates may also participate, as long as they were members of the team during the current competition year and the competition occurs within 7 months of graduation.] While most participants do major in engineering, SAE does not require participants to be engineering majors and in fact encourages

teams to recruit students from other fields, particularly business (Gruner, no date). Teams must have a faculty advisor. There are no rules regarding team size, leadership structure, or demographic diversity.

1.3 The ASCE National Concrete Canoe Competition

The American Society of Civil Engineers (ASCE) sponsors the National Concrete Canoe Competition. The competition consists of several events, including a technical paper and presentation, canoe design and display, and races. First-level competitions are held annually during the 18 regional student conferences; the winners of the regional competitions advance to the national competition.

The 2014 National Concrete Canoe Competition rulebook (ASCE, 2013) contains 88 pages of detailed instructions regarding technical requirements, competition administration and judging, safety, vehicle marking, registration, and logistics. ASCE sets specific requirements regarding team size and demographics. While any number of undergraduate and graduate students may participate in the design and construction of the canoe, the writing of the technical paper, and supporting activities, the official "registered team" is limited to ten members. All registered team members must be undergraduates enrolled in an engineering discipline during the competition year. Students cannot participate as a registered member for more than three years. At least 50 percent of the registered team members must be women. Teams must have two registered captains and a faculty advisor. At least one captain must sign the Engineer's Notebook submitted as part of the competition. No other leadership positions or duties are specified.

1.4 Motivation

Great potential exists for researching students' leadership development in a technical domain. Beginning in the late 1990s, researchers noticed that "many of the leadership development programs designed for college students [were] based upon studies and models that were developed with managers in business and public-sector organizations" (Posner, 2004, p. 443). In response, researchers proposed new approaches emphasizing a political or social-change approach to leadership (e. g. Zimmerman-Oster & Burkhardt, 1999; HERI, 1996; Posner, 2004), and this perspective now dominates the field of collegiate student leadership development (Dugan & Komives, 2013). I propose that engineering project teams have more in common with research & development and product-development work teams than with political, social, or charitable student organizations. Social-change approaches to leadership development emphasize several values relevant to the practice of engineering in team settings, such as collaboration, commitment, adaptivity, and concern for others (Dugan & Komives, 2013). However, these approaches sometimes lack a managerial component and emphasize producing "positive social change" (Komives, Wagner, & Associates, 2009, p. xii) rather than bringing a project to completion. Examining engineering students' leadership development solely through the lens of a social-change model may thus fail to identify leadership skills required for successful project execution in an operational engineering setting.

Scholars have recently begun to call for more attention to the levels at which leadership development occurs (Yammarino, Dionne, Chun, & Dansereau, 2005). Most research has focused on the development of leaders at the individual level, and this

study is no exception. This research seeks to explore individual leadership development among college students participating in engineering competition teams. To investigate this phenomenon, three specific questions will be addressed:

1. How do members of student engineering competition teams perceive leadership? What behaviors, skills, and characteristics do they associate with leaders and leadership?
2. How do members of the teams see themselves as leaders?
3. How does the engineering competition team experience contribute to this leader identity development?

Understanding how individual engineering students develop as leaders can provide a foundation for future work exploring the development of team-level leadership as a process within the engineering competition teams.

Chapter 2

A Review of the Literature

Leadership research is a vast field with many theories emanating from, building on, and often conflicting with other theories. Two main philosophical threads run through much of the scholarship from the last 100 years: individualistic, hierarchical leadership and collectivistic, relational leadership. Because so many theories incorporate concepts from earlier approaches, a detailed overview of the field can be helpful; this chapter is written with that purpose in mind. The constructs most important to this project include behavioral theories (Section 2.1.1), functional leadership (2.1.5), collectivistic leadership (2.1.6), social network theory (2.2.1), the Team Leadership Framework (2.2.3), shared leadership (2.2.5), and the Leadership Identity Development model (2.3). The chapter closes with an overview of leadership development in college (Section 2.4) and the limited literature regarding leadership and engineering competition teams (2.5).

2.1 Leadership Theories: A Brief History

The philosophy of leadership has a long history, and the centuries-old ideas of Sun Tzu, Plato, Machiavelli are studied even today. Grint (2011) traces "modern" leadership studies to Victorian England and the writer Thomas Carlyle, who advocated what is now known as the Great Man theory of leadership. In his view, which remained popular until the 1920s, leaders were born, not made. As cultural ideals, leaders were heroic individuals, almost always men, uniquely suited to lead by virtue of their personality, education, skills, or class.

The end of the First World War marked the end of the old imperialist order, and with it died the concept of leadership as a hereditary right. Instead, leadership was viewed "as administrative positions within formal hierarchies" (Grint, 2011, p. 9). Scientific Management held sway during the 1920s, but faith in rational approaches to leadership and management crumbled during the Great Depression and with the rise of fascism. Once again, the pendulum swung. Scholars again advocated a heroic, person-centered view of leadership and began the search for leadership traits.

Although trait theory remains an important concept in leadership studies, scholars eventually became frustrated. No core group of traits was possessed by all leaders, and specific traits did not reliably correlate to organizational performance. Clearly, something was missing. Perhaps the answer lay not in describing who leaders were but instead in investigating what leaders did.

Leadership has been defined in many ways. Dictionary definitions tend to be simple and reflective of Western individualistic, hierarchical values: Leadership is the ability or capacity to direct the activities of a group, or the position that allows one to lead (Webster's, 2010; American Heritage 2013). This view was common until the mid-20th century (Yukl, 2013). Since that time, scholars have defined leadership more broadly and descriptively, as a process of influence (Katz & Kahn, 1978), of sensemaking and motivation (Drath & Paulus, 1994), and of instigating organizational change (Schein, 1992). For the purposes of this research, leadership is considered to be a socially constructed influence process of goal-directed activities conducted by one or more people within a particular context (Collinson, 2011). As we will see, the evolution

of thought from the individualistic to the process-oriented perspective has been long and sometimes controversial.

2.1.1 Behavioral Theories

Behavioral approaches to leadership began in the early 1940s and gained steam following the close of World War II. Researchers at Michigan, Ohio State, and other universities began to examine the actions of leaders and managers. A number of influential theories were proposed. Researchers at Ohio State divided leadership behaviors into two categories, Consideration and Initiating Structure. According to Judge, Piccolo, & Ilies (2004, p. 36),

> Consideration is the degree to which a leader shows concern and respect for followers, looks out for their welfare, and expresses appreciation and support (Bass, 1990). Initiating Structure is the degree to which a leader defines and organizes his role and the roles of followers, is oriented toward goal attainment, and establishes well-defined patterns and channels of communication (Fleishman, 1973).

Other scholars picked up the thread, and the division of leader behaviors into "task-focused" and "person-focused" categories became an element of many approaches. Likert (1961), for example, classified leader behaviors as production-centered or employee-centered (Judge et al., 2004). Fleishman and colleagues (1991) detailed over 60 classifications of leadership behavior published between 1944 and 1986 and found that similar dimensions were included in "nearly every classification system" (p. 253). *Task-focused leadership behaviors* include actions such as establishing an operating structure, setting a schedule, communicating task-related information to subordinates, and boundary-spanning activities such as communicating

with external stakeholders and securing funding. *Person-focused leadership behaviors* include motivation, empowerment, support of individual team members, and other actions that enhance the internal social environment of the team (Carson et al., 2007).

2.1.2 Contingency Theories

The study of leader behaviors soon led to another question: Do different situations demand different behaviors? A number of contingency theories addressing this question were proposed, including Path–Goal Theory, Contingency Theory, and Situational Leadership Theory. Although they vary in their details, contingency theories invariably assume "that the 'correct' response is determined by the 'correct' analysis of the situation" (Grint, 2011, p. 9). Followers move through defined developmental stages, and leaders should adjust their approach to followers' needs at each stage (Collinson, 2011).

Despite the inherent attractiveness of this concept, most contingency theories have little or moderate empirical support and can be difficult to apply. The quest to develop a coherent set of rules encompassing all leadership situations and all people fell short. As Yukl (2013) explains, "Most contingency theories do not provide sufficient guidance in the form of general principles to help managers recognize the underlying leadership requirements" (p. 182).

Despite the limitations of the early trait, behavioral, and contingent theories, important concepts were being proposed and explored. Some traits, such as intelligence, need for power, conscientiousness, and agreeableness, were positively associated with effective leadership (Antonakis, 2011). Leader behavior mattered, and certain behaviors

were more effective than others. Effective leaders paid attention to personal relationships, task requirements, and changing situations, and they used knowledge and experience to choose appropriate strategies.

2.1.3 Leader-Member Exchange

In the late 1960s, leadership research began again to shift, this time from a leader-centric focus to an emphasis on relationships. Leader-Member Exchange (LMX) Theory, the most prominent of these new relational approaches, "is rooted in the principle that each leader–follower relationship within a work group is unique, varies in quality, and should be studied as a dyad" (Anand, Hu, Liden, & Vidyarthi, 2011, p. 311). High-quality relationships "are characterized by mutual influence, negotiability, trust, and respect," while low-quality relationships "tend to be transactional" (p. 312). Unlike older theories, which generally ignore the influence of followers on leaders, LMX contends that leaders and subordinates "mutually define the subordinate's role" (Yukl, 2013, p. 228). However, exchange theories pay little consideration to organizational context and do not address the leader's role in fostering effective relationships and processes among followers (Collinson, 2011; Zaccaro, Rittman, & Marks, 2001).

2.1.4 Transformational Leadership

The concept of transformational leadership emerged during the 1970s. Burns (1978) proposed that leaders could be grouped into two types: transactional and transformational. "Transformational leadership is fundamentally directed at aligning the motive states of individual members with the purpose of the team as a whole" (Zaccaro,

Rittman, & Marks, 2001, p. 469). In contrast, transactional leaders are more focused on exchanges between leaders and followers: you do this, and I'll do that; or, you do this, and you will receive that reward. In general, the transactional–transformational distinction mirrored the earlier task-focused and person-focused behavioral divisions.

Bass (1985) refined and popularized this approach. His Full Range Leadership (FRL) Model recognizes three categories of transactional behaviors and four categories of transformational behaviors. The final category, laissez-faire leadership, recognizes situations in which leadership is absent (Díaz-Sáenz, 2011).

Transactional behaviors include contingent reward, management by exception–active, and management by exception–passive. Leaders exercise contingent reward behaviors both through material means, such as performance bonuses, and through relational means, such as complimenting an employee on a job well done. "Management by Exception" (MBE) refers to actions taken by a leader in response to a problem. A leader who monitors a situation and provides corrective feedback before serious damage occurs is exercising active MBE. A leader who corrects an employee only when something bad happens is exercising passive MBE.

Transformational behaviors include idealized influence, inspirational motivation, individual consideration, and intellectual stimulation. A leader exercises idealized influence by behaving as "a role model that followers want to identify with and emulate" (Díaz-Sáenz, 2011, p. 300). Followers may attribute "extraordinary capabilities" to the leader, such as courage, brilliance, or self-sacrifice. A leader provides inspirational motivation by articulating a vision, showing a path to accomplish the vision, and expressing confidence in followers' capabilities. A leader expresses individual

consideration by treating "each follower as an individual," showing concern for their needs and helping them grow. And a leader provides intellectual stimulation by encouraging followers to actively participate in problem-solving, to question paradigms and assumptions, and to approach problems creatively.

While Bass contended that both styles can be effective, and that leaders often use a mix of the two approaches, he clearly believed that transformational leadership was superior:

> Transformational leaders are those who stimulate and inspire followers to both achieve extraordinary outcomes and, in the process, develop their own leadership capacity. Transformational leaders help followers grow and develop into leaders… (Bass & Riggio, 2006, p. 3).

The FRL has proved to be an extremely popular and persistent theory of leadership (Díaz-Sáenz, 2011), perhaps because it incorporates concepts from a range of theories proposed over several decades. "Idealized Influence" and "Inspirational Motivation" reflect the Great Man and trait theories of leadership; Individual Consideration is taken almost directly from the Ohio State model; and many task-oriented leader behaviors can be subsumed under the transactional categories. Yet despite its name, the Full Range Leadership Model does not incorporate the full range of leadership attributes or behaviors. True to the zeitgeist of the 1980s, it separates leadership from management (Díaz-Sáenz, 2011), positioning "transformational leadership" as superior to transactional leadership's mundane task-oriented accomplishments (Spector, 2014). It makes no mention of the other pillar of leadership identified by the Ohio State researchers, initiating structure. And, like many other 20th-

century conceptions, it is strongly leader-centric, suggesting that if a leader does the right things, followers will respond (Spector, 2014).

2.1.5 Functional Leadership

During the height of the transformational leadership movement, other scholars were returning to a simpler and more practical view of leadership. Mary Parker Follett (1928/1970) was probably the originator of the term "functional leadership," which she saw as leadership "adhering in the job and not in the person" (p. 147). Hackman & Walton (1986) revived McGrath's expanded definition of functional leadership, in which "the leader's main job is to do, or get done, whatever is not being handled for group needs" (McGrath, 1962, p. 3). Fleishman and colleagues suggested that leadership theories were cumbersome and incomplete because they tried to encompass all types of leadership domains (Fleishman, Mumford, Zaccaro, Levin, Korotkin, & Hein, 1991). They chose to narrow the field of inquiry by revisiting the behavioral theories as they applied to organizational leadership. By analyzing 65 leader behavior classification schemes developed between 1944 and 1986, they determined that organizational leadership behaviors could be grouped into four functional dimensions: Information Search & Structure, Information Use in Problem Solving, Management of Personnel Resources, and Management of Material Resources (pp. 260–261). Information Search & Structure included three categories: acquiring information, organizing and evaluating information, and feedback and control. Information Use In Problem Solving included identifying needs and requirements, planning and coordinating, and communicating information. Managing Personnel Resources included

obtaining and allocating, developing, motivating, and utilizing and monitoring people and their actions. Categories under Managing Material Resources included obtaining and allocating, maintaining, and utilizing and monitoring material resources.

A careful study reveals that Fleishman's Functional Organizational Leadership model shares several commonalities with the Full Range Leadership model. Certain behaviors associated with contingent reward, individual consideration and inspirational motivation, for example, are included in the category of managing personnel resources; elements of intellectual stimulation can be found within information use in problem solving and managing personnel resources. On the other hand, there are also marked differences. The functional model details management-oriented activities much more thoroughly than the Full-Range model, and it makes no mention of the leader as an ideal or role model.

The Functional Organizational Leadership Model, while not as well known as Transformational Leadership theory, proved influential and formed the basis for later models, including the Team Leadership Framework (Burke et al., 2006) and the Functional Team Leadership Model (Morgeson et al., 2010), which will be discussed shortly.

2.1.6 Collectivistic Leadership

As we have seen, most 20th century scholars viewed leadership within a command-and-control structure (Pearce & Conger, 2003). Leaders operated as individuals with a defined role and scope of influence and responsibility. Leaders led, followers followed, and followers gave input only when their input was requested.

Despite the prevailing philosophies, an undercurrent of other perspectives also ran through the twentieth century. Two important developments included the concept of collectivistic leadership and the complementary idea of leadership as process. These philosophies began to garner attention during latter part of the century, but their roots reached much earlier.

Mary Parker Follett (1924, 1928) is generally considered to be the earliest advocate of a collectivistic view of leadership (Pearce & Conger, 2003). Writing in the 1920s, between the triumph of the Bolsheviks in Russia and the collapse of Wall Street at the end of the decade, Parker promoted the radical idea that both workers and management had a vested interest in a company's well-being. Her "Law of the Situation" stated that people should follow the most knowledgeable person in a given situation, not necessarily the person with the most authority. Rather than seeing managers as having power over workers, she wrote of workers and managers having "power with" each other to achieve organizational success (Fletcher & Käufer, 2003). Leadership was a result of people working together (Sergi, Denis, & Langley, 2012). Follett's ideas were lauded by some but rejected by others; within the economic and political environment of the Great Depression and World War II, most people assumed that labor and management would always have "conflicting goals" (Pearce & Conger, 2003, p. 6).

During the decades following the war, a few scholars ventured into the waters of collectivistic leadership. Gibb (1954) called leadership a "group phenomenon" and said it was defined by what people did, not by their personality. Hodgson, Levinson, & Zaleznik (1965) studied a group of three co-leaders in a hospital. While each leader possessed distinct areas of expertise and had different functions, these individual

contributions were complementary and provided the full set of competencies necessary for successful leadership of their organization (Sergi, Denis, & Langley, 2012). Bowers and Seashore (1966) studied people working in insurance offices and concluded that "leadership influence process could come from peers" (Pearce & Conger, p. 7). Mutual leadership, as they called it, provided a positive benefit to companies. Katz & Kahn (1978) examined teams and influence relationships in organizations and came to a similar conclusion: "Those organizations in which influential acts are widely shared are most effective" (p. 332).

The 1990s and early 2000s saw an explosion of interest in collectivistic leadership, as researchers realized that individualistic theories of leadership could not be neatly applied to all settings. In action teams, such as expert surgical teams and small military units, multiple people assume various leadership functions during a course of action (Edmondson, 2003). W. L. Gore & Associates, a firm with over 8,000 employees, had a long history of successful operation in the absence of formal authority structures (Manz, Shipper, & Stewart, 2009). And in global politics, movements such as al-Qaida defied description by established leadership theories (Uhl-Bien, Marion, & McKelvey, 2007). Clearly, theory was not keeping up with reality.

Collectivistic leadership frameworks vary in approach and focus, yet they have a common theme. Yammarino, Salas, Serban, Shirreffs, and Shuffler (2012) explain that collectivistic leadership "involves multiple individuals assuming (and perhaps divesting themselves) of leadership roles over time in both formal and informal relationships" (p. 382). Major streams of thought include shared leadership, pooled leadership, distributed leadership, relational or interactional leadership, team leadership, network leadership,

complexity leadership, and collective leadership (Yammarino et al., 2012; Denis, Langley, & Sergi, 2012). Unfortunately, the definitions of the terms are not always unique; sometimes the same name is used for two different approaches. For simplicity, I will use the terms as defined in the recent review article by Yammarino and colleagues (2012). As they observed,

> "In today's organizations… the pace of technological change, increased complexity, competitive demands, challenging economics, and risks involved in decision-making have made it difficult for one individual acting alone, or even with limited interactions in formal units, to exert and display effective leadership… broader based and more comprehensive leadership approaches… that involve more extensive multi-person interactions are imperative (p. 384)."

Collectivistic leadership approaches often consider leadership as a process produced by interactions between people, rather than as simply a set of characteristics and behaviors possessed by individuals (Gronn, 2002). While a few models go so far as to discount the individual component entirely (see, for example, Crevani, Lindgren, & Packendorff, 2010), others acknowledge the contributions of individuals, consider individual differences, and allow for the incorporation of hierarchical structures (Denis et al., 2012). It is important to note that collectivistic leadership does not imply communism or anarchy. While some collectively led organizations lack an established hierarchy (e. g., the Orpheus Symphony cited by Hackman, 2002), collectivistic leadership can also emerge in organizations with official leadership structures (Pearce & Sims, 2002).

2.2 Teams, Teamwork, & Team Leadership

Leadership does not develop independently of context (Day, 2011). A leader must have a group to lead, and that group is commonly called a team. Teams have various manifestations—sports teams, small combat units, and workplace teams are a few examples. In the context of engineering competitions, a team is appropriately defined as "a distinguishable set of two or more people who interact, dynamically, interdependently, and adaptively toward a common and valued goal/object/mission, who have been assigned specific roles or functions to perform, and who have a limited life-span of membership" (Salas, Dickinson, Converse, & Tannenbaum, 1992, p. 4).

Teams are a specific form of a more general phenomenon, the social network. "Social networks are created from any collection of connections among a group of people" (Hansen, Shneiderman, & Smith, 2011, p. 4). Social networks can encompass vast numbers of people, such as the citizenship of a country, or they can be quite small, such as an immediate family. The context of the inquiry defines the boundaries of a social network. Because social networking theory is incorporated into some conceptions of collectivistic leadership, a brief overview of the major concepts will be helpful.

2.2.1 Social Network Theory

In social network theory, each individual is a member of a network. Social network theory is an application of general network theory. In the context of this research, the team is the network of interest, the team members are the nodes, and the relationships between the team members are the paths (Mayo, Meindl, & Pastor, 2003). The network can be evaluated at the individual level and at the network level.

Individual-level measures are used to evaluate an individual's importance within the network, while network-level measures provide an aggregated view of the individual social dynamics and connections within the group of interest.

A number of methods for measuring an individual's connections within the network exist. For example, Individuals can be evaluated in terms of popularity, power, prestige, influence, gatekeeping, and boundary-spanning. Individual-level metrics relevant to this research include degree centrality, betweenness centrality, closeness centrality, and eigenvector centrality. *Degree centrality* is a measure of an individual's connections within a group. Broadly speaking, degree centrality is a measure of popularity (Hansen, Shneiderman, & Smith, 2011). Degree centrality is computed by dividing the individual's degree, or number of connections, by n–1, with n being the number of people in the group. It can be an undirected measure, simply indicating a relationship between two people (as in, Erica is friends with Jeff), or it can be a directed measure (as in, Erica influences Jeff). When directed, degree centrality can be expressed in terms of *indegree* or *outdegree*. A person with high indegree centrality influences many other members, while a person with high outdegree centrality is influenced by many others.

Betweenness centrality is variously described as a measure of power, influence, or boundary-spanning (the connection of one network or subnetwork with another). According to Hansen and colleagues, betweenness is a "bridge score, a measure of how much removing a person would disrupt the connections between other people in the network" (p. 72). A high score "indicates that a person mediates relationships of a great number of actors" in the group (Mayo et al., 2003, p. 196). People with high

betweenness are often boundary spanners; they connect subgroups within a network. Mathematically, betweenness is the "frequency with which a point falls between pairs of other points on the shortest… paths connecting them" (Freeman, 1979, p. 221). Computing betweenness becomes increasingly complicated as the number of connections increases; for a thorough discussion, see Freeman (1979).

Closeness centrality measures "ease of access to others" (Mayo et al., 2003, p. 196) and is based on "the average distance between a vertex [or individual] and every other vertex in the network" (Hansen et al., 2011, p. 41). If a subset of people in the group contains members who are close to each other, this subset constitutes the group's center, or core. A low score means that a person is close to the most other people in the network. For ease of comparison with other centrality measures, the closeness inverse is often used, such that a high score indicates proximity to the core group. Wasserman & Faust (1994) give this general formula (p. 184):

$$C_C(n_i) = \left[\sum_{j=1}^{g} d(n_i, n_j)\right]^{-1}$$

Where C_C is closeness and $d(n_i, n_j)$ is the distance between actors *i* and *j*.

Eigenvector centrality is an indicator of influence and strategic connectivity. "A person with few connections [can] have a very high eigenvector centrality if those few connections [are] themselves very well connected" (Hansen et al., 2011, p. 41). For example, assume that Monique and Erica both work for the same company. Monique is the training manager and knows many people at the entry level of the organization. Erica is the assistant to the comptroller, who works closely with the CEO. Although Erica knows far fewer people within the company than Monique, Erica's close

association with the CEO means that she has the higher eigenvector centrality. "Unlike degree, which weights every contact equally, the eigenvector weights contacts according to their centralities. Eigenvector centrality can also be seen as a weighted sum of not only direct connections but indirect connections of every length" (Bonacich, 2007, p. 555). Eigenvector centrality can be computed by the following formula,

$$Ax = \lambda x, \qquad \lambda x_i = \sum_{j=1}^{n} a_{ij}\, x_j, i = 1, \ldots, n$$

in which *A* is the adjacency matrix for the graph representing the network, *i* and *j* are vertices (or nodes) on the graph, "λ is the largest eigenvalue of *A* and *n* is the number of vertices" (Bonacich, 2007, p. 556).

Individual actors are not the only items of interest in a social network. Network-level measures can be used to evaluate patterns of connections with a network (in the context of this research, the team). Common network-level measures include density and network centralization. *Density (D)* is "the number of influence relationships in the team divided by the number of all possible relationships" (Gockel & Wirth, 2010, p. 174).

$$D = \frac{ties}{n(n-1)}$$

If the strength of the relationship is of interest, then weighted densities can be used in the calculation.

Network centralization measures the variability of individual centralities within the network (Wasserman & Faust, 1994). It shows whether most relationships in a group are symmetrical, or whether certain individuals are much more influential than

others. Network centralization ranges from 0 to 1, with 0 indicating an even distribution of influence and 1 indicating that influence is concentrated in a single member. The formula is given by

$$C_X = \frac{\sum_{i=1}^{n}[maxC_X(p) - C_X(p_i)]}{\max \sum_{i=1}^{n}[maxC_X(p) - C_X(p_i)]}$$

As Gockel and Wirth (2010) explain (p. 174):

> First, each team member's individual indegree centrality, $C_X(p)$, is computed. Second, each team member's individual indegree centrality is subtracted from the highest indegree centrality in the team. Third, these numbers are… added… to get the numerator. Fourth, for the denominator one uses the highest possible value in a team of the same size. This number can be found when imagining that only one member influences all other members in the team and does not receive any influence in turn.

In the context of leadership, low centralization can suggest that all members participate and influence each other at a high level. But low centralization can also occur when members are disengaged and generally ignore each other, so results must be interpreted in context.

2.2.2 Characteristics of Effective Teams

Teams research is broad. For this study, I chose to examine the research related to work teams. Work teams are groups of people who are responsible for executing specific tasks and accomplishing specific goals, often in a professional context. Work teams can take many forms, including self-managing teams, action teams, product design teams, and research & development teams. Self-managing teams are those that are part of an organizational hierarchy but manage their own operations, sometimes with only limited direction from their manager (Hackman, 2002). They typically

operate on short- or medium-range task cycles. The crew of a commercial airliner is one example of a self-managing team. Action teams are "teams in which members with specialized skills must improvise and coordinate their actions in intense, unpredictable ways" (Edmondson, 2003, p. 1421). Surgical teams, sports teams, and Navy SEAL teams are examples. Each member of an action team possesses a high level of skill and serves as a specialist. Real-time communication and coordination of effort are essential for success (Kozlowski, Gully, McHugh, Salas, E., & Cannon-Bowers, 1996a). Product design and research and development teams operate within a longer time frame and often have considerable latitude to create and explore. The chief difference between these team types lies in their goals. A product design team must, in the end, have developed a working product. A research team may not have such a concrete deliverable. Although these types of teams differ in their in goals, cycles, and contexts, the characteristics of effective work teams cut across the categories.

Day and colleagues (2004) defined teamwork as "a set of interrelated and flexible cognitions, behaviors, and attitudes that are used to achieve desired mutual goals" (p. 863). Team performance is often taken as an indicator of teamwork effectiveness. But before a team can perform well, certain conditions must be present. Hackman (2002) contended that true teams must meet five conditions for team effectiveness: The team must be *real*; that is, team members must work interdependently toward a common goal. The team must have a *compelling direction*. An *enabling team structure* must exist. The team must operate within a *supportive organizational context*, and the team must receive *expert coaching*.

Salas, Sims, & Burke (2005) proposed that effective teams exhibit five characteristics. Team members engage in *mutual performance monitoring* by staying aware of the actions of other team members. They exercise *backup behaviors,* sharing the load when their comrades need help. Team members are *adaptable*, able to respond and adjust appropriately to unexpected events. Leaders, whether formally designated or emergent, practice *active leadership* by promoting shared mental models and creating a supportive climate. Finally, members of effective teams exhibit a *team orientation*, also called collective orientation. They identify as members of the team and seek the good of the team rather than pursuing their own agendas.

Day, Gronn, & Salas (2004) detailed other characteristics of effective teams that underpin the five characteristics proposed by Salas et al. (2005): psychological safety, moderate demographic heterogeneity, collective identity, and learning orientation. *Psychological safety* is critical for effective teamwork: Members must feel comfortable expressing ideas, especially when they disagree, and the team should discuss mistakes without threatening punishment. A moderate degree of demographic heterogeneity promotes team learning. If team members all come from similar backgrounds, new perspectives and methods may have trouble gaining acceptance. If team members' backgrounds are highly disparate, the team may never become comfortable enough to work effectively together. Team members also must think of the team first, rather than concentrating on their individual concerns. A team's *collective identity* can be enhanced by carefully considering diversity in experience, skills, and demographic makeup of the team. If subgroups within the team are too strong or too weak, performance can suffer. And while effective performance is important, teams should not emphasize performance

over learning. Team members with a *learning orientation* (as opposed to a performance orientation) are better at assessing and learning from both mistakes and accomplishments.

2.2.3 Team Leadership Theories

Team leadership researchers have argued that traditional leadership models do not accurately describe the development or the execution of leadership within teams (Zaccaro, Rittman, & Marks, 2001). By focusing on individual leaders, earlier scholarship discounted the role of cooperation, collaboration, and shared cognition that necessarily develops within effective teams.

The functional approach to leadership, however, did provide a good basis for extension to the team context. Several team leadership models, including the Team Leadership Framework (Burke et al., 2006), the Team Effectiveness Model (Zaccaro et al., 2001), and Functional Team Leadership (Morgeson, DeRue, & Karam, 2010), were developed by combining teamwork models with the four functions of leadership articulated by Fleishman and colleagues (1991). Hackman (2002) and Kozlowski and colleagues (1996a) also took a functional approach in their descriptions of effective team leader behaviors.

The Dynamic Theory of Team Leadership. Kozlowski and colleagues (Kozlowski et al., 1996a; Kozlowski, Gully, Salas, & Cannon-Bowers, 1996b) proposed a model for leader behaviors over the developmental cycle of teams. Although their model considered action teams specifically and assumed the existence of an expert team leader in a "formally designated" role (p. 259), some of their observations and

suggestions apply to other types of teams. Teams progress through stages, and each stage requires different actions and input from both the leader and team members. In the New Team stage, the objective is team formation. Most of the emphasis is on social aspects of the team–integrating new members, building relationships, and developing a cohesive understanding of the team's mission. In the Novice Teams stage, the building of technical skills and task-relevant knowledge are emphasized. Early in the team formation process, the leader should "discuss goals and objectives," explain the team's structure, behavioral expectations, and rules; "define performance standards;" facilitate an inclusive environment, especially with respect to new members; and provide opportunities for social interaction (Kozlowski et al., 1996b, pp. 266-267). During Stage 2, the leader should teach new technical skills, share information proactively, and ensure that new team members have opportunities to work on skill-building tasks and receive constructive feedback. Stages 3 and 4 are the Expert Team stages. Essential teamwork skills, such as coordination, mutual performance monitoring, and error detection, develop during Stage 3 (Salas, Sims, & Burke, 2005). At this stage the leader should ensure that the team's work process and mental model are consistent with the goal. Stage 4 action teams are capable of performing in a highly complex, rapidly changing environment. Situation assessment is critical at this stage. The leader is responsible for keeping the team apprised of the overall situation and "aiding situational assessment" (p. 262) by the team members themselves. If something goes wrong, the leader must also be ready to help the team recover so that the mission can be completed. Kozlowski and colleagues (1996b) note that no team is in high-demand mode all the time. During less demanding periods, time for reflection, learning, and planning should

be intentionally set aside. The hours immediately following a period of intense performance are especially fruitful for reflection. Such reflection helps the team learn and sets the stage for improved performance during the next action period.

The Team Leadership Cycle. Although Kozlowski and colleagues discussed leadership of teams, they focused on individual leaders. In contrast, Day, Gronn, and Salas (2004) proposed a framework for describing team-level leadership development: the Team Leadership Cycle (Figure 2.1). They maintained that leadership can develop as team members work together, whether or not a formal leader is present. Within the traditional perspective, a leaderless team will not remain that way for long. One or two people will emerge as leaders, and the leader-follower relationship will develop. Day and colleagues asserted that leadership development can take a different form, one of shared leadership, in which "all team members participate in the leadership process" (p. 859). Following the functional paradigm, these theorists maintain that promoting psychological safety, collective identity, and an emphasis on learning are all functions of team leadership. When this occurs, leadership is both an input—team members contribute their abilities—and an output of the process. The action of working toward a common goal can itself build the leadership capacity of a team. In the Team Leadership Cycle, each member brings to the team certain knowledge, skills, and abilities (KSAs). Members apply their KSAs to teamwork. By working together, the team learns, and through this process team leadership capacity develops. As a result, each team member continues to develop his or her own leadership KSAs.

Day and colleagues (2004) also noted that teams face both technical challenges and adaptive challenges—novel problems that are often difficult to solve. Because the

team may have "no preexisting resources, remedies, tools, [or] solutions" (p. 872). To address them, considerable leadership resources are required. Effective teams address adaptive challenges together, rather than waiting for the nominal leader to provide a solution. Team leadership capacity development is affected by moderators, including interventions and defined hierarchies. Formal interventions, such as teamwork training or coaching by an external advisor, can change the way a team works together. If the team has a formal leader, the leader's knowledge, skills, and abilities with regard to leadership will also have a moderating influence.

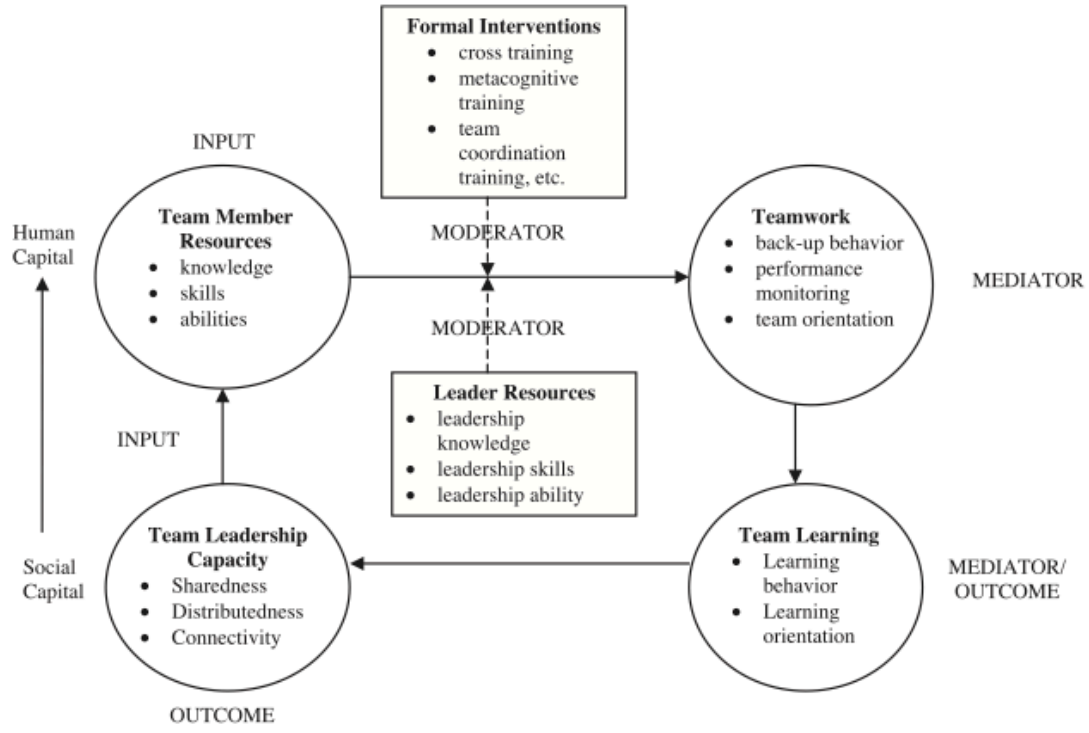


Figure 2.1. The Team Leadership Cycle (Day et al., 2004, p. 862).

The Team Leadership Framework. Burke and colleagues (2006) combined the Team Leadership Cycle with Hackman's conditions for team effectiveness (see Section 2.2) and Fleishman's Functional Organizational Leadership model (Section 2.1.5) to

build the Team Leadership Framework (Figure 2.2). Their meta-analysis sought to describe how a team works together to accomplish its goals, and the role of leadership in this process.

Leadership behaviors form the base level of the Team Leadership Framework. Specific behaviors are classified as task-focused or person-focused, and the authors contend that successful teams must be good at both. Task-focused behaviors include actions such as establishing an operating structure, setting a schedule, and communicating with external stakeholders. Transactional leadership behaviors are always task-focused. Person-focused behaviors include transformational leadership behaviors such as motivation, empowerment, support of individual team members, and other actions that enhance the internal social environment of the team (Carson et al., 2007).

Hackman's Five Conditions for team effectiveness form the second level of the model. Within the TLF, specific leadership behaviors correspond with each of these conditions, and behaviors can support more than one condition. For example, considering individual team members' needs is a component of expert coaching. Initiating structure can promote three of Hackman's conditions: compelling direction, enabling structure, and expert coaching.

In turn, the conditions of team effectiveness correspond to the leadership functions identified by Fleishman, which constitute the third level of the TLF. To continue the previous example, expert coaching, enabling structure, and compelling direction are all part of the Managing Personnel Resources function.

The behavior structure is then overlaid with Day's Team Leadership Cycle

(Figure 2.1) to demonstrate that the management of personnel and material resources directly influences a team's performance outcomes. As the team works together, the team learns and increases its capacity for teamwork and leadership. The team improves its ability to search and structure information and then to apply that information to solving problems. As the team builds a knowledge base and improves its ability to problem-solve, it improves its capacity to manage resources, continuing the cycle. Throughout this process, the team becomes more able to solve unanticipated problems that inevitably arise (Day et al., 2004).

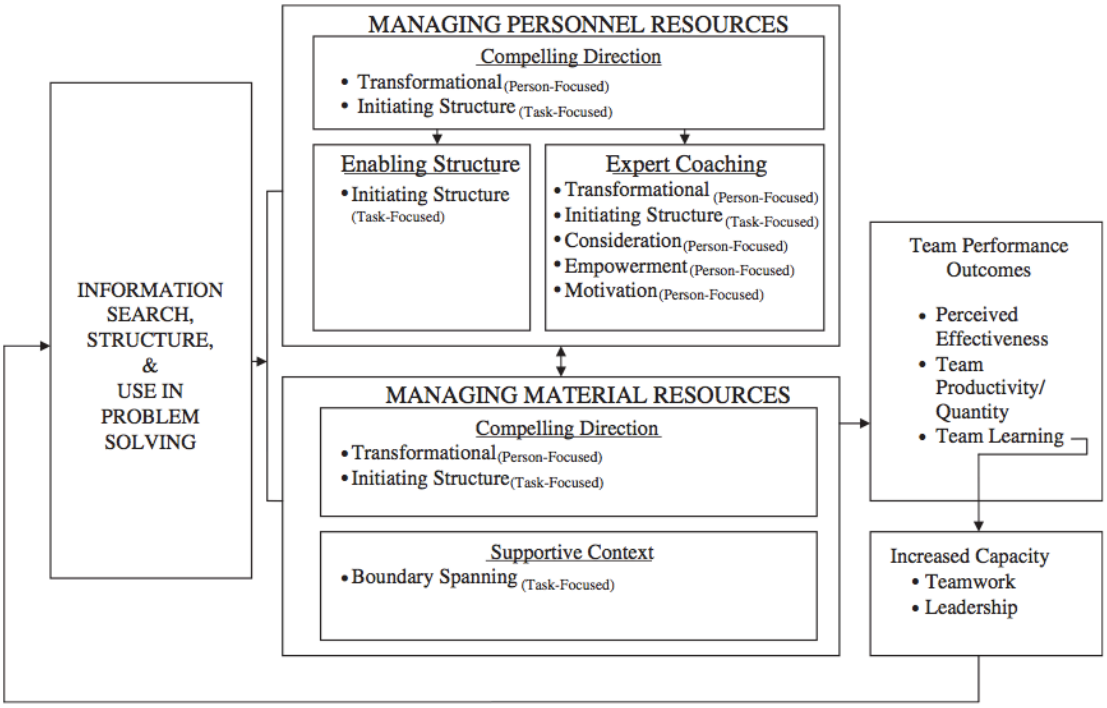


Figure 2.2. The Team Leadership Framework (Burke et al., 2006, p. 290).

The Team Effectiveness Model: The Team Effectiveness Model (Zaccaro et al., 2004) also adopts a functional approach to the examination of team leadership and incorporates the concept of team processes. The model applies to "action, performing, and production work teams" with a specified leader in a hierarchical structure.

Rejecting a situational approach, the authors assert that their "generic leadership functions and… propositions apply generally across different team tasks" (p. 453).

The Team Effectiveness Model rests on a general and fairly recent definition of leadership—that of leadership as "social problem solving" (p. 454). The model avoids a prescriptive approach to leader behavior, instead assuming that "any behavior pattern that reflects effective goal-directed action by [the leader] would constitute leadership" (p. 454).

In this model, team processes are categorized as cognitive, motivational, affective, or coordination. *Team cognitive processes* include shared mental models for strategies and performance, information processing, and metacognition (an understanding of how the team thinks as a group). The leader affects team cognitive processes by activities such as interpreting situations and information, planning, motivating team members, and encouraging post-action analyses of team performance. *Team motivational processes* include task cohesion and collective efficacy. Leadership processes affecting the motivational category include several of the same processes useful for promoting team cognition, with the addition of setting goals, performing real-time feedback, and coordinating performance strategies. *Team affective processes* include those related to conflict management and the regulation of emotion. Leaders can improve team processes in this arena by modeling appropriate behavior and helping team members develop productive strategies for handling conflict. They can also improve the odds of a positive emotional climate by careful selection of team members. The final category, *team coordination processes*, includes such functions as situational assessment, information exchange, resource allocation, timing, and coordination of

individual actions. Relevant leadership processes include, again, environmental monitoring and providing feedback, as well as "matching member capabilities to role requirements" and guiding the team's adaptation to changing situations.

Functional Team Leadership. The Functional Team Leadership model (Morgeson, DeRue, & Karam, 2010) takes a more specific behavioral approach to team leadership processes and adds the element of leadership sources. In this view, team leadership is defined as "the process of team need satisfaction in the service of enhancing team effectiveness." Unlike the Team Effectiveness Model, Functional Team Leadership does not assume the existence of a defined leadership role or designated leader. Leaders can be internal or external, and formal or informal. An internal leader is a "member of the team and thus engaged in part of the team's task cycle" (p. 8), while an external leader is not. A formal leader has an assigned leadership role and is directly accountable for the team's performance. Under this model, "team leadership can come from multiple sources simultaneously" (p. 9), and certain leadership behaviors are most appropriately performed by leaders from different sources.

The FTL model divides the team performance cycle into two phases: the transition phase and the action phase. Leadership functions performed during the transition phase include composing the team, defining the mission, establishing expectations and goals, structuring and planning, training and developing the team, sensemaking, and providing feedback. Leadership functions performed during the action phases include monitoring the team, managing team boundaries, challenging the team, performing team tasks, solving problems, providing resources, encouraging team-self management, and supporting the social climate. As we will soon see, several of

these behaviors are characteristic of the leadership conceptions of the engineering competition team members interviewed in the present study.

In contrast to Zaccaro's claim of general applicability for the Team Effectiveness Model, the developers of the Functional Team Leadership Model acknowledge potential contingencies: "Although some of the leadership functions identified herein might be appropriate and effective regardless of the team or the context… we expect that the effectiveness of these functions will also vary based on numerous team, organization, or environmental factors," (p. 29) including team composition, task design, and team members' knowledge, skills, and abilities.

2.2.4 Team Leadership Research

As Morgeson and colleagues (2010) noted, a team's purpose and performance context can affect the types of leadership behaviors most needed. Studies of leadership in four types of work teams—self-managing teams, traditional work teams, action teams, and creative teams—illustrate some of these different approaches.

Although this concept sounds similar to contingency theory, there is an important distinction. Contingency theories attempted to specify leader behaviors at the if-then level: If Situation X occurs, then execute Response Y. Modern recommendations are more flexible. They seek to provide general guidelines appropriate to the team's context, structure, and purpose, rather than prescribing responses for particular situations.

Self-Managing Work Teams. Recall that self-managing work teams are those that are part of an organizational hierarchy but manage their own operations, sometimes

with only limited direction from their manager (Hackman, 2002). In their research on team effectiveness, Hackman (2002) and Hackman & Walton (1986) studied a variety of work teams. They found that self-managing work teams can be ideal places for leadership to emerge, assuming that the five conditions for team effectiveness (detailed above) exist.

Hackman's approach occupies the middle ground between leader-centric and collectivistic leadership models. While he tends to discuss the group's immediate supervisor as the team leader, he leaves room for team members to exercise leadership as well. In his view, "Anyone who succeeds in getting performance-enhancing conditions in place or helps strengthen them is exercising team leadership" (p. ix). A team leader's primary purpose is to get the team moving in the right direction, to coach the team, and to be sure the organizational environment allows the team to operate successfully. A team leader must be sure that members' talents are "fully engage[d]" (p. 59) and that less-experienced members have the opportunity to learn the skills necessary to contribute to the group. A team leader should also specify the team's boundaries with respect to action. Teams should know what actions they should "always do" and what they should "never do" (p. 106), but within those boundaries the team should have wide latitude to manage its own activities.

Traditional Work Teams. I define a traditional work team as a group of people performing a prescribed task in a specified way under the direction of a formal supervisor. Pearce (2004) noted that collectivistic leadership can exist within vertical leadership structures, although he was writing about so-called knowledge work. Hiller, Day, and Vance (2006) conducted a field study to determine whether shared leadership

can emerge within a blue-collar, hierarchical environment: road maintenance. Road maintenance crews have moderately interdependent tasks, operate under both routine and emergency conditions, and have a formal supervisor. The researchers developed a questionnaire based on four categories of leadership activities: planning and organizing, problem-solving, support and consideration, and development and mentoring. The *planning and organizing* category included items related to setting goals, organizing tasks, and allocating resources. The *problem-solving* category included items such as anticipating problems and "using our team's combined expertise" (p. 392). *Support and consideration* included such behaviors as encouragement, listening to complaints, and providing assistance. *Development and mentoring* included role-modeling, helping new team members learn skills, providing performance feedback, and "learning skills from all other team members." Road crew workers rated the frequency with which their team members shared the various activities. Each team's effectiveness in performing each item was rated by its foreman; foremen also rated their teams' overall effectiveness. Teams exhibiting greater collectivistic leadership received higher team performance ratings.

Action Teams. Action teams are "teams in which members with specialized skills must improvise and coordinate their actions in intense, unpredictable ways" (Edmondson, 2003, p. 1421). Surgical teams, sports teams, and Navy SEAL teams are examples. Each member of an action team possesses a high level of skill and serves as a specialist. Real-time communication and coordination of effort are essential for success (Kozlowski, Gully, McHugh, Salas, & Cannon-Bowers, 1996). Leader behaviors set the tone for team interactions. Team effectiveness improves when all team members feel

free to offer input. But, as Edmondson (2003) noted, even in teams consisting nominally of peers, power can influence team members' willingness to speak up. Less powerful members may "defer to those with more power" and may practice "self-censorship" (p. 1423). Team members who believe that their input is not valuable or appreciated may also keep quiet. Coaching by the team leader can encourage team members to speak up. Edmondson studied 16 operating room teams learning to use a novel surgical method. When the lead surgeon encouraged other team members to provide input, team learning improved. This coaching included behaviors such as providing "clarification and feedback, seeking members' input, listening to concerns, being accessible, and [being] receptive to others' ideas and questions." Leaders of the high-performing teams also exhibited a willingness to admit error.

Creative Teams. Creative teams can include those working in research and development (R&D), new product development, academic research, and software engineering, to name a only a few. Despite the large number and long history of creative organizations, leadership in the creative context has received only limited attention from scholars (Mumford, Hunter, Eubanks, Bedell, & Murphy, 2007).

Creative organizations, and the people who populate them, are different in important ways from the types of organizations most commonly considered in leadership studies. Creative groups have different goals from other types of work groups. For example, R&D operates on a much longer timeline and with fewer expectations regarding return on investment than operational organizations, even within the same company. Academic researchers can spend entire careers working on arcane problems with elusive solutions (Greene, 2014), yet still be considered productive.

Creative people are often valued for their unique perspectives and individualistic orientations—but such attitudes can also result in resistance to leadership. It stands to reason, then, that effective leadership in creative organizations might differ from effective leadership in other contexts. While the skills considered important for leadership in general are also important in the creative context, current research suggests that technical, organizational, and domain knowledge; a creative approach to problem-solving; and the ability to "turn ideas into organizational products" (Mumford et al., 2007, p. 406) are especially important to leadership for innovation.

Elkins and Keller (2003) reviewed 24 studies to determine whether leadership of R&D organizations differed from leadership of organizations in general. While most of the findings were consistent with more general frameworks, the importance of technical skill stood out. Leaders in R&D groups are expected to possess a high level of expertise, and teams with knowledgeable managers tend to exhibit better performance.

Team members' technical skill is also an influencing factor. When a team is inexperienced, leader behaviors and characteristics such as "supportiveness, task emphasis, technological skill, and participation" positively affect the team's "contributions to scientific knowledge" (p. 594). On the other hand, a technically experienced team can do well with a less technically knowledgeable leader, if the leader adopts the right approach. An early study at NASA revealed that "when supervisors were perceived as possessing less technical skill, higher performance was associated with giving subordinates more freedom to explore, discuss, and challenge ideas" (Elkins & Keller, 2003, p. 594). In other words, less technically skilled leaders should take care to practice empowering behaviors and create a supportive climate for innovation.

2.2.5 Shared Leadership in Teams

A concept popularized by Pearce and Conger during the late 1990s and early 2000s, shared leadership is a "dynamic, interactive influence process among individuals in groups for which the objective is to lead one another to the achievement of group or organizational goals or both" (Pearce & Conger, 2003, p. 1) Where shared leadership exists, leadership within the team is "not determined by positions of authority but rather by an individual's capacity to influence peers and by the needs of the team in any given moment" (Pearce & Conger, 2003, p. xi).

Shared leadership is more of a philosophy than a true model. Leadership behaviors and skills are not much different than those identified in other approaches. Rather, it is the recognition that leadership is, at its core, a form of social influence, and that people other than occupants of official positions can exercise such influence.

Definitions of shared leadership have since proliferated, and each has its own nuances. Pearce, Manz, & Sims (2008) gave a more detailed explanation than the definition above, describing shared leadership as "a process where all members of the team are fully engaged in the leadership of the team. Shared leadership entails a simultaneous, ongoing, mutual influence process involved the serial emergence of official as well as unofficial leaders… with all members possessing significant power and exercising meaningful influence *as needed* in the process of performing work" (p. 354, emphasis added). It is important to note that, while the leadership *process* is ongoing, individual members perform leadership-related actions "as needed." Thus, shared leadership should not be misunderstood as a whirlwind of simultaneous activity in which everyone is trying to lead but no one is following.

In a summary and comparison of collectivistic leadership approaches, Yammarino and colleagues (2012) wrote that shared leadership "views leadership as a shared responsibility among team members" and is "a set of role functions that can be accomplished by a variety of individuals in various ways…" They note that leadership "might be distributed… in any number of ways; and decisions and actions made by the team are not the result of a single leader acting toward the team" (p. 389–390). Unlike the Pearce, Manz, & Sims (2008) definition, which implies that all team members have similar and considerable levels of power, this definition suggests that the level of power exercised by individuals in the team may vary. The distribution need not be symmetrical for shared leadership to exist.

In this vein, Mayo and colleagues (2003) proposed that the amount of shared leadership within a team, and the level of leadership exercised by individuals within the team, could be measured using social network theory. Carson and colleagues (2007) built on this idea and tested the concept in a study of MBA student teams, the details of which are discussed below. Because the Mayo/Carson construct is a key theory applied in this research, when discussing the measurement of shared leadership I will rely on Carson and colleagues' (2007) simple definition: "Shared leadership is an emergent team property that results from the distribution of leadership influence across multiple team members" (p. 1218).

A number of researchers have sought to identify attributes of shared leadership. Pearce and Sims (2002) reviewed the leadership literature and found that the leadership behaviors evident in vertical leadership structures are also exercised when shared leadership is present. However, the target of the influence is different. In the traditional

view, leadership behaviors are exercised by a designated leader in an effort to influence followers. With shared leadership, on the other hand, "The agents of influence are often *peers* of the targets of influence" (p. 176).

Shared leadership should not be seen as the paragon of leadership structures. Like all leadership constructs, it is better suited to some contexts than to others. Shared leadership is most appropriate when tasks are interdependent, are complex, and demand creative problem-solving approaches (Burke et al., 2011). As sufficient time is needed to develop effective shared leadership processes, shared leadership is not appropriate "with teams in the early stages of development or performing a task under time urgency" (Burke et al., 2011, p. 342). Other researchers have even stronger reservations: "Shared leadership is held to be valuable only when followers possess mission critical information or expertise" (Mumford, Friedrich, Vessey, & Ruark, 2012, p. 408).

Caveats aside, Carson, Tesluk, and Marrone (2007) did find that shared leadership was positively associated with good performance by MBA student teams. Recognizing that previous shared leadership research had not sufficiently considered the social relationships of team members, Carson, Tesluk, and Marrone (2007) built on the work of Mayo and colleagues by employing the social network paradigm to examine shared leadership development within 59 MBA student teams assigned to work on consulting projects for corporate clients. They also sought to identify the conditions necessary for the development of shared leadership. They suspected that the internal team environment and the quality of coaching would affect shared leadership development. The researchers measured shared leadership via the social network concept of density. Team members were asked to rate each of their teammates on the

question, “To what degree does your team rely on this individual for leadership?” To compute team leadership density, the weighted ratings were summed and then divided by the number of possible relationships between team members. A high score indicated a dense network and therefore high shared leadership. Shared leadership was found to be “a strongly positive predictor” of client satisfaction (p. 1228). Furthermore, both internal environment and external coaching contributed to shared leadership development. If the internal environment was supportive, shared leadership developed even if coaching was minimal. If the internal environment was not supportive, good coaching could still promote the development of shared leadership.

2.3 Models of Leader(ship) Development

The terms “leader development” and “leadership development” are often used interchangeably. Day (2001) reviewed the research and proposed distinct but related definitions. In his view, *leader development* refers to the individual acquisition of knowledge, skills, and abilities (KSAs) exemplified by leaders. Self-confidence, and trustworthiness, commitment to task completion, and task-relevant knowledge are examples. The development of human capital is primary emphasis. In contrast, *leadership development* is a relational process devoted to the development of social capital. Day (2001) describes leadership development as “a strategy for helping people understanding how to relate to others, coordinate their efforts, build commitments [to people], and develop extended social networks by applying self-understanding to social and organizational imperatives” (p. 586). Leadership development promotes “empathy, [a] service orientation” and a focus on “developing others.” Collaboration, relationship

building, and managing conflict are emphasized. Attention must be paid to both levels of development in order for "effective development to occur" (p. 605). Furthermore, this teaching must be both intentional and "embedded within the work." Effective leadership development does not occur automatically simply as a result of doing leadership-related activities. And leadership skills that are taught in special workshops and retreats often do not transfer to actual practice on the job.

Other researchers have advanced theories of leadership development based on changing conceptions of the self as a leader, a phenomenon variously called *leader self-concept*, *leader identity* or *leadership identity*. Three approaches useful for this research include the Leadership Development Trajectory (Lord & Hall, 2005), the Integrated Model of Leader Development (Day, Harrison, & Halpin, 2009), and the Leadership Identity Development Model (Komives, Owen, Longerbeam, Mainella, & Osteen, 2005).

*The Leadership Development Trajectory (*Lord and Hall, 2005) describes how novice, intermediate, and expert leaders differ with respect to leadership identity, knowledge structures, information processing, skill development, and leadership practice. Novice leaders have an individualistic leadership identity and focus on "learning leadership behaviors and being seen as leaders by others." They learn leadership heuristics and "common sense" leadership theories (p. 598) and apply them indiscriminately. Advancement to the intermediate stage requires "attempt[ing] leadership in varied environments and [receiving] accurate feedback to help them tune their skills to an understanding of context" (p. 601). Intermediate level leaders take a more sophisticated approach. They have more domain experience than novices and can

draw on mental schemas to appropriately match leadership behaviors with the situation. Intermediate-level leaders are motivated to improve their leadership skills and will seek opportunities to do so. They have a relational, collective leadership identity and often associate their leadership with a particular group. Expert leaders can draw upon a considerable battery of domain, situational, and personal knowledge to exercise effective leadership. They have a high level of emotional maturity and are sensitive to others' emotions, cognitions, and motivations. In contrast to novice leaders, who are focused on self-development, and intermediate leaders, who are focused on their relationships with the group, expert leaders seek to develop others. Their leadership identity is based on core principles and values, and their decisions are guided by these values.

The Integrated Model of Leader Development (Day, Harrison, & Halpin, 2009) conceptualizes leader identity development within the larger process of adult development. The visible, surface-level behaviors and characteristics of a "competent" leader are supported by internal leader identity and self-regulatory processes, which result from fundamental processes of adult development. The model predicts that being perceived as an effective leader is preceded by the development of a leader self-identity, which rests upon personal maturation. The authors argue that "the processes that contribute to successful aging involving the selection of goals, optimization of resources, and compensation strategies for dealing with a lack of goal achievement… should… play an important role in shaping trajectories of leader development" (p. 546).

For many people, college coincides with the transition from adolescence to adulthood and is a period of intense personal development. Drawing from human

development theory, student development theory, and shared leadership constructs, Komives and colleagues (2005) proposed the *Leadership Identity Development Model* (LID) to describe how college students develop as leaders. As students advance through the stages, their understanding moves from leadership as positional to leadership as process, and the associated behaviors become more collaborative and inclusive.

Using a grounded-theory approach, the researchers identified six stages of student leadership development: awareness; exploration and engagement; leader identified; leadership differentiated; generativity; and integration/synthesis. The stages correspond with those identified by Lord & Hall (2005), although in the LID they are more finely described. The concept of shared leadership is central to the LID model (Komives et al., 2005, 2006). The Leadership Identity Development Model is reproduced from Komives, Longerbeam, Owen, Mainella, & Osteen (2006) in Figures 2.3a and 2.3b.

The first two stages represent the early formation of leadership concepts. Stage One, *Awareness*, typically occurs during childhood. Children are aware of the existence of leaders and authority figures. They follow leadership, or resist it, or both—but they may not see themselves as influential. In Stage Two, *Exploration and Engagement*, students "prepare for leadership" (p. 404). They join groups and teams. Friendships are important. They begin to develop skills and build self-confidence. In school, family, and organizations, students begin to hear about "leaders" and "leadership." Adults and older friends are often leadership role models. Students are given the opportunity to be responsible for certain activities within their groups. Through these influences, some students begin to develop a self-identity as a leader.

Stages →	1 Awareness		2 Exploration/Engagement		3 Leader Identified	
Key categories		*Transition*		*Transition*	*Emerging*	*Immersion*
Stage Descriptions	•Recognizing that leadership is happening around you •Getting exposure to involvements		•Intentional involvements [sports, religious institutions, service, scouts, dance, SGA] •Experiencing groups for first time •Taking on responsibilities		•Trying on new roles •Identifying skills needed. •Taking on individual responsibility •Individual accomplish-ments important	•Getting things done •Managing others •Practicing different approaches/styles *Leadership seen largely as positional roles held by self or others; Leaders do leadership.*
Broadening View of Leadership	"Other people are leaders; leaders are out there somewhere"	"I am not a leader"	"I want to be involved"	"I want to do more"	"A leader gets things done"	"I am the leader and others follow me" or "I am a follower looking to the leader for direction"
Developing Self	•Becomes aware of national leaders and authority figures (e.g. the principal)	•Want to make friends	•Develop personal skills •Identify personal strengths/weaknesses •Prepare for leadership •Build self-confidence	•Recognize personal leadership potential •Motivation to change something	•Positional leadership roles or group member roles •Narrow down to meaningful experiences (e.g. sports, clubs, yearbook, scouts, class projects)	•Models others •Leader struggles with delegation •Moves in and out of leadership roles and member roles but still believes the leader is in charge •Appreciates individual recognition
Group Influences	•Uninvolved or "inactive" follower	•Want to get involved	•"Active" follower or member •Engage in diverse contexts (e.g., sports, clubs, class projects)	Narrow interests	• Leader has to get things done •Group has a job to do; organize to get tasks done	•Involve members to get the job done •Stick with a primary group as an identity base; explore other groups
Developmental Influences	Affirmation by adults (parents, teachers, coaches, scout leaders, religious elders)	•Observation/ watching •Recognition •Adult sponsors	•Affirmation of adults •Attributions (others see me as a leader)	•Role models •Older peers as sponsors •Adult sponsors •Assume positional roles •Reflection/retreat	Take on responsibilities	•Model older peers and adults •Observe older peers •Adults as mentors, guides, coaches
Changing View of Self With Others	Dependent				Independent / Dependent	

Figure 2.3a. The Leadership Identity Development Model, Stages 1–3 (Reproduced from Komives et al., 2006, p. 402).

The KEY	4 Leader*ship* Differentiated			5 *Generativity*		6 Integration/Synthesis
Transition	*Emerging*	*Immersion*	*Transition*		*Transition*	
• Shifting order of consciousness •Take on more complex leadership challenges	•Joining with others in shared tasks/goals from positional or non-positional group roles •Need to learn group skills *New belief that leadership can come from anywhere in the group (non positional)*	•Seeks to facilitate a good group process whether in positional or non positional leader role •Commitment to community of the group *Awareness that leadership is a group process*		•Active commitment to a personal passion •Accepting responsibility for the development of others •Promotes team learning •Responsible for sustaining organizations		•Continued self-development and life-long learning •Striving for congruence and internal confidence
"Holding a position does not mean I am a leader"	"I need to lead in a participatory way and I can contribute to leadership from anywhere in the organization"; "I can be a leader without a title"; "I am *a* leader even if I am not *the* leader"	"Leadership is happening everywhere; leadership is a process; we are doing leadership together; we are all responsible"	"Who's coming after me?"	"I am responsible as a member of my communities to facilitate the development of others as leaders and enrich the life of our groups"	"I need to be true to myself in all situations and open to grow"	"I know I am able to work effectively with others to accomplish change from any place in the organization"; "I am *a* leader"
•Recognition that I cannot do it all myself •Learn to value the importance/talent of others	•Learn to trust and value others & their involvement •Openness other perspectives •Develop comfort leading as an active member •Let go control	•Learns about personal influence •Effective in both positional and non-positional roles •Practices being engaged member •Values servant leadership	•Focus on passion, vision, & commitments •Want to serve society	•Sponsor and develop others •Transforming leadership •Concern for leadership pipeline •Concerned with sustainability of ideas	•Openness to ideas •Learning from others	•Sees leadership as a life long developmental process •Want to leave things better •Am trustworthy and value that I have credibility •Recognition of role modeling to others
•Meaningfully Engage With Others •Look to group resources	•Seeing the collective whole; the big picture •Learn group and team skills	•Value teams •Value connectedness to others •Learns how system works	•Value process •Seek fit with org. vision	•Sustaining the organization •Ensuring continuity in areas of passion/ focus	•Anticipating transition to new roles	•Sees organizational complexity across contexts •Can imagine how to engage with different organizations
•Older peers as sponsors & mentors •Adults as mentors & meaning makers •Learning about leadership	•Practicing leadership in ongoing peer relationships	•Responds to meaning makers (student affairs staff, key faculty, same-age peer mentors)	•Begins coaching others	•Responds to meaning makers (student affairs staff, same-age peer mentors)	•Shared learning •Reflection/ retreat	•Re-cycle when context changes or is uncertain (contextual uncertainty) •Enables continual recycling through leadership stages
	Interdependent					

Figure 2.3b. The Leadership Identity Development Model, Stages 4–6 (Reproduced from Komives et al., 2006, p. 403).

In Stage Three, *Leader Identified*, the leadership concept becomes leader-centric: "Students in this stage [believe] that leadership [is] a position, and therefore the person in that position [is] the leader" (p. 407). People who are not positional leaders are, by definition, followers or group members. Students become "aware of their leadership potential" (p. 408) and appreciate being given increasing responsibilities, which give them opportunities to practice leadership. The typical high-school and early-college student is in this stage, and some people never progress beyond Stage Three (Komives, Longerbeam, Mainella, Osteen, Owen, & Wagner, 2013).

The transition between the third and fourth stages is critical. Labeled "*the KEY*" by the model's developers, students in this phase are beginning to see themselves as interdependent with others and to recognize that the ability to exercise leadership is not contingent on a person's position within an organization. Students at this key transition are ready to engage in shared leadership processes.

In Stage Four, *Leadership Differentiated*, students understand that leadership can be exercised by people who are not positional leaders. Their view of leadership activities expands from strictly directive and managerial to also encompass actions that help the group achieve its goals. Stage Four students understand the importance of teamwork and believe that "we are doing leadership together" (p. 405).

Students begin to see beyond themselves in Stage Five, *Generativity*. Their interests become commitments and passions, and they want to make a difference in the world. They are "concerned for the sustainability of their groups" (p. 411), and they take action, such as mentorship and coaching, to help develop younger members. They

have a deeper understanding of their personal values and their own "philosophies of leadership" (p. 411).

In the final phase, *Integration/Synthesis*, students have fully developed their self-concept as a leader; simultaneously, they see leadership development as a life-long process. They understand their status as role models and are "trustworthy" and "credible." They realize that organizations are complex, and that different situations call for different leadership approaches. They are confident in their abilities to effect change "from any place in the organization" (p. 405).

Within each stage, students exhibit characteristic beliefs and behaviors falling under five categories: a broadening view of leadership, developing self, group influences, developmental influences, and the changing view of self with others. Within the categories are properties "that [change] throughout the development of leadership identity" (Komives et al., 2005). The category of Broadening View of Leadership includes such properties as "the external other, as positional… as nonpositional… [and] as process." Properties exemplifying the category of Developing Self include "deepening self awareness," "building self-confidence," and "applying new skills." Properties falling within Developmental Influences include "adult influences, peer influences, meaningful involvement, [and] reflective learning." Group Influence properties include "engaging in groups, learning from membership continuity, [and] changing perceptions of groups." The category of Changing View of Self with Others includes three properties: "dependent, independent, [and] interdependent." The researchers also identified transitions between stages—statements of belief or action

that indicate a student's advancement toward the next level. (All quotations in this paragraph are from Komives et al., 2005, p. 599).

The category of Changing View of Self with Others supports the stages. In the first two stages, students view themselves as dependent. They rely on others, typically authority figures, to set direction and make decisions. In the third stage, students act in both dependent and independent roles: When they hold a leadership position, they behave independently; otherwise, they assume a dependent follower role. As students transition to the fourth stage, they begin to understand that many leadership activities are complex—too complex for one "leader" to handle alone. They develop an interdependent view of the self in relation to others. Possessing an interdependent perspective is characteristic of reaching the advanced stages of the Leadership Identity Development model.

The researchers cautioned against using the LID Model to put students into leadership "boxes." As they explained,

> The reality of leadership identity development is much more complex and appears cyclical rather than linear…. Rather than exhibiting behaviors and meaning making strategies that reflect a single stage, student responses and behavior may be more likely to signal multiple stages concurrently. Additionally, students may recycle to an earlier stage when faced with a situation that challenges their way of understanding themselves as leaders or in understanding a new leadership context. These factors can make it difficult to assess which stage a student primarily operates from… Another challenge to assessing leadership identity development is that some students are able to discuss leadership in ways that would indicate one stage, but their actual behaviors reflect an earlier stage. This challenge is not unique to LID research. In self-report data it is not uncommon to find that participants self-report survey responses that are one stage higher than their actual behavior. Their observed behaviors may then mask the identity they are developing" (Komives et al., 2013, pp. 26-27).

2.4 Leadership Development in College

College represents a unique developmental opportunity for young adults, and college students' development differs from the development of young adults who do not attend college (Chickering & Reisser, 1993). Although research regarding leadership and college students is not extensive (Dugan & Komives, 2010), important observations have been made in the areas of leadership emergence, development, and practice.

2.4.1 Predictors of Student Leadership Emergence & Effectiveness

As we saw earlier, leadership scholars have attempted for many years to identify and measure predictors of leadership emergence and effectiveness. (See DeRue, Nahrgang, Wellman, & Humphrey, 2011, for a recent review and meta-analysis.) Within the research among college students, "precollege leadership capacity and knowledge regularly emerge as the most significant predictors of leadership" (Dugan & Komives, 2010, p. 527). Other important factors associated with college students' leadership development include "general student involvement, community service, internships, interracial interaction, positional leadership roles, formal leadership training programs, faculty interactions and mentoring, and formal leadership training programs" (Dugan & Komives, 2010, p. 528).

Leadership self-efficacy has also been associated with leadership skills development. Dugan and Komives (2010) tested the predictive validity of eight collegiate experiences and leadership self-efficacy scores on values as measured by the Socially Responsible Leadership Scale (Tyree, 1998). Collegiate experiences included membership in student organizations, leadership positions in student organizations,

community service, internships, on-campus employment, socio-cultural conversations with peers, mentoring relationships (faculty/staff and peer), and participation in leadership training programs. The strongest predictors of high SRLS scores were the frequency of socio-cultural conversation with peers, mentoring relationships with faculty, and community service. Interestingly, leadership self-efficacy was negatively associated with most values. The authors propose that young students may have an inflated sense of efficacy that "could lead to students' avoidance or dismissal of important leadership learning experiences in college that foster socially responsible leadership" (p. 541). However, the cross-sectional design of the study precluded further analysis of the cause.

Atwater, Dionne, Avolio, Camobreco, & Lau (1999) used a longitudinal approach to investigate predictors of leadership emergence and effectiveness among cadets at the United States Military Academy. Seven factors "suggested in prior literature to be conducive to effective leadership in both civilian and military settings" (p. 1548) were chosen: cognitive ability, self-esteem, physical fitness, stress tolerance, conscientiousness, moral reasoning, and prior influence experiences (that is, experiences in which the student had exerted influence over others). Cadets were evaluated on these factors at the beginning of the freshman year. During their fourth year, leadership emergence (as indicated by achieved rank) and leadership effectiveness (as indicated by peer ratings) were measured. Pre-collegiate influence experience and freshman-year physical fitness were the only factors positively associated with both emergence and effectiveness. Leadership emergence was also predicted by cognitive ability and self-esteem. Conscientiousness, stress tolerance, and moral reasoning, on the

other hand, did not predict either outcome. It is important to note that a cadet's rank was determined by a committee of faculty, officers, and ranked cadets using "a variety of leadership criteria" not described in the article (p. 39). The correlation of physical fitness, self-esteem and cognitive ability—traits historically associated with leadership—suggest that the committees may have relied at least in part on the cultural concept of the Ideal Leader. However, the correlation of prior leadership experience to both emergence and effectiveness supports the idea of leadership as a skill set that can be improved with practice.

Leader self-identity has received empirical support as a predictor of leadership effectiveness. Day and Sin (2011) performed a longitudinal test of the integrated model of leader development (Day et al., 2009), employing first-year university students as participants. All participants were enrolled in a leadership course featuring a service-learning project, and each project team was advised by an upper-class student. Three times during the course of the project, participants rated themselves according to a leader self-identity scale. Team advisors rated the individual team members' leadership effectiveness four times during the semester. At all data collection times, leader self-identity positively predicted leadership effectiveness ratings, thus supporting the model's validity.

2.4.2 Engineering Students' Understanding of Leadership

Leadership and teams research in engineering education is particularly limited. Recent areas of inquiry within the domain of engineering project teams include students' understanding of leadership and teamwork, results of formal programs for leadership

development, observed behaviors and attributes of teams and team leaders, reported behaviors and attributes of teams and team leaders, and the relationship between engineering competition team participation and leadership development.

Laguette (2013) surveyed students in a team-based civil engineering capstone course. At the beginning of the course, students completed a free-response survey regarding their expectations of the course, including their expectations of team leaders. Respondents expected their leaders to manage conflict, organize meetings, coordinate the team's efforts, monitor team members' performance and provide "leadership" (p. 8). They did not want their team leaders to engage in "power trips" (p. 8). Team leaders, who completed a free-response survey following the first academic quarter, had a similar but expanded view of their role. In addition to project management and coordination, they listed responsibilities such as reviewing and submitting technical documents, motivating team members, facilitating team functioning, and communicating. Team leaders enjoyed "guiding the team" and were frustrated by team members who lacked a strong work ethic (p. 8).

In a study of engineering student capstone project teams at the United States Military Academy, Jones, Boettner, Dillon, Ivey, Lambert, Novoselich, & Suhr (2009) examined students' perceptions of the teaming experience. Two of the teams produced a project intended for intercollegiate competition (Design Build Fly and Mini Baja); the other team produced a Spirit Tank that could drive onto athletic fields and shoot t-shirts to the crowd. The teams were small: Team Baja had 10 members, Team Spirit Tank had six, and Team DBF had only four. About one month after the completion of the projects, team members submitted a reflective essay in response to open-ended questions about

their experience with the project, their personal strengths and weaknesses, personal growth, and lessons they expected to apply to their future military career. The authors grouped the responses into three categories: team processes for communication and collaboration, attribution factors of communication and collaboration, and transfer of lessons learned to leadership. Perceptions of communication processes were rated as positive or negative. Attribution factors were categorized as internal or external. Leadership lessons were categorized as leader-centric (lessons that will help "the student guide and direct others," p. 6) or follower-centric (lessons that "help the student perform better due to internal factors," p. 7). The degree of alignment, or similarity of responses within a team, was also assessed.

Leadership lessons mentioned by respondents included the common themes of motivation, project management, goal achievement, problem solving under constraints, teamwork, persistence, overcoming challenges, and leading by example. The categorization of responses as leader-centric or follower-centric appears to be based on the respondent's frame of reference (self or others) rather than the specific leadership lesson mentioned. Persistence, for example, appears in two of the cited responses from DBF members; the response coded as "follower-centric" includes only a reference to the speaker, while the response coded as "leader-centric" includes references to both the speaker and the team. Specific counts of leader- and follower-centric behaviors were not reported, although the authors clearly believed that "balance" between leader-centric and follower-centric lessons was desirable and indicated good teamwork. The Baja team was found to have the greatest degree of alignment and the most "balance" between leader-centric and follower-centric lessons learned. The team placed 39th of 100 teams

in the national Mini Baja competition; the authors considered this a success. The Spirit Tank team had good alignment and balance and completed most of its requirements. The project was deemed successful by the faculty. The Design Build Fly team, on the other hand, exhibited poor team functioning—one respondent said they "never got past the storming phase"—and exhibited low alignment. This team crashed their aircraft just a few weeks prior to the competition and was unable to compete as a result.

The authors blamed Team DBF's poor functioning on excessive leadership, stating that the team's persistent internal conflicts and apparent lack of a shared mental model "would indicate a significant amount of too many leaders in the group" (p. 11). This curious statement is indicative of the authors' military perspective; without a clear enumeration of specific team member behaviors, the validity of that assertion is difficult to evaluate. The authors further stated that "This is a common occurrence within student groups as peer leadership is one of the most difficult" (p. 10). While the authors made some recommendations for improving the teaming experience, including more frequent reflection assignments and team self-assessments, intentional team-leadership training was not mentioned.

2.4.3 Formal Programs of Leadership Development within Engineering Education

Özgen, Sánchez-Galofré, Alabart, Medir, & Giralt (2013) employed behavioral interviewing and 360° feedback surveys to examine leadership exhibited by 11 fourth-year engineering students serving as mentors to first-year student design teams. The mentors were enrolled in the final course of a multi-year leadership development program that emphasized leadership in technical noncompetitive project teams, with the

goal of preparing students for teamwork in industry. The curriculum was designed to support the development of eight team-level leadership competencies: client orientation, commitment to learning, drive for excellence, integrity, interpersonal communication, responsiveness to change, results orientation, and teamwork. During the interview, mentors were asked to "describe specific events in which they felt particularly effective or ineffective as a leader" (p. 67). Mentors most frequently described competence in behaviors related to commitment to learning, interpersonal communication, teamwork, and results orientation. Team leaders and team members also completed a 360° feedback survey in which team leaders were rated on each of the eight competencies. While both team leaders and the first-year team members considered the team leaders to be satisfactory leaders, the first-year students gave the leaders higher ratings than the leaders gave themselves.

Despite the claims that the ECT experience helps students develop their leadership and teamwork skills, participation in and of itself may not guarantee such development (Day, 2011). For example, engineering faculty at an institution in the northern U. S. were disappointed in the performance of their university's teams at competitions (Dolan, Batchelder, McReynolds, Osberg, Koontz, Mahon, Keegan, & Weiss, 2011). A root-cause analysis identified a "lack of quality of teaming" (p. T3C-5). In 2001, the institution began a formal program designed to teach values-based teaming to all members of ECT teams. Students learned the values of affection, respect, skill, understanding, proper use of power and influence, proper use of goods and services, well-being, and responsibility. Following the competition, each team assessed its own performance of these values according to Rucker's (1969) Value Deprivation—

Enhancement Continuum. The team's faculty advisor facilitated this discussion. To assess the effectiveness of this approach, Dolan and colleagues evaluated 20 teams; 11 of those finished in the top 10% of their respective competitions. The 11 successful teams exhibited strong positive performance on all the values. In contrast, four of the less-successful teams scored poorly on at least one value. These results suggest that leadership and teamwork development can be facilitated by intentional and formal interventions by instructors and advisors.

2.4.4 Reported Behaviors & Attributes of Project Teams & Team Leaders

Zafft, Adams, & Matkin (2009) explored the relationship between leadership behaviors and group project grades in an upper-level undergraduate Construction Management and Architecture course. At the end of the course, the students evaluated themselves and their teammates according to the four leadership profiles in Quinn's Competing Values Framework (1988): relating to people, producing results, managing processes, and leading change. Groups scoring well on at least three of profiles received higher projects grades than those scoring well on two or fewer profiles. In particular, Producing Results, Managing Processes, and Leading Change were significantly associated with higher grades.

2.4.5 Observed Behaviors & Attributes of Project Teams & Team Leaders

In a landmark study of engineer identity development, Tonso (2006a, b) studied the interactions of engineering students at a large university in the Midwestern U. S. Over the course of four years, she observed ten teams at the freshman, sophomore, and

senior levels. During the course of the study, she also interviewed engineering students about the terms used to describe engineers on their campus.

Through analysis of these engineer identity terms, Tonso identified three primary student types. *Nerds* "use[d] science and engineering principles to understand real-world situations" (292). Although their interest in social activities ranged from low to high, Nerds did not have high social status on campus. *Academic-Achievers* focused on making high grades on tests and assignments; for some, deep understanding of concepts was of secondary importance. They were seen as ideal engineers and hard workers, but they also had a tendency to dominate groups and "assume other people's work [without asking]" (p. 289), especially if grades were at stake. Like that of Nerds, the Academic-Achievers' interest in social activities ranged from low to high. In contrast to Nerds, they were more likely to participate in campus life and thus possessed a higher social status. The third group, *Greeks*, consisted of highly social students (usually but not necessarily members of fraternities or sororities) who valued both grades and campus leadership positions. As with the Academic-Achiever group, for some Greeks making good grades was more important than developing deep knowledge; unlike Academic-Achievers, Greek men had a reputation for using unethical means to obtain high grades. Greeks and Academic-Achievers with an excessive focus on visible accomplishments were referred to, often disparagingly, as Over-Achievers.

The students identified by interview respondents as "Leaders" occupied a space in the center of the socializing–academics continuum; some were Greeks and some

were Academic Achievers. Nerds were not generally identified as leaders, although they often provided excellent leadership within their project groups.

Although not the central focus of her research, Tonso described the leadership behaviors exhibited within the various observed teams. She noted a mismatch between students' leadership effectiveness and their perceptions as leaders by faculty and the larger university community. Two students from a case study of teams in a senior-level engineering design course exemplified this difference (Tonso, 2006b).

Pete, an Academic Over-Achiever, was adept at getting other students to do work while representing himself as an outstanding team member. In group meetings, Pete often dominated the discussion and refused to compromise. Although other students were aware of Pete's academic laziness and relative lack of engineering skill, he was recognized and rewarded by the faculty as a "campus leader."

Among engineering students, technical expertise and the ability to complete a project in a timely fashion are highly valued. Tonso observed that, in groups without a dominating member, the team leader was often a person of considerable technical skill. Martin, a Nerd, exemplified this type of leader. Although an outstanding engineer and programmer, he actively sought his team members' input and encouraged collaboration. In exercising a relational leadership style, Martin facilitated discussion. He even saw to his team members' social needs, often hosting team meetings at his home and providing refreshments. Martin did not self-promote, although he had more legitimate reasons for doing so than many of the Over-Achievers. Despite the fact that Martin's group functioned well as a team and received a better grade on the project than Pete's team,

Tonso observed that his style of leadership was not valued at his university–in fact, it was not even recognized as leadership.

2.5 Engineering Competition Team Participation and Leadership Development

2.5.1. Faculty Perceptions of Competition Benefits

In a 2005 study, Wankat surveyed team faculty advisors at five institutions with a history of success at engineering competitions to determine factors associated with winning and to identify benefits students receive through participation. All questions on the survey were open-ended. Benefits mentioned included practical experience, decision-making, and "teamwork, management, and leadership skills" (346). Specific details regarding these skills were not included.

More recently, Barry, Meyer, Arnett, & Spittka (2013) surveyed civil engineering department heads regarding the educational value of 11 civil engineering student competitions "relative [to] the 24 Outcomes identified" in the ASCE *Body of Knowledge* 2nd Edition (p. 7). These outcomes are considered "a comprehensive list" of those "required for entry into professional practice" (p. 6). Department heads rated each outcome on a 5-point Likert scale ranging from Not Applicable (1) to Completely Satisfied by the Competition (5). Leadership received an average score of 4.03 across all competitions. Good ratings were also given to outcomes related to leadership: Teamwork (4.09), Problem Recognition and Solving (3.96), Project Management (4.00), and Communication (3.87). Among specific competitions, Concrete Canoe was rated the best for Leadership (4.25) and received above-average ratings for the related skills.

Bigelow, Glick, and Aragon (2013) performed a grounded theory study of the positive and negative effects of student competitions in the construction management domain, a discipline related to engineering. Through interviews with 13 team coaches and a single-question survey administered to 43 students, they identified 11 perceived positive effects. Although leadership was specifically cited by only two coaches, other positive effects related to leadership were identified, including problem solving (5), teamwork (3), and confidence (3).

2.5.2 Student Perceptions of Competition Benefits

Sirianni, Lee, LeFevre, Lindholm, Aghayere, & Valentine (2003) surveyed civil engineering students and recent graduates regarding the skills "acquired throughout your [collegiate] experience" (p. 13). Students who had participated in Concrete Canoe or Steel Bridge competitions were more likely than nonparticipants to say that they had gained experience in leadership, project management, teamwork, and communication. The paper reported average scores for the participant groups but did not include information regarding statistical significance.

Sánchez-Alejo, Aparacio, Álvarez, & Galindo (2010) surveyed student Formula SAE (FSAE) team members at a university in Spain. Team members were primarily senior undergraduates majoring in industrial engineering (IE). They rated the importance of 24 skills to their personal and professional development and then rated the degree to which their IE academic experience and the FSAE experience contributed to the development of these skills. Students considered FSAE more effective for the development of leadership qualities and several related dimensions, including motivating others, identifying problems, resolving conflicts, making decisions, and

interpersonal skills. On some dimensions, the difference was pronounced. On a scale of 1 to 5, FSAE ratings were two or more points higher than the academic experience ratings on leadership (3.6 vs. 1.1), the ability to motivate others (3.8 vs. 1.3), and the ability to make decisions (4.0 vs. 2.0). The experiences were deemed equivalent on only one dimension, organization and planning skills.

None of the construction management students participating in the Bigelow et al. (2013) study mentioned leadership or problem-solving as an effect of the competition experience. This contrasts to results of other studies and to the faculty responses in the Bigelow study. Thirteen students identified teamwork as a positive effect of the experience, and one mentioned increased confidence.

As the studies above suggest, the engineering competition team experience is widely believed to contribute to leadership development. But this belief is largely based on conventional wisdom and anecdotal accounts. Furthermore, much of the research has relied on surveys, a method which restricts the investigation of leadership to parameters already identified by the researcher. By employing a mixed-methods approach to investigate leadership development among student members of engineering competition teams, the present study enriches our knowledge regarding students' understanding of leadership in the engineering context.

Chapter 3

Method

This research is a descriptive, instrumental case study of two engineering competition teams at a large public university in the central United States, conducted over the course of a single competition season. At the time of the research, the university sponsored ten competitive engineering teams, with approximately 200 students participating. The Jets and the Sharks are the largest engineering competition teams at this institution. Both teams are extra-curricular and largely self-managed, and their membership is drawn from all undergraduate levels. These teams provide opportunities for students to participate over several years, making it possible to examine the contribution of the ECT experience to students' leadership development. Despite these similarities, the teams differ markedly in composition and culture. For example, the Jets are predominately male, and the typical member is involved in few or no other extracurricular activities. The team is proud of its historical success and emphasizes commitment as a core value. The Sharks team, on the other hand, features a more even gender balance, and members often participate in one or more additional collegiate organizations. While this team is also proud of its historical success, the team members emphasize fun and friendship more than hard work and sacrifice. These differences provide contrasting contexts in which to explore the effects of ECT participation on students' leadership development. (For a different discussion of culture within an engineering competition team, see Walden, Foor, Shehab, & Trytten, 2013).

Instrumental case studies are useful for describing how a phenomenon can occur "and are the preferred strategy when the investigator has little control over events and

when the focus is on a contemporary phenomenon within some real-life context" (Klenke, 2008, p. 64). I chose to study these two teams during a single competition year to understand some of the ways the ECT experience can contribute to student leadership development. I used various theories to "frame the research questions" and as "a sensitizing device to offer certain insights and interpretations," (Klenke, 2008, p. 60), but I also left room for themes to emerge from the data.

I employed a mixed-methods design with an interpretivist approach. According to Creswell (2009), a mixed-methods design "collects both quantitative and qualitative data" (p. 17). In Phase 1 of the study, students completed a Likert-scale questionnaire and identified influential team members. The use of surveys is one example of a quantitative method (Creswell, 2009); the application of social networks theory is another (Mayo, Meindl, & Pastor, 2003). In Phase 2, I interviewed members of the teams. The interview employed open-ended questions, and the analysis sought to identify themes emerging from the data—both characteristics of qualitative research. The results of the two phases were compared to develop the study's conclusions, satisfying the criterion that a mixed-methods design should "integrate the data [collected] at different stages of inquiry" (Creswell, 2009, p. 17). Using a mixed-methods design allowed me to explore students' understandings of leadership from both a quantitative and a qualitative perspective, and permitted me to compare the conclusions drawn from each phase of the project.

Approaches to leadership research range from quantitative analyses of leadership effectiveness, often measured by Likert-style questionnaires, to fully inductive qualitative methods such as the grounded theory approach. Bryman (2004)

observes that qualitative studies tend to reveal more functional leadership behaviors than do quantitative studies. Quantitative studies often ask participants to rate leaders on transformational behaviors, such as vision, charisma, and inspiration. When people are asked to talk about leadership, they tend to speak in practical terms, emphasizing task accomplishment, communication, integrity, and trust. "Qualitative research has brought to the fore several aspects of leadership processes that might otherwise have been relatively unexplored" (Bryman, 2004, p. 754).

The use of narratives is common in qualitative research (Klenke, 2008) and includes the analysis of "textual materials… autobiographies and biographies, life stories, recorded interviews of ordinary experiences," and other methods of storytelling. Asking people to tell a story encourages them to go beyond the bounds of simply answering the question, and I frequently encouraged participants to do so. This approach provided a rich basis for "understand[ing] leadership from the perspective of the actors involved" (Fairhurst, 2011). The semi-structured interview format allowed me to maintain some consistency among interviews so that key questions were answered by each person. The format also allowed room for exploring the stories and assertions made by the respondents.

Narrative analysis has seen limited use in leadership research, perhaps because of the difficulty in analyzing the source material (Klenke, 2008). Generalizing the findings is always a challenge, because the exact conditions under which the research occurred cannot be replicated. Instead, the trustworthiness of qualitative research must be evaluated by other means. For example, case studies can be "generalizable to theoretical propositions" (Yin, 2013, p. 21), an approach I have employed in this project.

The goal of a narrative analysis is fidelity: Can the study's conclusions be fully supported by the data? In an attempt to ensure fidelity, I triangulated the participants' accounts of events, sometimes by asking a participant to discuss an event that had been related in a previous interview. I also iteratively compared and contrasted participants' comments within each interview. If the participant made a statement that appeared to coincide with a particular theoretical viewpoint, I looked for additional statements in support of or counter to that statement. In this way, I could be satisfied that the conclusions had emerged from the data, rather than the data being forced to fit the theory.

Interpretivism is similar to constructivism, in that both theories support the idea of leadership as a socially constructed concept (Collinson, 2011). Constructivism holds that "understandings of the world are socially constructed, transmitted, and shared through systems of language and symbols" (Scribner, Cockrell, Cockrell, & Valentine, 1999, p. 137), a framework that at first seems well suited to the present study. Pure constructivism, however, has several restrictive assumptions. In particular, constructivists "reject *a priori* theory as a source of categories for deductive analysis" (Klenke, 2008, p. 22). Interpretivism is more flexible and rests on the following assumptions (Klenke, 2008, p. 23):

- Human beings… embrace multiple realities which need to be understood in context.
- The social world cannot be described without investigating how people use language, symbols, and meaning to construct social practice.
- No social explanation is complete unless it adequately describes the role of meaning in human actions.

Interpretivism holds that multiple realties exist, and that the goal of the researcher is to provide meaning to the participants' narratives. In the case of leadership and competition team participation, each student experiences his or her own reality. By employing theoretical frameworks as lenses through which to interpret the students' interview responses, I was able to compare and contrast these realities to build a picture of team members' individual and collective views about leadership and ECT. The theoretical models serving as lenses include the measurement of shared leadership via social network theory (Mayo et al., 2003; Carson et al., 2007), functional leadership (Fleishman et al., 1991), team leadership behaviors as summarized by Burke et al. (2006); and the Leadership Identity Development model proposed by Komives et al., (2005, 2006).

I approached this study with the idea that engineering competition teams would benefit by exercising leadership from a collectivistic and process-oriented standpoint. Because engineering students are developing their technical expertise, they must rely on collaborative learning and the sharing of knowledge in order to produce a quality product. Despite this bias, I approached the project as an explorer. My goal was not to support a proposition. Instead, I sought to determine *what* engineering students understood about leadership and *how* team participation influenced that understanding. I acknowledge that by interviewing the students about their leadership experiences, the students and I participated in creating a new reality. The interviewed students' leadership identities may have progressed simply as a result of participating in the study (Komives et al., 2006).

3.1 An Overview of the Teams

Some details in the descriptions of the teams below have been omitted to protect the team members' anonymity.

3.1.1 The Jets

The Jets team is probably the most visible of this institution's engineering teams. The Jets are frequently featured in local publications, and its vehicles are prominently displayed in the college's showcase building. The Jets compete in the Formula SAE Collegiate Design Series conducted by the Society of Automotive Engineers and most often race in the Michigan and Lincoln competitions.

Because of the complexity of the product, design work begins in the summer and continues through the fall semester. During the fall, students begin construction of the components. Construction continues over the winter break and into the spring semester, with the goal of having a running car completed four to six weeks prior to the first competition. This allows time for testing the car and driving practice. While participants do benefit from applying knowledge learned in the classroom to the design and construction of the car (and vice-versa), the focus is competitive rather than academic.

While housed within an academic department, the Jets team is a registered student organization in its own right. In addition to engineering students, students from other majors, such as business and journalism, also participate. The Jets team is primarily an undergraduate organization. FSAE rules permit graduate students to participate, and two graduate students were on the roster during the study year.

The Jets team is small by FSAE standards; 25 students were on the roster in the spring of the study year. As has been the case throughout the team's history, the members were primarily Caucasian men born in the U. S. There was one woman on the team. Four members were Latino, and one was an enrolled member of a Native American tribe. About half the team members were in their first year on the team; most of those were also university freshman. On average, team members had a little more than 2 years' experience.

3.1.2 The Sharks

The Sharks team is the largest of this institution's engineering competition teams, with 45 members on the spring roster during the study year. The National Concrete Canoe competition series is one of several competitions sponsored by the American Society of Civil Engineers. The first rounds are held at regional student conferences; regional winners advance to the national competition. The competition consists of several events, including a technical paper and presentation, canoe design and display, and races.

Design work on the canoe typically begins during the fall semester. Although some teams choose to redesign their hull mold each year, the Sharks have opted to retain the same hull design for the last several years. Fall work consists of the formulation, testing, and selection of concrete mixes; the visual design of the canoe and display; fundraising; materials procurement; and paddling practice. Heavy work begins mid-spring with Casting Day, when all the members participate in mixing and placing concrete on the canoe mold. The canoe is left to cure for three to four weeks, after

which the mold is removed and sanding begins. A smooth surface is prized, so team members (and their friends) sand the canoe by hand for many hours over several days before it is ready to be painted. As with the Jets, the focus is competitive rather than academic.

In addition to civil, architectural, and environmental engineering students, team members included mechanical and industrial engineers. While college students at any level and majoring in any field may assist in the design and construction of the canoe, the official rules limit the competition roster to 10 undergraduate engineering students; no student can be on the competition roster for more than three years. At least half of the registered team members must be women.

During the year under study, about 40% of the team members—and 67% of the officers—were women. Although Caucasians predominated, other ethnicities were represented, including Native American, Asian, Asian American, and Latino. About half the team had two or more years' experience with the Sharks.

3.2 Approach

Data were collected in two phases. In the first phase, attendees at mid-fall team meetings of the Sharks and the Jets responded to a paper-and-pencil questionnaire regarding team processes and influential team members. During the second phase, influential team members participated in individual recorded semi-structured interviews exploring the team experience and their own leadership development journey.

3.2.1 Phase 1: The Team Environment and Social Network Questionnaire

Design. For the questionnaire, I used the instrument used by Carson and colleagues (2007). Their questionnaire was divided into two parts. Questions in one part included 13 statements regarding three dimensions of internal team environment (shared purpose, social support, and voice) and the level of coaching support provided by the faculty advisor (Table 3.1). Respondents indicated their level of agreement with each statement on a five-point Likert scale, with higher scores indicating greater agreement. The other part of the questionnaire was used to examine the teams' social networks and assess the level of shared leadership within each team. In Carson's study, each team member used a five-point Likert scale to rate "each of his/ her peers on the following question: "To what degree does your team rely on this individual for leadership?" (p. 1225).

The Carson study investigated small teams of MBA students, so every team member was evaluated. Because the teams in the ECT study were much larger, I modified the social network portion of the questionnaire. Rather than rating all members of the team, respondents wrote the names of the current team members who influenced them. I added the influence question in an effort to identify members who exhibited leadership behaviors but who might not fit a respondent's idea of a leader. These slight modifications nonetheless produced results consistent with the findings in the study by Carson et al. (2007).

Framing the list around influential members broadened the scope of analysis and facilitated the investigation of leadership development across the team rather than the development of students who were already considered leaders. Had I asked respondents

to list leaders on the team, some would have listed only officers or positional leaders. For each person listed, the respondent used a Likert scale to indicate the extent to which that person influenced him or her personally, and the extent to which the team relied on that person for leadership. On the five-point scale, a score of 1 indicated "not at all" and a score of 5 indicated "to a great extent." Respondents worked individually, rating only the people they personally had listed. These ratings informed the development of a social influence network for each team and facilitated the identification of influential team members.

Table 3.1. Statements regarding dimensions of internal team environment and coaching. After Carson et al. (2007).

Internal Team Environment	Shared Purpose	1. The members of my team spent time discussing our team's purpose, goals, and expectations for the project.
		2. The members of my team discuss our team's main tasks and objectives to ensure that we have a fair understanding.
		3. The members of my team devise action plans and schedules that allow for meeting our team's goals.
	Social Support	4. The members of my team talk enthusiastically about our team's progress.
		5. The members of my team recognize each other's accomplishments and hard work.
		6. The members of my team give encouragement to team members who seem frustrated.
	Voice	7. People in this team are encouraged to speak up to test assumptions about issues under discussion.
		8. As a member of this team, I have a real say in how this team carries out its work.
		9. Everyone on this team has a chance to participate and provide input.
		10. My team supports the active participation of everyone in decision-making.
Coaching		11. The team's faculty advisor expresses confidence in the capabilities of our team.
		12. The team's faculty advisor effectively motivates and guides our team toward accomplishing challenging goals for this project.
		13. The team's faculty advisor is sensitive to the needs of our team and tries to help us however he or she can.

No demographic questions were included in this questionnaire. So that respondents could be divided into two groups (new members and returning members), they were asked, "Is this your first semester to participate on this competition team?" They were also asked if they had previously participated on an engineering competition team at this university, and, if so, which team(s). The questionnaire is including in the appendix.

Participant Recruitment. Early in the fall semester, I emailed the faculty advisors and captains of the Jets and Sharks to request permission to attend a team meeting and administer the questionnaire. I attended one mid-fall meeting for each team. At the meetings, I described my research in general terms and explained the purpose of the questionnaire. I invited all students present to complete the questionnaire, and I reviewed the informed consent form. All instruments, recruitment scripts, and consent forms had been approved by the Institutional Review Board. The recruitment script included the following statement:

> To protect the identities of those choosing to participate, I respectfully request that all of you complete the questionnaire. Once the questionnaire is completed, you may choose whether or not to have your responses included in the study.
> If you do agree to have your responses included, please mark the blank on the consent form that states, "I have read the above information. I have asked questions (if any) and have received satisfactory answers. I consent to participate in the study."

Participants signed an informed consent form, which was attached to each questionnaire. No identifying data were collected via the survey instrument. After the data were collected, I assigned code numbers to each participant and wrote the code

number on the questionnaire. Informed consent forms were then separated from the questionnaires. Participants were not compensated.

3.2.2 Phase II: The Interview

A number of researchers have employed a narrative approach to investigate leader development (Shamir, Dayan-Horesh, & Adler, 2005; Shamir & Eilam, 2006; Mumford, Marks, Connelly, Zaccaro, & Reiter-Palmon, 2000; Jones et al., 2009; Özgen et al., 2013; Komives et al., 2005, 2006). While the number of published formal theories of leadership is vast, laypeople also develop their own ideas of leadership. These implicit theories are "construct[ed]—from a complex set of… experiences" (Bresnen, 1995, p. 500) and may or may not match a particular scholarly or conventional definition. In investigating leadership, researchers should seek to understand "what people actually mean when they attribute actions to leadership" (p. 498). A semi-structured interview provides such an opportunity for participants to express their implicit leadership theories.

Design. For the leadership development interview, four categories of questions were developed: Teamwork within the Engineering Competition Team, Individual Perceptions of Leadership and Teamwork, Leadership Development within the Team, and Individual Contributions to the Team. To allow validation and enrichment of the responses to the Social Network Questionnaire, some questions were repeated, with wording altered to better suit the semi-structured interview format.

Questions in the first category, *Teamwork within the Engineering Competition Team*, were formulated from the critical elements of theoretical frameworks including shared leadership (particularly from Carson et al., 2007), Hackman's Conditions of

Team Effectiveness (2002), the Big Five of Teamwork (Salas et al., 2005), and the Team Leadership Framework (Burke, et al., 2006). Questions addressed the team's purpose, goal, and structure, as well as team member interactions (Table 3.2).

Table 3.2. Teamwork within the engineering competition team.

1. What is the purpose of your team?
2. What is your team's goal this year? a. How did your team decide on that goal?
3. How is the team structured? (e. g., work groups, subteams, officers, managers)
4. Which subteam are you a member of? a. How are tasks assigned within your [sub] team? b. Who decides?
5. About how many hours per week have you spent working on the [project]? b. When do you usually work? c. With whom do you usually work? d. How do you decide when to work? e. How do you know what to work on?
6. How would you describe the team chemistry?
7. Describe communication within your team. Is it good, okay, poor? a. What makes someone a good communicator? Do you notice that some teammates are better at communication than others? b. What do they do to facilitate team communication? c. How does the team communicate with new members?
8. Tell me about coaching within the team. Who coaches? What do they do? Who receives coaching? *(Coaching* specifically refers to helping members learn technical and other project-related skills.)
9. How does the team handle member errors, conflicts or disputes? a. What happens when a team member makes a mistake?
10. How do team members support each other? Can you give an example? *(Support is broader than coaching. Can refer to assistance with workload, encouragement, cooperation, flexibility in scheduling, etc.)*

Questions in the second category, *Individual Perceptions of Leadership and Teamwork*, were designed to elicit information that would indicate the respondent's developmental stage within the Leadership Identity Development model (Komives et al., 2005, 2006). The first question asked, "What do you think leadership is?" and the

follow-up question asked the respondent to describe how that idea of leadership had changed over the years. Other questions in this section were chosen to reveal specific leadership behaviors exercised by the respondent, such as those included in the Team Leadership Framework (Table 3.3).

Table 3.3. Individual perceptions of leadership and teamwork.

11. What do you think leadership is? a. How has that changed over the years?
12. Other than [team], what groups are you involved in? a. Level of involvement, activities, positions
13. In general, do others consider you a leader? How do you know?
14. Have you had any particular leadership training? Tell me about that.

The third category, *Leadership Development within the Team*, included two specific and critical questions. First, the respondent was asked to identify the leaders on the team. The intent was twofold—to corroborate the list of influential team members identified via the Phase 1 questionnaire, and to determine whether the interviewee recognized nonpositional leaders—that is, members of the team who behave as leaders even though they do not hold a specified office. Then, for each of the team members named, the respondent was asked, "What makes this person a leader?" This very open question allowed the respondent to reveal, unprompted, the attributes he or she associated with leadership (Table 3.4).

Table 3.4. Leadership development within the team.

15. Who are the leaders on [team]?
16. [For each leader mentioned in Q15] What makes this person a leader, in your opinion?

The final category, *Individual Contributions to the Team*, connected the team experience with the respondent's view of leadership and provided further insight into the respondent's LID stage and leadership behaviors. The most important question in this section asked "What has your experience on the team taught you about leadership?" (Table 3.5).

Table 3.5. Individual contributions to the team.

17. How do you contribute to the team? Think beyond your particular job/role.
18. You mentioned earlier that others [consider/do not consider] you a leader. Do you view yourself as a leader on the team? How? a. What makes you [not] a leader? What experiences inform that assessment?
19. What has your experience on the team taught you about leadership?
20. Describe a situation within [team] where you applied leadership training, or applied some knowledge you had gained from previous experience.
21. Is there anything you'd like the team to do differently this year? a. What are you planning to do to make that happen?
22. Is there anything else you'd like to share about leadership?

A modified, shorter set of interview questions was developed for the first-year members. This set excluded questions for which a new member would have no personal knowledge and included questions related to their specific experience as a new member. New members were asked if they had been a part of the team's goal-setting discussions, if they felt comfortable speaking up in meetings, and how the veteran team members communicated with and coached the new members. Interview participants also completed a demographic questionnaire. The interview protocols and demographic questionnaire are included in the appendix.

Participant Recruitment. Potential interview participants were selected from the results of the Phase 1 questionnaire. Team members listed as influential and receiving an indegree centrality score in the top half of their team were invited to participate. First-year members listed as influential were also invited, regardless of indegree score. Additional potential interviewees were nominated by the team captains and/or were mentioned by team members during interviews. Although this method of selection probably introduced bias, I used it as a check to be sure I had not missed important potential participants. I suspected that new members would not have been have been recognized as influential in October, but might have demonstrated some impact in the intervening months. People who were mentioned as leaders during the interview but who had not been listed on the questionnaire could be considered as potential interview participants. For example, two new Sharks who were interviewed were identified using this method. Their centrality scores were too low to have gotten them past the first cut.

First-year participants were included so that the influence of ECT participation on leadership could be evaluated across a range of experience levels. Most perceptions of leadership held by first-year members were likely to have been developed prior to ECT participation.

Potential participants were invited via email to be interviewed. If the candidate did not respond within the first week, two additional attempts were made. The response rate among returning members was generally good; unfortunately, first-year members were less interested. Two first-year Sharks were interviewed, but no first-year Jets participated.

Of the 25 members on the spring Jets roster, 13 were invited to be interviewed. Six members participated in the interview; all were returning members and most held named positions of responsibility. Of the 45 members on the spring Sharks roster, 11 were invited to be interviewed. Eight members, including two first-year members, participated in the interview. With the exception of the new members, all participants were team officers. Interview participants will be more thoroughly described in Chapter 5.

Procedure. With one exception, interviews took place in January and February, approximately the midpoint of the competition year for both teams. One Shark was interviewed in June, a few months after the regional conference. I conducted all interviews. Interview durations ranged from 50 to 120 minutes, with most lasting about 90 minutes. Interviews were digitally recorded.

Prior to the interview, each participant completed an informed consent form and expressly consented to audio-recording of the interview. Each participant then completed a short questionnaire regarding previous competition team experience, high schools and colleges attended, academic majors, family educational background, and demographics. Those who had not answered the Phase I Questionnaire were given the opportunity to do so; all agreed. Participants were paid $25 via deposit to their university dining card accounts.

The interview followed a semi-structured format. I encouraged participants to tell stories and elaborate upon experiences they mentioned. I took care to phrase follow-up questions neutrally, in an effort to avoid suggesting "correct" responses.

Occasionally, I reminded participants that I was interested in learning how they understood leadership, not in evaluating their performance as leaders.

Data Reduction & Analysis. Interview transcriptions and analyses were performed using NVivo 10 for Windows, distributed by QSR International. I transcribed all the interviews. This process improved my understanding of the source material and allowed me to hear nonverbal vocalizations and tonal nuances. The large dataset included almost 17 hours of interviews, which, when transcribed, produced about 200 single-spaced typed pages.

NVivo allows the analyst to establish categories of interest called nodes. Transcript passages can be marked and associated with various nodes, a process known as coding. I employed a qualitative approach with both structured and inductive coding procedures. Before beginning the analysis, I established nodes for each of the interview questions, for the categories and stages of the Leadership Identity Development Model (Komives et al., 2006), for the indicators of internal team environment (Carson et al., 2007), and for leadership behaviors, especially those detailed in the Team Leadership Framework (Burke et al., 2006). I also established nodes for each team member mentioned in an interview, for the teams' respective faculty advisors, and for team leadership positions. I began coding with a structured approach, following the nodes established *a priori*. The structured coding process was followed by several iterations of open coding, during which I re-read the interviews and created nodes for concepts as they emerged, without confining the coding to items already identified (Klenke, 2008). I also analyzed the entire transcripts for frequent words to identify emergent themes.

Two transcripts were also independently coded and analyzed by a colleague. I selected these transcripts for validation because the participants' responses did not easily map into the Leadership Identity Development model (Komives et al., 2006). The identities of the speakers were obscured from the second rater. The second rater's results verified my analysis.

Chapter 4 discusses the results from the questionnaire. This one-time survey gave a snapshot of the teams' internal environments near the beginning of the competition year and allowed me to identify influential team members. This chapter also quantitatively describes the internal social networks of the teams using various individual- and team-level measures. Chapters 5 and 6 discuss the findings from the interviews, including students' ideas about leadership, the behaviors they associate with leadership, and the students' leadership identity development. Chapter 7 integrates the quantitative findings from Chapter 4 with the qualitative findings from Chapters 5 and 6. Quotes from the interviews are used extensively in Chapters 5, 6, and 7 and are indicated by quotation marks. Ellipses indicate omitted words, and square brackets indicate words replaced for the purposes of clarity or anonymity.

Chapter 4

Questionnaire Results

4.1 Participants

The Jets. Approximately 29 students attended the mid-fall Jets meeting. The faculty advisor was present. Twenty-four students answered the questionnaire, and all agreed to have their responses included. In total, 26 Jets completed the Social Network Questionnaire; two who were absent from the meeting completed the questionnaire during an interview session conducted later. Fifteen respondents were first-year members, and 11 were returning members. Due to membership attrition, the number of questionnaire participants slightly exceeded the number of students listed on the spring roster a few months later.

The Sharks. Fifteen students attended the mid-fall Sharks meeting. All of the attendees answered the questionnaire and agreed to have their responses included. The faculty advisor was present. In total, 17 Sharks completed the Social Network Questionnaire; as with the Jets, some absent members completed the questionnaire during subsequent interviews. Seven were first-year members and 10 were returning members. In contrast to the Jets, the Sharks membership tends to peak in the spring, when there is more work to do. Consequently, the number of questionnaire respondents constituted only a third of the membership on the spring roster. As mentioned earlier, no demographic data were collected.

To protect participants' anonymity, masculine and feminine pseudonyms are used in this analysis. Because a chosen name may not match a participant's gender

identity, no implications regarding gender should be drawn. In addition, some identifying details have been changed.

4.2 Data Reduction and Analysis

Calculations were performed using Microsoft Excel for Macintosh (2011) and Windows (2007). The NodeXL template (version 1.0.1.333, 2014) was used for most of the social network calculations and for producing the social network graphs. Statistical analyses were performed using IBM SPSS (version 21).

The collection of influence and leadership ratings of named individuals allowed me to identify key team members and their roles within the teams' social networks. Individual indegree centrality scores were used to select participants for the Phase II interview. I also used the ratings to compute the team-level measures of density and network centralization.

4.3 Internal Team Environment and Coaching

Responses for each question were averaged across respondents within a team to compute subscores for the dimensions of shared purpose, social support, voice, and external coaching (see Table 3.1). An overall internal team environment score was computed by averaging the shared purpose, social support, and voice subscores for each team.

The Jets. Internal team environment ratings for the Jets were generally positive (Table 4.1). The overall Internal Team Environment Score was 4.5. Scores in the Shared Purpose category received the highest mean rating (4.5), while the Social

Support category received the lowest mean rating (3.9). Only Shared Purpose and Social Support differed significantly ($t = 3.401, p = 0.002$).

While the Voice category received an overall average score of 4.1, one question received lower marks than the others. The average score for Statement 8, "As a member of this team, I have a real say in how this team carries out its work," was 3.65; it differed significantly from Statement 7, "People in this team are encouraged to speak up to test assumptions about issues under discussion" ($t = 2.416, p = 0.023$), Statement 9, "Everyone on this team has a chance to participate and provide input" ($t = –3.049, p = 0.005$), and Statement 10, "My team supports the active participation of everyone in decision-making" ($t = –2.440, p = 0.022$). Forty-seven percent of new team members and 36% of returning team members gave this statement a neutral or lower agreement rating. These opinions were not always consistent with other beliefs; three participants who did not feel as though they had a say nonetheless agreed that the team "supports the active participation of everyone in decision-making" (Carson et al., 2007, p. 1233). However, one influential returning team member disagreed with Statement 7, "People on this team are encouraged to speak up" and Statement 8, "My team supports the active participation of everyone in decision-making."

Coaching by the faculty advisor received high marks, with a category mean of 4.3. Only one participant, a new member, gave the advisor low marks on any statement.

The Sharks. Internal team environment ratings for the Sharks were positive (Table 4.1). The overall internal team environment score was 4.4. Category averages for all three dimensions were statistically similar, and subscores for each question all

exceeded 4.0. Coaching by the faculty advisor received high marks as well, with a category average of 4.5.

Table 4.1. Internal team environment ratings.

	Jets			Sharks		
	Team	New Members	Returning Members	Team	New Members	Returning Members
n	*26*	*15*	*11*	*17*	*7*	*10*
Internal Team Environment	4.5	4.3	4.1	4.4	4.2	4.5
Shared Purpose	4.5	4.6	4.4	4.4	4.3	4.5
Social Support	3.9	4.0	3.9	4.3	4.3	4.4
Voice	4.1	4.2	4.0	4.4	4.1	4.5

4.4 Social Network Measures: The Jets

Twenty-four of the 26 questionnaire respondents chose to complete the second portion of the questionnaire. Fourteen individual team members were listed as influential; about half of those held officer positions. Data for one name had to be discarded; there were two people with the same first name on the team, and I was unable to differentiate the responses. As a result, only the 12 individually identifiable members were considered in the analysis.

4.4.1 Team-Level Measures

For the computation of unweighted density and network centralization measures, I assumed a team size of 26. The team had an unweighted density of 0.15 and a network centralization of 57% (Table 4.2).

Following the method used by Carson and colleagues (2007), the leadership density was computed by summing the leadership ratings received by individual team members and dividing by the sum of maximum possible ratings. (In other words, the

denominator assumed that all respondents had given all other team members a rating of 5 on that dimension.) The Jets had a team leadership density of 0.15.

Core group measures. As is common within organizations, the Jets team has a core group of influential members. By using a combination of indegree and eigenvector centralities obtained from the questionnaire results and comments from team member interviews, I identified seven core members: Luke, a system lead; Connor, the captain; Kate, a system lead; Ethan, an executive officer; Mark, an executive officer; Cameron, an administrative officer; and Jacob the Sage, a graduate student with seven years of team experience.

Considering all respondents' ratings of these seven members, the core group's leadership density was twice that of the team as a whole (0.36 vs. 0.15). Within the core group itself (that is, considering only core members' evaluations of other core members), the leadership density was 0.57.

Table 4.2. Team-level social network measures.

				Leadership Density, Core	
	Network Centralization	Density (unweighted)	Leadership Density, Team	As Rated by All Respondents	Within Core Group
Jets	57%	0.15	0.15	0.36	0.57
Sharks	54	0.18	0.20	0.48	0.48

4.4.2 Individual-Level Measures.

Centralities. Indegrees (the number of people listing that person as influential) for the 12 individually identifiable influential team members ranged from a high of 19 to a low of 2, with four members having indegrees of 15 or higher. Corresponding unweighted indegree centralities ranged from 0.67 to 0.07. Four members had indegree centralities of 0.50 or higher, indicating that half the respondents had listed them as influential (Table 4.3).

Betweenness centralities, the score indicating a person's status as a shortest-path connector between team members, ranged from 0 to 153. Normalized betweenness ranged from 0 to 0.51. The highest scores were held by a group of three members: Luke, a system lead (153, 0.51), Connor, the captain (128, 0.43), and Kate, a system lead (117, 0.39). They were followed at a distance by Ethan, an executive officer (50, 0.17), Mark, another executive officer (21, 0.07), and Cameron, an administrative officer (18, 0.06). All other members' normalized betweenness scores fell below 0.04.

Eigenvector centralities, which measure team members' connections to the group's center of power, ranged from 0.014 for a part-time student to 0.09 for Luke, and followed the same pattern as betweenness scores.

Leadership and Influence Ratings. Mean leadership ratings for the 12 influential members ranged from 1.5 (received by an influential new member) to 4.9 (received by Connor and Mark). The overall mean leadership rating for the team was 3.6 ($\sigma = 1.08$). Influence ratings ranged from 2.5 to 4.8 ($\bar{x} = 3.82$, $\sigma = 0.81$). Keep in mind that the leadership rating is a measure of "the extent to which the team looks to this person for leadership" and not a measure of quality or effectiveness.

Mean leadership ratings received by individual team members were correlated with eigenvector centralities ($r = 0.66$) and mean weighted influence ratings ($r = 0.78$), indicating that influential team members were likely to be perceived as team leaders. Note that the social network measures and leadership and influence ratings were calculated from the entire dataset of questionnaire responses, but only the core members' scores are shown in Tables 4.3 and 4.4.

Table 4.3. Jets core group social network measures, calculated using all responses.

	Centrality			Mean Ratings	
	Indegree	Betweenness (Normalized)	Eigenvector (Team)	Leadership	Influence
Luke, a system lead	0.67	0.51	0.09	4.3	4.2
Connor, the captain	0.62	0.43	0.09	4.9	4.7
Kate, a system lead	0.55	0.39	0.08	4.4	4.3
Ethan, an executive officer	0.52	0.17	0.07	4.1	3.9
Mark, an executive officer	0.31	0.07	0.06	3.2	3.4
Cameron, an officer	0.17	0.06	0.06	3.2	3.4
Jacob, the Sage	0.21	0.02	0.04	4.2	4.8

4.5 Social Network Measures: The Sharks

Fifteen of the 17 questionnaire respondents chose to complete the second portion of the questionnaire. Sixteen individual team members were listed as influential; about half of those held officer positions.

4.5.1 Team-Level Measures

For the computation of unweighted density and network centralization measures, I assumed a team size of 17. The team had an unweighted density of 0.18 and a network centralization of 54%. The Sharks had a leadership density of 0.20 (Table 4.2).

Core group measures. The eight-member core group consisted of Danna, the captain; Jasmine, an officer; André, the secretary; Tom, an officer; Rob, an officer; Anita, an officer; Lee, an officer; and Patrick, an executive officer. As rated by all respondents, the core team's leadership density was 0.48, over twice the leadership density of the overall team. Within the core group itself, the leadership density was also 0.48.

4.5.2 Individual-Level Measures

Centralities. Indegree counts for the 16 influential team members ranged from a high of 12 to a low of 1. The top 2 members had indegrees of 11 (Jasmine) and 12 (Danna); a cluster of three members had indegree counts ranging from 5 to 7 (Tom, André, and Rob). Corresponding unweighted indegree centralities ranged from 0.75 to 0.06. Only two members had indegree centralities of 0.5 or higher; centralities for the next four members ranged from 0.31 to 0.44 (Table 4.4).

Betweenness centralities for the Sharks ranged from 0 to 82. Normalized betweenness ranged from 0 to 0.57. The two highest scores were held by the captain (82, 0.57) and Tom (65, 0.45). They were followed by André (45, 0.31), Jasmine (37, 0.26), Patrick (39, 0.25) and Rob (13, 0.08). All other members' normalized betweenness scores fell below 0.02.

Eigenvector centralities ranged from 0.01 to 0.11. Again, the captain received the highest score. In contrast to the betweenness measure, Jasmine held the second-highest eigenvector centrality (0.10), followed closely by André, Rob, and Tom (0.095, 0.094, and 0.093).

Leadership and Influence Ratings. Leadership ratings ranged from 1 to 4.83 ($\bar{x}$ = 2.75, σ = 1.29). Influence ratings ranged from 1 to 4.17 ($\bar{x}$ = 3.1, σ = 0.88). The captain had the highest score on both measures. The overall Sharks team had a leadership density of 0.20 and an influence density of 0.20. For the eight-member core group, leadership density was 0.36 and influence density was 0.33.

Mean leadership ratings received by individual team members were closely correlated with eigenvector centralities (r = 0.82) and mean weighted influence ratings

($r = 0.74$), indicating that influential team members were likely to be perceived as team leaders.

Table 4.4. Sharks core group social network measures, calculated using all responses.

	Centrality			Mean Ratings	
	Indegree	Betweenness (Normalized)	Eigenvector (Team)	Leadership	Influence
Danna, the Captain	0.75	0.57	0.10	4.8	4.2
Jasmine, an officer	0.69	0.26	0.10	3.7	3.5
André, the secretary	0.38	0.31	0.09	3.6	3.4
Tom, an officer	0.31	0.45	0.09	3.6	3.4
Rob, an officer	0.44	0.08	0.09	4.2	3.5
Anita, an officer	0.31	0.02	0.09	2.6	3.4
Patrick, an executive officer	0.19	0.03	0.09	4.3	3.3
Lee, an officer	0.25	0.00	0.06	3.3	3.5

4.6 Discussion

4.6.1 Internal Team Environment

Both teams appeared to have a positive internal environment, with both new and returning members of both teams giving strong marks in all categories. At this early point in the season, it appears that both new and returning members felt included in the teams. Although a later questionnaire was not administered, retention was estimated by comparing the names of the fall respondents to the names on the roster for the following spring. The Sharks appeared to have retained most of their members: Of the fall questionnaire respondents, all but one were on the spring membership list. The Jets did not fare as well: Nine questionnaire respondents (6 new members and 3 returning members) were not listed on the spring roster. Care should be taken in interpreting these results, however. The Jets' roster appeared to be carefully assembled and included team roles, academic major, classification, contact information, and number of years on the team. The roster supplied by the Sharks, on the other hand, included only names and

appeared to have been pulled from an email distribution list. Because building a canoe requires considerable labor during the sanding phase of construction, it is possible that the team performed only limited curation of its membership list.

4.6.2 Team Social Network Measures

The overall social network measures for the teams appear similar. Both had network centralizations around 0.55, suggesting an intermediate amount of shared leadership within each team (Gockel & Wirth, 2010). The unweighted densities (constructed from the lists of influential members) were also similar, with officers and experienced members receiving the largest indegree counts.

The mean leadership rating was higher for the Jets (3.6) than for the Sharks (2.75); however, the Sharks' average was lower in part because some respondents listed several members as personally influential but gave them low leadership ratings. The leadership density of the Sharks (0.20) was higher than that of the Jets (0.15), suggesting a greater level of shared leadership within the Sharks team as a whole. However, because questionnaires were not completed by all team members, these results may not accurately characterize the teams.

The team-level social network measures were neither surprising nor enlightening. A deeper exploration of the roles played by certain influential members and the relationships within the core groups reveals the contrasts between the two teams' leadership styles.

4.6.3 Individual Social Network Measures

The Jets. Within the Jets, Luke was the most influential member. He held the highest indegree, having been named an influential member by 79% of respondents. He also held the team's highest betweenness and eigenvector centralities, indicating his role as a bridge between team members and between the core group and the rest of team. While it was clear from the questionnaire results that both new and returning members held Luke in high esteem, the reasons were not obvious. This member was not the captain, and his tenure on the team was not particularly long. Interviews conducted a few months later revealed the source of these high ratings: Luke's active inclusion and patient training of new members, positive attitude, friendly demeanor, and work ethic. He had a positive view of younger members and expressed a willingness not only to guide them but to listen to and learn from them as well. This attitude was evident in his list of influential members. While most of the returning members listed only other returning members as influential, Luke listed two new members as personal influences.

The second-most influential member of the Jets—as indicated by indegree, betweenness, and eigenvector centralities—was the captain. With an average leadership rating of 4.9—the highest of any member—Connor was clearly respected. The respect was mutual. Like Luke, Connor listed two new members as personal influences. Interview participants elaborated on his skill in collaborative decision-making, project management and boundary spanning.

The Sharks. Within the Sharks, the captain was clearly the most influential member. She had the highest indegree, betweenness, and eigenvector centralities, and her 4.8 leadership rating exceeded the next highest rating by half a point. Influence

patterns were more mixed for the Sharks than for the Jets. For example, Jasmine and Tom had similar eigenvector centralities, indicating similar levels of power. But Tom played a more important role in connecting team members, as shown by betweenness scores (Table 4.4). Patrick's score differences were particularly extreme. As expected for the leader of a related engineering organization, his eigenvector score was high (0.09). But his indegree centrality was the lowest of the core Sharks team members, and he clearly did not serve as an important bridge between members.

4.6.4 Core-Group Social Network Measures

The differences between the teams' leadership styles are clearly shown by the relationships among the core team members, as illustrated in the sociograms below (Figures 4.1 and 4.2).

The Jets. The seven members of the Jets' core had a dense web of influence relationships, including seven strong reciprocal relationships; that is, pairs of members who gave each other personal influence ratings of 4 or higher. These are represented in the sociograms as double arrows (Figure 4.1). This sociogram suggests a free flow of information and a large amount of collaboration, an observation corroborated by later interviews. (One of the core team members—the Sage—did not complete a questionnaire; the lack of reciprocal relationships including this member is therefore merely an artifact.

Furthermore, the core Jets team clearly believed that the team at large looked to the core members for leadership. Leadership was not concentrated within a few individuals. Of the eight reciprocal pairs in the leadership sociograms (Figure 4.2), three

included Connor and five included Mark. The medium level of leadership density of the core group (0.57) indicates some shared leadership.

The reader will notice that the Jets' influence sociogram shows eight members. The Veteran, a part-time student with several years of team experience, is not included in the core group centrality calculations because his social network measures were too low, probably because he is unfamiliar to the first- and second-year members. He is included in the graph because of his long association with the core team in general and strong friendship with one core team member.

The Sharks. The Sharks' core group contained 8 members. Although the leadership density within the Sharks core suggests some amount of shared leadership, there were only two strong mutual leadership ratings, and both included the captain (Figure 4.2). Similarly, all but one of the core team members were strongly influenced by the captain, but the captain was not strongly influenced by anyone. This suggests some impedance to the flow of information. Although leadership in the team appeared unbalanced, the captain was not the only leader. Four members of the core Sharks group believed that Jasmine and Rob also provided strong leadership to team. However, both Jasmine and Rob appeared to associate leadership with position. Jasmine listed only Patrick, Danna, and Rob as personally influential (Figure 4.1) and gave all of them strong team leadership ratings (Figure 4.2). Rob gave three people strong influence ratings (Figure 4.1). Although Rob did not consider Danna a strong source of personal influence, Danna was the only team member to receive a strong team leadership rating from Rob (Figure 4.2).

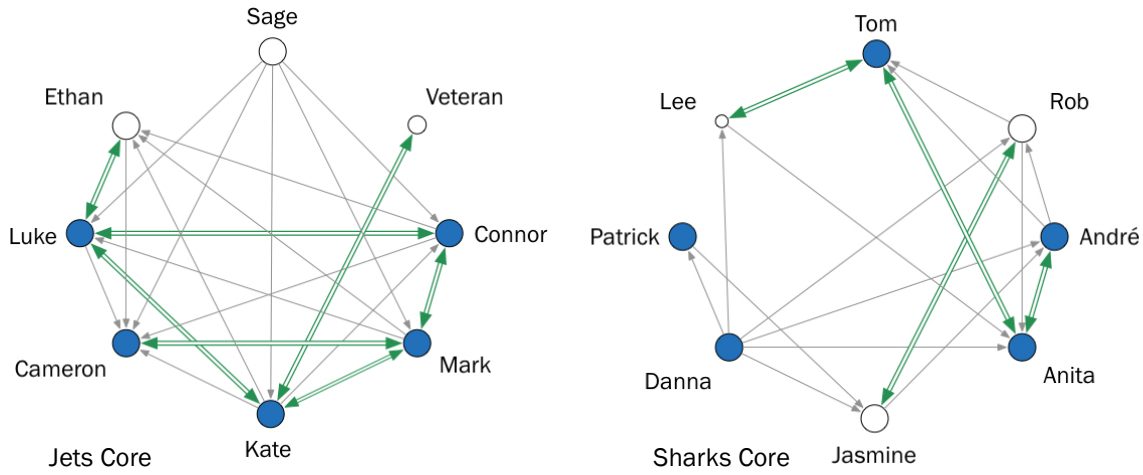


Figure 4.1. Core-group influence sociograms. Shaded circles represent high within-core eigenvector centralities. Arrows indicate the direction of influence. Only within-core influence ratings of 4 or higher are shown.

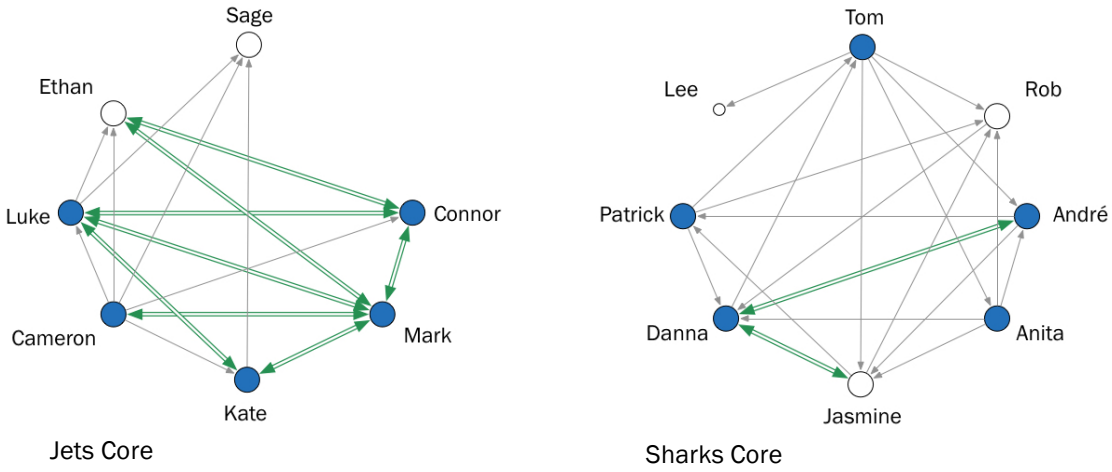


Figure 4.2. Core-group leadership sociograms. Shaded circles indicate high within-core eigenvector centralities. Arrows represent leadership ratings and indicate that the sender considers the receiver to be a source of leadership for the team. Only ratings of 4 or higher are shown.

Recall that eigenvector centralities are a measure of power and influence. In apparent contrast to the shared leadership findings, seven members of the Sharks had eigenvector centralities of 0.10 or 0.09, suggesting a fairly even distribution of power. But being considered does not always translate to the exercise of influence. Taken

together, these findings suggest that the core Sharks team exhibited less shared leadership, less information sharing, and less collaboration than the core Jets team. This assessment is strongly supported by comments made during the spring interviews.

Comparison. The difference between the teams' sociograms is striking. The core Sharks group had just four strong influence relationships, while the Jets core had seven (Figure 4.1). This may be due in part to the nature of the competitions and the timing of questionnaire administration. A car is a complex machine. Design and fabrication of each part affects the others, and frequent communication between the system leads is necessary. Design work begins in the summer, and the project is well underway by mid-fall. The concrete canoe is technically simpler; the design of the hull and the choice of concrete mix are not contingent on each other. During the fall, the subteams (e. g., display, mix design, paddling, and construction) work fairly independently, and communication among the officers regarding technical issues is less frequent.

While timing explains some of the difference between the teams' influence structures, it does not tell the whole story. The difference between the captains is notable. The Jets captain was strongly influenced by four other core members. The Sharks captain, on the other hand, listed four members as personal influences but gave all of them a level-three rating on the Likert scale. This apparent insensitivity to influence likely reduced the captain's effectiveness. As we will see later, some members tried to share relevant information with the captain throughout the season. The failure of the captain to heed the advice of the core team members negatively affected both canoe construction and competition performance.

4.6.5 Limitations

Social network analyses are most meaningful when all members of a group are included. Fewer than half of the Sharks and approximately two-thirds of the Jets completed the questionnaire, so influence and leadership patterns were not fully characterized. One member of the Jets core group, the Sage, did not respond to the survey, so his opinions are not reflected in the analysis.

The questionnaire was administered once, providing only an early-season snapshot of each team. Administering the questionnaire a second time, perhaps midway through the spring semester, would have provided meaningful information regarding the internal team environment and relationships among team members during the high-stress period prior to competition.

4.6.6 Conclusion

Social network measures are a useful tool in evaluating leadership development at both the team and individual levels. While the core Sharks appear to have strong friendships with each other, the captain is clearly considered The Leader. Power within the core group of the Jets, in contrast, is not concentrated with one person; this group appears to share more of the decision-making than does the core Sharks group.

At the individual level, advancement to an executive position can be an indicator of leadership development. Hansen and colleagues (2011) noted that "…individuals who bridge structural holes are promoted faster than others" (p. 40); that phenomenon was evident in this study. Betweenness (or bridge) scores predicted attainment of top leadership positions in the subsequent season for members of both teams in this study.

Of the students who remained in school, the highest-scoring Jet and the top four Sharks were subsequently named to high officer positions, either within the team or in another engineering organization.

Of course, social network measures show only patterns; they are not particularly rich in meaning. For a deeper understanding of leadership development within competition teams, we must also examine the stories of the team members themselves. The following chapters discuss the findings from the interviews, including students' ideas about leadership, the behaviors they associate with leadership, and students' leadership identity development.

Chapter 5

What Behaviors and Characteristics Do Engineering Competition Team Members Associate with Leadership?

Author's Note: This paper was accepted for publication in the *Proceedings of the 2015 ASEE Annual Conference*. It is reproduced here with only minor changes, primarily typographical corrections. Tables and figures were renumbered and the citation format was changed to maintain consistency with the rest of this document. One citation was added. The "first author" mentioned below is the author of this dissertation.

Engineering student competition teams (ECT) are promoted as incubators for the development of leadership (Wankat, 2005; Sulzbach, 2007), yet we know little about how leadership actually develops within these teams. A case study of two teams at a public university in the central U. S. was performed, with the objective of exploring leadership development at the individual and team levels. Implicit in the concept of team leadership development is the development of individuals as leaders. This paper discusses the behaviors and characteristics that students participating on those teams associate with leaders and leadership. Team members strongly associated five categories of behavior with leadership: Ideal Behavior, Individual Consideration, Project Management, Technical Competence, and Communication. Other leadership behaviors, including Collaboration, Training & Mentoring, Problem-Solving, Motivating Others, Delegation, and Boundary-Spanning, were less consistently recognized, and some behaviors were valued more highly within one team than the other. When asked to define leadership, most team members ascribed to a mainstream view. A few team members revealed a more mature understanding of the nonpositional and collectivistic aspects of leadership.

5.1 Background

The Jets and the Sharks are the largest engineering competition teams at this institution. The Jets compete in the Formula SAE Collegiate Design Series (FSAE), and the Sharks compete in the National Concrete Canoe Competition. Both teams are extra-curricular and largely self-managed, and their membership is drawn from all undergraduate levels. Team members can participate over several years, making it possible to examine the contribution of the ECT experience to students' leadership development.

Formula SAE is one of many collegiate vehicle design competitions sponsored by the Society of Automotive Engineers. The product is a small race car similar in style to a Formula One machine. The vehicle is powered by a purchased motorcycle engine; all other vehicle systems are designed and/or built by the student team members. Each competition consists of several events. Teams earn points on the basis of design, the writing and presentation of a technical report, and, of course, race performance. Competitions are held in late spring and early summer and are not hierarchical. Some teams participate in more than one competition each year, and participation is not dependent on prior performance.

The American Society of Civil Engineers (ASCE) sponsors the National Concrete Canoe Competition. The competition consists of several events, including canoe design and display, a technical paper and presentation, and races. First-level competitions are held annually during the spring at 18 regional student conferences; the winners of the regional competitions advance to the national competition.

5.2 Method

Study data were collected in two phases; this paper reports a subset of results from the second phase. Participants for Phase 2 were identified using a social network influence measure captured in Phase 1.

In the first phase, attendees at mid-fall team meetings of the Jets and Sharks teams responded to a paper-and-pencil questionnaire regarding team processes and influential team members. Each respondent wrote the names of the current team members who influenced them. The term "influence" was chosen in an effort to identify members who exhibited leadership behaviors but who might not fit a respondent's idea of a leader. Framing the list around influential members broadened the scope of analysis and facilitated the investigation of leadership development across the team rather than the development of students who were already considered leaders.

Respondents worked individually. For each person they listed as influential, the respondent used a 5-point Likert scale to indicate the extent to which that person influenced them personally, and the extent to which the team relied on that person for leadership (following the method proposed by Carson et al., 2007). These ratings were used to compute several social network measures. One of these measures, indegree centrality, was used to identify potential interview participants.

A brief explanation of indegree centrality is in order. In social network theory, there are several ways to measure an individual's connections within a group. The simplest measure, *degree,* refers to the number of connections a person has to others. It can be an undirected measure, indicating a relationship between two people (as in, Erica is friends with Jeff), or it can be a directed measure (as in, Erica influences Jeff). When

directed, degree can be expressed in terms of *indegree* or *outdegree*. A person with high indegree influences many other members, while a person with high outdegree is influenced by many others. To ease comparisons between members of different-sized groups, a normalized measure, *degree centrality,* is often used. Degree centrality is computed by dividing the degree by n–1, where n = the number of people in the group (Wasserman & Faust, 1994).

Team members listed as influential and receiving an indegree centrality score in the top half of their team were invited to participate in the Phase 2 interviews. First-year members listed as influential were also invited, regardless of indegree score. Additional potential interviewees were nominated by the team captains and/or were mentioned by team members during interviews.

5.2.1 Participants

At the time of the interviews, the Jets roster listed about 25 members and the Sharks roster listed about 45 members. In total, fourteen students, all engineering majors, participated in individual recorded semi-structured interviews exploring the team experience and their own leadership development journeys. Six participants were Jets, and eight were Sharks. Thirteen were pursuing the bachelor's degree, and one was in graduate school. Four were women, and four identified as members of nonwhite ethnic groups (1 Hispanic, 1 Asian-American, and 2 Native American). No freshmen were interviewed.

Of the participating Jets, all had been on the team for at least one year, and most held named positions of responsibility. All had completed at least 5 semesters at the

university, and experience on the team ranged from about 12 months to 5 years. None had been involved with any other collegiate engineering competition teams.

Of the participating Sharks, eight were returning members and two were first-year members. The youngest had completed 3 semesters at the university; all others had completed at least 5 semesters. With the exception of the new members, all participants were team officers. Experience on the team ranged from about 6 months to almost 5 years. One student had briefly participated in another collegiate engineering competition team.

5.2.2 The Interview

Interviews have been used to explore leadership development among several groups, including athletes (Dupuis, Bloom, & Loughead, 2006), members of the military (Mumford et al., 2007; Jones et al., 2009), and college student leaders (Jones et al., 2009; Komives et al., 2005). The technique is especially valuable for uncovering participants' implicit leadership theories, allowing researchers to understand "what people actually mean when they attribute actions to leadership" (Bresnen, 1995, p. 498).

The first author conducted all interviews. With one exception, interviews took place early in the spring semester approximately the midpoint of the competition year for both teams. One Sharks participant was interviewed in June, a few months after the regional competition. Interview durations ranged from 50 to 120 minutes, with most interviews lasting about 90 minutes.

The interview followed a semi-structured format. Participants answered several questions designed to elicit their understanding of behaviors and characteristics associated with leadership. Specifically, respondents were asked, "What is leadership?"

Later, they were asked to name leaders on the team; for each person named, they answered the question "What makes this person a leader?" They also described their leadership self-identity (Komives et al., 2005) and gave examples of their own leadership behaviors. Most respondents spent several minutes explaining their views, and many gave multifaceted definitions.

5.2.3 Researcher Bias

The first author and interviewer approached this study with the idea that engineering competition teams would benefit by exercising leadership from a collectivistic and process-oriented standpoint. Because engineering students are developing their technical expertise, they must rely on collaborative learning and the sharing of knowledge in order to produce a quality product. Despite her bias, the author approached the project as an explorer. Her goal was not to support a proposition. Instead, she sought to determine *what* engineering students understood about leadership and *how* team participation influenced that understanding.

The second author works with a multidisciplinary research team focused on building a more equitable and diverse cultural climate within engineering education. One focus of the research group has been on issues of diversity and inclusion within ECTs. For this project, the identities of participating ECT members were obscured from this author.

5.2.4 Trustworthiness

The interviewer took care to phrase follow-up questions neutrally, in an effort to avoid suggesting "correct" responses. Occasionally, the interviewer reminded

participants that the research team was interested in learning how they understood leadership, not in evaluating their performance as leaders.

The first author transcribed all the interviews. The original recordings were retained, making it possible to review and correct the transcriptions as needed. Thematic interpretations were proposed through an iterative process between the authors and refined through discourse with the larger research team.

5.2.5 Coding

Interview transcription and analysis were performed using NVivo 10 for Windows, distributed by QSR International. The analysis followed a qualitative approach with both structured and inductive coding procedures.

A limited set of *a-priori* codes was established, including a code for each interview question and umbrella codes for "Leadership Behaviors" and "Leadership Characteristics." Specific attributes were not identified prior to coding. The umbrella categories were analyzed for emergent themes, which were then compared to existing definitions of leadership and leader behavior found in the literature.

A few notes on terminology are in order. First, respondents typically referred to members with defined areas of responsibility as "leads" or "system leads" rather than "officers." In this paper, the terms are used interchangeably. Second, in an effort to obscure the identities of the respondents and the teammates discussed, some pronouns, including those in quotations, have been changed. No implications regarding gender are intended. Third, the term "behaviors" will be used as a short reference for both behaviors and characteristics.

5.3 What is Leadership?

As expected, most team members ascribed to a mainstream view: Leadership is getting a group of people to work together toward a goal (Bresnen, 1995; Yukl, 2013). That ten of the fourteen team members gave some form of this definition was not surprising. All team members had received some collegiate leadership education through a required professional development course. All but one participant had received additional explicit leadership education through other courses, extracurricular activities, and leadership workshops at both the high school and college levels. Even the one participant who reported no focused leadership training did mention high school sports as a source of leadership learning.

Most students elaborated on the mainstream definition, and their additional comments were revealing. Like students interviewed by Komives and colleagues (2006), team members did not always distinguish between "leaders" and "leadership." While some scholars promote the idea of leaders and leadership as separate phenomena (Crevani et al., 2010; Day, 2001), the college students in this study did not generally recognize such nuances. For example, four team members discussed leadership in terms of the leader's responsibility to act as an example or ideal. Although most of these students also mentioned other aspects of leadership, one respondent defined leadership exclusively in heroic terms: "Leadership [is] standing up and doing what needs to be done even when… the odds are against you… doing the right thing, making sure work gets done [and] gets done correctly."

The existence of followers as a necessary condition for leadership was identified by four team members. A veteran Sharks team member who had been an officer in

several large engineering organizations said, “Leadership is about having people follow you. If you don't have all the skills necessary to make people want to attach themselves to what you're doing, then you're not a leader.” A Jets officer said, “You have to have followers to be a leader. You can't lead by yourself.” The same person believed that he had been chosen as an officer because “I was doing something right that people thought [I was] leading in the right direction. I had a mentality of the team that others liked and then [they] elevated me to a designated role to be a leader on the team.” A Shark expressed a similar view, defining leadership as “[having] abilities or ideas… that people think would be best for them and the team.”

Four team members defined leadership in terms of guidance, particularly in relation to team-related technical and procedural knowledge. Although none used the word “mentor,” their definitions were consistent with the concept. One Sharks officer said, “A leader is... a person that knows what they’re doing… I have the knowledge to teach somebody… So after I graduate whoever was [working] with me that’s a younger age, they’ll probably do the same thing or better.” Another said a leader “[makes] sure they know why they’re doing the things that they’re doing… and [that they are] learning along the way.” This view was also expressed by two Jets, one of whom said “leadership is being able to work with other people and use your experiences as a form of guidance or suggestion. And to show through your own actions how your experience has impacted how you do things.”

Two themes indicating a mature understanding of leadership emerged: the concepts of nonpositional leadership and shared leadership (Komives et al., 2005, 2006). Three Jets recognized nonpositional leadership—that leadership is not confined to those

who hold official positions. In the words of one officer, “You don't even have to set out to be the leader... Apparently I was doing something right that people thought [I was] leading in the right direction… and then [they] elevated me to a designated role to be a leader on the team.” Another longtime officer said, “There's a difference between having a leadership role or title and actually leading… It's not necessarily what title you have. It's what you do with what you know, and how you interpret situations or impart that information to others.”

These three Jets and one Shark expressed ideas consistent with the concept of shared leadership, although they did not use that term. One officer believed that “If you have a lot of people who are leading, it's easier in my opinion to develop the team… Having a lot of people who will lead in various areas… is helpful to team development and personal development.” Another said that the team competition team experience “showed me that you can’t have just one leader. When you have that, everything does start falling through the cracks.” A system lead spoke at length along these lines: “Leadership is… not about one person. It's much more of a group effort… So it's not any one person being the leader… maybe one guy is organizing it, and he is necessarily a leader in that instance, but I think it's more the communication between the group as far as working together for one goal.”

A Sharks officer expressed a similar view: “Before I joined Canoe, I always thought leadership is one person. One person should be in charge of everything and making sure everyone plays their part. But when I’m in Canoe, it’s a lot different. We have multiple people who [are] leaders. All the leads, you shouldn’t just have the title,

but you actually contribute to the whole… if you're a leader, then you should always step up and help out the other leaders. It's more of a group thing I think."

As the quotations above indicate, most team members gave a conventional answer when asked to define leadership, while a few revealed a more mature understanding of the nonpositional and collectivistic aspects of leadership. The answers to additional questions regarding leadership practice were examined to develop a more complete understanding of the team members' implicit theories of leadership.

5.4 What Makes a Leader?

Shortly after describing their definitions of leadership, team members named the leaders on the team and then explained, for each person named, what made that person a leader. Team members were later asked to identify and describe new members who might become team leaders in the future. Toward the end of the interview, they were asked about their own leadership behaviors. These descriptions revealed a range of depth and understanding. In several cases, the team members' descriptions of leadership behaviors were much richer than their definitions of leadership.

Because team members used different words to describe similar behaviors and characteristics, responses were grouped by semantic similarity. For example, "looks to the future" and "has a vision for the team" were put in the same group. Another group included such comments as "helps others" and "supports struggling members." A third group included statements such as "slightly bossy" and "likeable and authoritative."

Behaviors were also compared to definitions from various leadership constructs, including but not limited to the Ohio State Model (as described by Judge, Piccolo, & Ilies, 2004), Transformational & Transactional Leadership (Burns, 1978; Bass, 1985),

Functional Leadership (Fleishman et al., 1991), Functional Team Leadership (Morgeson et al., 2010) and the Team Leadership Framework (Burke et al., 2006) The Ohio State model, developed in the 1950s, proposed the division of leadership behaviors into two major categories: Consideration, which focused on interpersonal relationships, and Initiating Structure, which focused on task accomplishment. Burns (1978) and Bass (1985) extended these ideas to construct one of the 20th century's most influential frameworks for describing leadership behaviors: Transformational and Transactional Leadership. Transformational behaviors are exercised when leaders pursue positive organizational change through inspirational motivation, intellectual stimulation, idealized influence, and individual consideration. Transactional behaviors, on the other hand, are those focused on an exchange relationship between leaders and followers: contingent reward is one example. Functional Leadership took a different approach. Rather than focusing on a leader's charisma and other personal attributes, the functional perspectives held that the "leader's main job is to do, or get done, whatever is not being handled for group needs" (McGrath, 1962). The Functional Organizational Leadership Model (Fleishman et al., 1991) proposed that leadership behaviors could be grouped under four categories: Information Search & Structure, Information Use in Problem Solving, Managing Material Resources, and Managing Personnel Resources. Functional Team Leadership (Morgeson et al., 2010) extended this concept (which had assumed a focal leader) to team settings. Burke and colleagues (2006) conducted a meta-analysis of these and other leadership models. Their resulting Team Leadership Framework identified and described the range of leadership behaviors exhibited within teams.

Thematic coding of the ECT transcripts produced 11 categories of leadership behaviors: Ideal Behavior, Individual Consideration, Project Management, Technical Competence, Communication, Collaboration, Motivating Others, Training & Mentoring, Delegation, Problem-Solving, and Boundary-Spanning (Table 5.1). To assess the relative importance of these concepts, team members mentioning behaviors in each category were counted (Table 5.2).

Table 5.1. Definitions of behavioral categories.

Behavioral Category	Definition
Ideal Behavior	Behaving as a role model for team members.
Individual Consideration	Recognizing that each team member is an individual person with particular talents, needs, constraints, and desires.
Project Management	Establishing and managing team processes for scheduling the work, accomplishing tasks, and meeting goals.
Technical Competence	Possessing practical and theoretical knowledge and skill relevant to the project.
Communication	Sharing information via formal and informal channels; discussing the project with team members; listening to team members.
Collaboration	Working with teammates to create solutions. Collaboration is characterized by a mutual and multidirectional exchange of ideas.
Motivating Others	Encouraging team members to participate, persist, and excel.
Training & Mentoring	Helping team members develop relevant technical and administrative skills.
Delegation	Assigning tasks to team members, and trusting team members to complete those tasks with reasonable competence.
Problem-Solving	Identifying problems and seeking solutions to technical challenges. Seeking improvement in team functioning and performance.
Boundary-Spanning	Working with stakeholders outside the team, including the advisor, university administrators, sponsoring companies, and alumni. Also, bridging the gap between factions within the team.

Team members strongly associated five categories with leadership: Ideal Behavior, Individual Consideration, Project Management, Technical Competence, and Communication. The first four were mentioned by all respondents, and Communication was mentioned by all but one member of each team. These categories closely corresponded with the themes they had expressed when defining leadership.

"Coordinating a group of people to achieve a goal"—the most common definition given by the team members—requires the exercise of behaviors from all of these groups.

Other leadership behaviors were less consistently recognized. Collaboration, Training & Mentoring, and Problem-Solving were highly valued by the Jets, while Motivating Others and Delegation were more important to the Sharks. Boundary-Spanning was associated with leadership only by only a few members of each team.

Table 5.2. Behavioral categories and frequency of mentions, by team.

	Sharks		Jets	
	Team Members Mentioning	Percentage	Team Members Mentioning	Percentage
Ideal Behavior	8	100%	6	100%
Individual Consideration	8	100%	6	100%
Project Management	8	100%	6	100%
Technical Competence	8	100%	6	100%
Communication	7	88%	5	83%
Collaboration	5	63%	6	100%
Motivating Others	6	75%	4	67%
Training & Mentoring	3	25%	5	83%
Delegation	6	75%	2	33%
Problem-Solving	2	25%	5	83%
Boundary-Spanning	3	25%	3	50%

Ideal Behavior. Leaders exercised Ideal Behavior by "set[ting] the example," working "for the benefit of the team," being "willing to take up any challenge," and "accept[ing] responsibility for mistakes." In the words of a Jet, "As a leader you almost have to be perfect or someone's going to call you out on it." Regular attendance and hard work were frequently mentioned. One respondent astutely recognized that "If somebody new comes and you're there every time they're there, then they're going to remember you and consider you a leader." A new member of the Sharks noted that "Time commitment… is another leadership quality you need… I don't think [the captain] and [another officer] slept for the three days leading up to competition."

Commitment was regarded as a critical aspect of team leadership. In the words of a senior executive on the Jets team, "As a leader, you have to sacrifice a lot."

*Individual Consideration***.** The association of Individual Consideration with leadership was evident throughout the interviews. The practice of Individual Consideration involves the treatment of each member as a unique person with particular needs and desires.[16] Individual consideration can be exercised through such behaviors as friendly acknowledgement, encouragement, invitations to participate, and personal recognition–in short, treating each member as a valued colleague.

Team members frequently mentioned the nature of the team as a "volunteer organization" and recognized that, as such, there were few material rewards or punishments that could be employed to induce participation and commitment. In environments where contingent-reward behaviors are not effective, individual consideration becomes crucial for recruitment, retention, and good team performance. Several students described systematic approaches for addressing recruitment and retention. According to a Shark, "When we go team meetings… we don't sit next to our friends who are leads. We all separate and go talk to new people… And so through that we're forced to build relationships with the new people on the team." A Jet who frequently works with new members explained that "you have to figure out what's the best way to communicate with [a new] person." According to a teammate, the Jets captain was especially good at this: "If a new guy comes in and… doesn't have anything to do and nobody talks to him, [the captain] is the first guy that says, 'Hey, what do you want to do today?'"

Helping others accomplish tasks and helping members find meaningful involvement were valued behaviors in both teams. A member of the Jets explained it this way: "If you can't do your system, let me help, and then you can help me with mine later… I'm not going to dog you for [struggling]; I'm going to help you out.'" A similar philosophy was expressed by a Sharks lead, who said, "[One aspect of leadership is] making sure that everyone can play their part, and making sure that each part is played by someone that can handle it. And if they can't handle it, helping them out… As a leader I think it's important to not take [away a struggling member's] responsibilities but help them out with that." On the other hand, some team members had learned to recognize and accept others' weaknesses. Said one officer, "It's learning how to deal with certain people and knowing where their strengths are, so that you don't put too much on them so it puts the team back… I've realized some people are very good at manufacturing… [but] if you give them a system to [design] they can't get it done."

Project Management. Team members clearly recognized the necessity of good structures and processes. The Project Management category included behaviors associated with establishing structure (Judge et al., 2004) such as keeping the team on schedule and assigning tasks, and broader descriptors such as "getting things done" and making decisions. The fact that all team members considered behaviors in this category as indicators of leadership was unsurprising given the project-oriented nature of the competitions.

For both teams, organizing the team to achieve a goal was the most common project-management behavior mentioned. Many team members associated "making sure everything gets done" with leadership, a perspective corresponding the functional

leadership models (Fleishman et al., 1991; Morgeson et al., 2010; Zaccaro et al., 2001). As explained by a team officer with extensive leadership role experience, "You have to show that you've thought things out, you have a plan, and that you're going to execute it. You're not just going to attempt to do something; you're actually going to do something."

Planning, scheduling, and monitoring progress were especially valued. One lead was described as "very meticulous… he's very good at putting schedules in order and making sure everyone knows what their job is… So he's never going to lead a meeting but he's very good at making sure everyone's on the same page." Another lead "has that ability to make sure a project she's working on comes to completion… she knows where she needs to be at every checkpoint along the way." A third officer was complimented because she "always has her sights set ahead of where we need to be. So last year we didn't start [event] practices until maybe two weeks before competition. We're a couple of months out now and she's already trying to plan one for this weekend. We had multiple [practices] last semester… She's really into making sure that she's doing everything she can to make the team as strong as possible."

Coordinating schedules and obtaining progress feedback were especially important to the Jets. According to one officer, "during [design] meetings we go through the whole car and the components, and it's literally my job to talk to everyone and figure out why you're behind and why you're not." Of course, staying on schedule was rarely easy. One Jet said that it was important for leaders to "Make a note, make a weekly report, and ask everyone's status. And if you start hearing the same status every week, that's on paper, you can hold them accountable."

Two officers on each team mentioned the importance of holding people accountable. The Jet, who had extensive team experience, clearly understood the difficult side of leadership. He mentioned the need to "hold people accountable," "make tough decisions," and "relieve people [of responsibility] when necessary." Speaking from personal experience, he remarked that the exercise of leadership sometimes required "aggressive" behavior, even when such behavior did not come naturally.

Technical Competence was the fourth category of leadership characteristics mentioned by all team members. As one person succinctly stated, "The people who seem the most knowledgeable about the topics are going to be the leaders." A Jet explained that the "complexity of the project" demanded technically knowledgeable leaders: "Being well-rounded helps. [If you have] manufacturing experience, … you can look at a [design] and within thirty seconds say, yeah, we can machine this here or no, we can't… and if there's conflicting designs… you can identify and say [how this will affect the other parts of the car]."

In the view of a Shark, technical competence was more important for leadership in competition teams than in other organizations: "If you ask [a team member] to do [something] and they think you know what you're talking about, then they'll do it for you. And if you don't, then they won't. And I think that's different from the leadership experience I've had in the past."

Several team members mentioned technical competence as one of their leadership strengths. In the words of one officer, "I'd say [that others consider me a leader]… They know I'm competent and I can do what I say I'm going to do." Another credited obtaining a leadership role to her technical skill: "[The previous office holder]

liked that I learned really quick, really fast. So he told [the captain] to make me the lead for [activity]."

One Jets member with several years of experience expressed frustration with his lack of ability to lead without relying on technical competence. As he explained, "I can lead people… just because I have a knowledge base… I don't have influence in [team administration]. But it seems like if I'm trying to teach them about [my vehicle system] they're wide-eyed, will accept anything, just because they know I did [that system] for four years… I haven't figured out how to lead people without using my knowledge base."

Within the Sharks team, valued technical knowledge extended beyond construction of the canoe. Prior attendance at a competition was a prerequisite for a position of responsibility, particularly with regard to the captaincy. "We could have elected a captain before Regionals but it wouldn't really make sense because we wouldn't know who… does a really good job helping the team out," said one longtime member. "Regionals is a… challenging time… It changes a lot of people's viewpoints on the team. A lot of them come back stronger, wanting to be better next year. We definitely want to go through that before selecting a captain." Another cited the knowledge obtained by attending the competition. "If you didn't go to competition last year you can't see how we are placed with other teams… [and you won't know] the evolution of all the concrete techniques that build up over the years… With an inexperienced member as captain, they don't have that foundation of all that knowledge."

The willingness to acquire technical competence was an important indicator of leadership potential within both teams. Speaking of a new member, one Shark said, "He

asks a lot of questions… I think he would be a good leader because he's always curious about what we're doing and wants to come up with new ideas." A Jet expressed similar thoughts about one of their new members: "She's picked up CNC manufacturing already, which very few people do freshman year… she's been interested in multiple aspects of the car… so she'll be [a leader] in the future."

Communication is a broad term with several meanings. Team members used the term to refer to informative messages, individual and small-group conversations, and team discussions. Communication was specifically mentioned by seven Sharks and five Jets; in fact, communication was mentioned more times during all interviews than any other behavior. "Communication is the heart of all leadership," said one senior member. Team members understood the critical role of communication as a tool for coordinating teamwork: "If you're not communicating, it's really easy to lose track of what someone's doing."

In general, members believed that the leaders did a good job of announcing events and meetings to the groups. Frustration arose when team members did not share project-related information or were not present for informal discussions. One officer recognized her own failure to share timely information; several important tasks had been delayed because she had not requested assistance or notified officers of deadlines. "I don't like to bug people," she explained. Another officer complained that a key person had recently moved out of the team's shared office space and was consequently absent for many informal but important discussions.

Overall, team members were generally consistent in the recognition of the above behaviors with leadership. Recognition of the remaining leadership attribute categories

was less consistent, and in some cases marked differences between the two teams emerged.

Training & Mentoring behaviors include those directed toward helping team members develop relevant technical and administrative skills that would enable them to accept greater responsibility. Items in this group included task-oriented training and coaching, sharing mistakes and lessons learned with the team, and apprenticing students identified as potential leads for the next competition season. Behaviors in this category were more important to the Jets (5/6) than to the Sharks (3/8), perhaps because a car is a more complex piece of machinery than a canoe. Interestingly, the one Jet who did not mention training as an indicator of leadership was considered by his teammates to be the foremost technical coach on the team. "He [is a leader because] he's always someone you can ask questions to. He'll be happy to teach you."

The recognition of training as a special form of leadership was evident on both teams. One Jets officer viewed his leadership role as that of an "educator" rather than an administrator. "I try to keep everyone getting better at building the race car. It's a great thing to be able to design it... but it needs to work. [Last year] we [scored well] in design finals but the car blew up." A similar view was expressed by a Sharks officer, who asserted that teaching activities were a way of distinguishing leaders from managers: "I think what makes a good leader is… making sure [the team members] know *why* they're doing the things they're doing… while we are making progress towards our goal, they're learning along the way… compared to a manager [who says] you need to get it done, there you go, got it done, let's move on."

Motivating Others. Six Sharks and four Jets members mentioned behaviors associated with Motivating Others. Items in this category included having a vision for the team, motivating team members to achieve, and sharing the excitement of team participation. Said one Shark, "It's the passion for the team and the passion for each other is what I think really makes them all [leaders]." Having vision was not merely important for team morale; it also helped leaders persist in executing their responsibilities. In the words of Jet, "To have that vision… that's a very important leadership quality, because sometimes you have to make that tough decision along the way that other people might not see the vision at the end." On both teams, the person with the longest tenure made the most comments related to this category.

Delegation. The Delegation category included two related behaviors: delegation & trust. Behaviors in this group were especially important to the Sharks. Five members, all of whom held positions of official responsibility within both the team and other campus organizations, believed that these attributes were indicators of leadership. While the other behaviors mentioned referred to actions performed by team members, Delegation was mentioned because of its absence. The captain's failure to delegate was a particular source of frustration to the most experienced members. "I wish she would have asked us for help," one lead remarked. "I could have taken care of that myself," said another lead, "but I didn't want to go behind [the captain's] back." A third member remarked, "At some point, you have to trust younger members to talk to companies… They don't necessarily have much experience working with older people in professional settings. So I can see the hesitancy in throwing them into calling someone on the phone

and asking about a donation, but at some point you have to throw people in the fire and get them used to that sort of thing."

In contrast, this category was less important to the Jets, with only two members mentioning behaviors in this group. Nonetheless, it was clear that the interviewed team members trusted each other and frequently delegated responsibilities. Perhaps these team members all felt fully empowered in their positions and thus did not recognize these as specific leadership behaviors.

Collaboration. The category of Collaboration included behaviors that facilitated group decision-making and the coordination of multiple interdependent tasks, such as sharing ideas, learning from others, and being willing to disagree. All Jets and half of the Sharks mentioned collaborative behaviors as evidence of leadership.

The importance of collaborative behaviors to the Jets is unsurprising, given the complexity of the project. Said one officer, "We really don't know what we're doing. We don't know how to build a car. Not one of us could build a car by ourselves." Sharing ideas and information was particularly important. As another officer explained, "Leadership is… five or six guys that are able to filter down information to some of the newer guys, and five or six guys that make the decisions, and five or six guys that bounce ideas off each other… that communicate frequently, all the time, every day, about certain topics."

A willingness to discuss ideas was valued. In the words of one Shark, "everybody that's leading on the team [is] open to discussion, open to new ideas, and receptive on problems that come up." Another remarked "It's not about knowing everything. It's admitting that you don't know everything, and telling the people that

you're leading that you are also following somebody that knows more about it… How I looked at it in years past is, he leads the team because he knows how to do everything. That's not necessarily the case. He leads the team because he's good at communicating, he's good at taking advice, he's good at being open-minded to ideas."

Students recognized that exercising leadership did not rely require a dominant personality, and that dominant team members might actually be detrimental. Said one participant, "I guess [my idea of leadership] has changed a little bit, because now I look a lot more to the quiet person, because they usually aren't as overbearing in their ideas, so it's more of a collaborative process."

Problem-Solving. Conventional wisdom holds that engineers are problem solvers. Problem-Solving is also recognized as a characteristic of leaders (Fleishman et al., 1991) particularly those in creative or technical organizations (Mumford et al., 2007; Barnowe, 1975). In addition to behaviors such as identifying technical problems and seeking solutions, this category included seeking improvement in team functioning and performance. Problem-Solving behaviors were mentioned by more Jets (5/6) than Sharks (2/8). Two Jets specifically mentioned the ability to adapt or adjust to situations as evidence of leadership. One officer was described as "a team player. She can adjust to make things work." Another officer learned from ECT participation that to be a leader "you have to be able to adapt. You have to be able to identify different situations, how different people deal with different situations in different ways, and how to work with them." As with Training & Mentoring, the between-teams difference may be attributable to the respective levels of project complexity.

Boundary-spanning activities are defined as "politically oriented communication that increases the resources available to the team and networking communication which expands the amount and variety of information that is available to the team" (Burke et al., 2006). Boundary-spanners can also bridge the gap between factions within a group (Hansen et al., 2011), helping to facilitate team discussions.

Boundary-spanning activities were specifically mentioned as leadership functions by three Sharks and three Jets. The willingness of particular students to talk with sponsoring companies, alumni, departmental and university administrators, and the faculty advisor was much appreciated by their teammates.

The Jets complimented their captain's boundary-spanning ideas and believed that he had exceeded expectations in this regard. A system lead described two occasions in which the captain spanned boundaries to help the team gain knowledge. In one case, the captain called an experienced alumnus to request assistance with technical training. "Nobody really thought to contact him except [the captain]." In another case, the captain proposed visiting the FSAE team at a nearby university. Apparently this was unusual: "Nobody ever does that on our team. We don't ever look at anyone else's program—we have a good program!... But he's new enough that he can say, we don't have as good a program as they do, let's see what they're doing right."

Intra-group spanning efforts were valued within the Sharks team. When one officer was asked if others considered him a leader, he responded, "I guess so… Everyone comes to me with the stuff they want to take to the captain. So I guess I'm the through-person." This self-perception was supported by a comment by a teammate, who remarked on the officer's role in team discussions: "If you don't agree with someone

and you don't want to say anything out loud, he's always a great person to get behind…. Because usually when he says [something] he's not the only one who's noticed or who has thought about it. So it's kind of like he does the majority of the confrontation for us. We're appreciative."

Although boundary-spanning responsibilities were considered necessary, they were not always prized assignments. Most members, it seemed, would much rather work on designing and building the product. Within the Sharks, boundary-spanning was considered an activity for people brave enough to confront team members or oppose the advisor. Within the Jets, boundary-spanning was considered "grunt work" and less desirable than the "fun design work."

5.5 Discussion

As found in previous studies of engineering student teams (Laguette, 2013; Jones et al., 2009), ECT members understood leadership from a functional perspective (Fleishman et al., 1991). Team members' understanding of leadership behaviors aligned with leadership paradigms identified in the professional technical domain (Barnowe, 1975; Pelz, 1963; Elkins & Keller, 2003). While previous studies of engineering student teams investigated leadership associated with positional roles, the current study revealed that engineering competition team members recognize the value of nonpositional leadership. In fact, several participants noted that the exercise of leadership behaviors often preceded the attainment of a leadership position. Team members who worked hard and often, possessed strong technical skills, treated teammates well, exercised good project management, and communicated effectively were considered team leaders.

Some leadership behaviors were more commonly recognized by one team than the other. Collaboration, Training & Mentoring, and Problem-Solving were recognized by more than 80% of the Jets but were mentioned less often by the Sharks, possibly because a race car is more complex than a canoe. The Jets team has several subteams devoted entirely to building the car. Collaboration is necessary because systems designed and built by one subteam must fit and work with systems designed by other subteams. Construction is conducted over several months, and delays in one area can affect completion of other systems. A concrete canoe, on the other hand, has no moving parts, and the bulk of the assembly is accomplished over a single day. While members do assist with multiple parts of the project, the functional divisions of the Sharks team (paddling, construction, mix design, display, and fundraising) operate independently. Only two of the subteams—mix design and construction— can actually affect the seaworthiness of the canoe. And if one group is behind schedule, the others can usually continue without interruption. Consequently, collaboration between the Sharks subteams is needed infrequently.

Project complexity may also contribute to the Jets' greater emphasis on Training & Mentoring. Technical skill is a critical aspect in the design and construction of a running vehicle. Knowledge of welding, composites, machining, electronic control systems, fuel pumps, vehicle dynamics, and ergonomics are all required, and a successful team must include several specialists. Members often work on a subteam for a year or more before they gain enough experience to take responsibility for even a small part of the car. In contrast, technical learning opportunities within a Concrete Canoe team are more limited. Mix design is handled by largely by the mix design lead,

with occasional assistance from others. Historically, this team has rarely changed its hull design ("If it works, why change it?" said one team member), and the mold for the hull is milled by outside contractor. Casting—perhaps the biggest technical learning experience for the team as a whole—is a one-day event. Successful casting requires experience with applying concrete to the mold and installing the post-tensioning cables, but the task can be accomplished by a team of "laborers" under the direction of one or two knowledgeable team members.

Sharks were more likely than Jets to mention Motivating Others and Delegation as leadership behaviors. While self-motivation was identified by respondents on both teams as a characteristic of engineering competition team members in general, the ability to motivate others was associated with leadership slightly more often by the Sharks. The reasons are not clear, but the difference in team work schedules could account for the discrepancy. During the fall semester of the year under study, the Sharks held meetings but had little real work to do. Delays in obtaining materials set back the schedule by many weeks. Keeping new members engaged during the slow period may have required effort on the part of veteran members. Involvement of new members on the Jets team, on the other hand, was not constrained by such delays. New members could spend the fall semester learning to use milling machines and CAD software, and experienced members could focus on designing their respective systems. Simply being engaged in a challenging task may have reduced the need for external motivation.

One of the more striking differences between the teams arose in the discussions of Delegation. While most of leadership behaviors were discussed in terms of positive actions performed by team members, delegation was the exception. Sharks saw the

failure of the captain to delegate as a flaw in her leadership. Several expressed regret at not having been asked to take on more responsibilities. However, few team members were willing to take action without the captain's blessing. Even the member praised for being confrontational was willing to let the schedule slip rather than usurp the captain's authority. In contrast, the Jets hardly mentioned delegation at all. Nonetheless, it was clear that the interviewed Jets trusted each other and frequently delegated responsibilities. Perhaps these team members all felt fully empowered in their positions and thus did not recognize delegation as a specific leadership behavior.

The leadership behavior category recognized by the fewest team members (3 from each team) was Boundary-Spanning. Almost all of the members who mentioned boundary-spanning behaviors had considerable prior leadership experience, within either ECT or other organizations. This suggests that students may not be able see the value of boundary-spanning until they have gained more experience.

Certain leadership attributes may be over-valued within the teams. Within each team, certain behaviors and characteristics are considered part of the ideal and serve as filters for leadership positions. Among the Sharks, team experience was the most frequently mentioned attribute and was cited as the single most important factor in selecting the captain. Only senior team members were considered for the captaincy, despite the acknowledgement that some younger members of the team may have been better suited for the position. For the Jets, commitment, as evidenced by "hard work," was the most commonly mentioned ideal. While the members associated other behaviors with leadership as well, they made it clear that a person who does not spend

many hours in the work area will never be considered a member of the "core" team. This finding is consistent with a pattern previously identified by Foor et al. (2013).

5.6 Conclusion

Previous explorations of leadership in student engineering teams (Laguette, 2013; Jones et al., 2009) focused on positional leaders. No other studies were found that examined leadership in engineering competition teams from a non-positional and process-oriented perspective.

In general, leadership behaviors identified in the functional leadership literature were recognized by at least a few members of each team. That said, understanding leadership is not the same as exercising leadership. Respondents were unsure of how to address deficiencies in team performance, and they sometimes failed to recognize deficiencies in their own behavior. Team members expressed frustration with project management and communication in particular. They bemoaned the lack of technical depth and were concerned about the development of members' skills. They told stories of intense disagreements, toxic teammates, and conflicts that went unresolved. And, despite team members' claims of excellence, the teams did not perform particularly well at their respective competitions during the year under study.

The students in this study had a good mental conception of leadership and credited the team experience for helping them develop as leaders. But experience alone is an insufficient teacher (Day, 2011). For the engineering competition team experience to be a true vehicle for leadership development, students must learn more than how to define leadership. They must also learn how to exercise leadership. Future work will

explore ways that colleges can actively support the leadership development of engineering competition team members.

Chapter 6

The Influence of Engineering Competition Team Participation on Students' Leadership Identity Development

College students have the opportunity to engage in a range of activities purported to develop leadership. Engineering competition teams (ECTs) offer a specialized environment for learning about and practicing leadership within a technical domain. However, much of the published literature regarding leadership and the ECT experience has relied on anecdotal evidence, surveys, and logical reasoning. This work is an attempt to systematically describe aspects of student leadership development in the context of engineering competition teams. The preceding chapters have examined influence relationships among team members (Chapter 4), teams' social networks as indicators of collectivistic leadership (Chapter 4), and team members' understanding of leadership attributes (Chapter 5). This chapter describes the leadership identity development of ECT participants and identifies ways in which the engineering competition team experience can contribute to this development.

College students' identities develop in ways distinct from the development of same-aged people who do not attend college (Chickering & Reisser, 1993). A person's effectiveness in an endeavor depends in part on that person's self-identity, and leadership is no exception (DeRue, Ashford, & Cotton, 2009). A person who sees herself as a leader will act in ways she believes to be consistent with leadership, and will likely be more effective than a person who reluctantly or timidly accepts the mantle.

Leadership identity is socially constructed (DeRue et al., 2009). People develop an understanding of themselves as leaders through their interactions with other people

in groups. Komives and colleagues define leadership identity as "the cumulative confidence in one's ability to intentionally engage with others to accomplish group objectives" (2005; p. 608). In their view, students who adopt a collectivistic, relational, and process-oriented view of leadership exhibit a more mature leadership identity than those who view leadership in hierarchical terms associated with positions of formal authority (a view also shared by Lord & Hall, 2005). Relational leadership identity is characterized by "a sense of self as one who believes that groups are comprised of interdependent members who do leadership together" (2005, p. 608).

According to Komives and colleagues' Leadership Identity Development model, the typical college student matriculates with a Stage 3 leadership identity, which the authors call "Leader Identified." At this stage, students believe that leaders and followers have distinct roles and responsibilities, that leaders are in charge, and that followers "[look] to the leader for direction" (Komives et al., 2006, p. 404). Some may accept leadership roles during this stage; others may stay firmly in the follower camp.

As students progress through their college years, their leadership identities also tend to progress—although this is not guaranteed. Central to the LID model is the concept of shared leadership, evidenced by an understanding of leadership as a relational process rather than a set of attributes contained within a person. In order to move from Stage 3 (the Leader Identified stage) into Stage 4 (the Leadership Differentiated stage), a student must recognize that leadership is a process of moving the group toward its goals and can come "from anywhere in the organization" (p. 405). A student's understanding of self in relation to others also shifts. While people in Stage 3 may see themselves as operating either independently or dependently, according to

the situation and their own positional role, students at more mature stages increasingly see their relationship with others as one of interdependence. During Stage 4, students "begin coaching others," value "servant leadership," and perform effectively "in both positional and nonpositional roles," although they may "struggle to define [relational behaviors] as leadership" (p. 405). They are passionate about their organizations and interests, and wish to share those experiences with others.

Stage 5 is called Generativity, reflecting the creative nature of a maturing leadership identity. Students at this stage see themselves as leaders, and they work to develop leadership skills in others (p. 405). Organizational sustainability is important to students at this stage, and they often work to improve internal group processes for the benefit of future members. They also actively assess and improve their own leadership skills and understand the importance of "learning from others."

At Stage 6, Integration/Synthesis, a student possesses a secure self-identity as a leader and believes that he or she is able to exercise leadership and work with others to effect change in a wide variety of situations regardless of position. Rather than seeing leadership as an achievement, Stage 6 students consider it to be "a lifelong developmental process."

Although none of the students in the Komives et al. (2005, 2006) study appeared to have participated in technical learning experiences such as engineering competition teams, I believe that the collaborative nature of engineering design makes the LID model an appropriate tool for examining the effects of ECT participation on leadership identity development.

There are several challenges to applying the model, some of which were noted by Komives and colleagues in a paper published while this research was underway (2013). As is familiar within identity scholarship, students may operate at one leadership identity stage but talk about leadership at another. Students may simultaneously exhibit behaviors and understandings at more than one stage. And students may recycle through some stages as they encounter new situations. A student's progression through the stages depends on several factors in addition to the competition team experience. Pre-collegiate developmental influences (particularly family interactions and participation in extracurricular activities), collegiate experiences (both curricular and extracurricular), and employment in high school and college all contribute to leadership identity development. Age, personal maturity, and personality also contribute.

Before proceeding, I should stress that the LID model is a tool for examining students' self-identities as leaders. While progressing through the stages does imply some success with leadership activities, the LID model is not a tool for measuring leadership effectiveness.

6.1 Method

For this study, engineering competition team members' leadership identities were assessed according to the Leadership Identity Development model proposed by Komives and colleagues (2005, 2006) to examine college students' leadership identity development.

Students' responses throughout the interviews were considered as evidence for LID stage identification. Questions written specifically to aid in assessing LID included the following:

- What do you think leadership is? How has that changed over the years?
- Other than {team}, what groups are you involved in?
- In general, do others consider you a leader? How do you know?
- Have you had any particular leadership training? Tell me about that.
- Who are the leaders on {team}?
- [For each person mentioned in the previous answer] What makes this person a leader, in your opinion?
- How do you contribute to the team? Think beyond your particular job/role.
- You mentioned earlier that others [consider/do not consider] you a leader. Do you view yourself as a leader on the team? What makes you [not] a leader?
- What has your experience on the team taught you about leadership?
- Describe a situation within {team} where you applied leadership training, or applied some knowledge you had gained from previous experience.

Although an assessment instrument is under development (Komives et al., 2013), the instrument was not available for use during this project. Instead, team members' interview responses were carefully and iteratively compared to the stage descriptions (described briefly below and more fully in Chapter 2). While each student's LID stage was primarily determined via analysis of his or her own statements, the interviewees'

descriptions of their own behaviors and beliefs were triangulated with statements made by their teammates in order to build a more complete picture of each participant's development.

I adopted a conservative stance toward stage identification. In particular, I honored the model's bias toward shared leadership. If a student did not express thoughts or describe behaviors consistent with an understanding of leadership as a shared process not restricted to positional roles, that student's leadership identity was considered no higher than Stage 3.

Unless otherwise stated, quotation marks indicate a statement made by an interviewed student. Ellipses indicate omitted words, and square brackets indicate words replaced for the purposes of clarity or anonymity. Some quotes illustrate more than one theme and are therefore repeated. These quotes are marked with the abbreviation *q. v*. (For more information on the use of *q. v.,* see "Latin Terms and Abbreviations" from the University of North Carolina Writing Center, http://writingcenter.unc.edu/handouts/latin-terms-and-abbreviations/.)

6.2 General Findings

Responses revealed that the engineering competition team experience benefited students' leadership identity development. Of the 12 participants with at least one year of team experience, only one remained firmly at Stage 3. Four were experiencing the Key transition between Stages 3 and 4, three were in Stage 4, two were in Stage 5, and two had reached Stage 6. Several students were able to clearly describe the specific contributions of each experience to their development as leaders. As Shamir & Eilam

(2005) also found, those who were most able to express a well-articulated narrative exhibited a greater degree of leadership maturity than those who struggled to tell their stories.

Pre-collegiate organizational experiences differed widely among the students interviewed. For students without significant pre-collegiate leadership experience—or even organizational involvement—the engineering team provided an opportunity to develop leadership capacity through a series of progressively larger assignments. Several interviewees had not seen themselves as leaders prior to joining ECT. One talked about being asked to mentor younger members. "I've never done that before [this year]… It's a lot harder than it looks." Another told about recruiting two freshmen to help organize a large quantity of donated materials. "I managed those two guys and I was proud of myself because that was my first—It was weird because it's not really in my demeanor to tell people what to do… I could [have done] it myself, but we got it done before lunch." ECT gave these students the opportunity to "try on" leadership roles (Komives et al., 2005, p. 605)—roles some may not have pursued in environments that required self-selection as a leader.

For students with pre-collegiate leadership experience, ECT provided opportunities for leadership to expand to new contexts. Several students described how the new context of an engineering team required new approaches, particularly greater attention to interpersonal skills, more collaboration, and an increased emphasis on technical knowledge. As a Sharks officer explained, he had learned through ECT that "It's a lot easier to get people to do what you want them to do if you are likeable and authoritative… The mean kids… or the sarcastic kids that really aren't nice, nobody

wants to do what they say. It's not high school anymore." The same officer noted the importance of technical expertise to leadership within engineering teams: "If you ask [a teammate] to do [something] and they think you know what you're talking about, they'll do it for you. And if you don't, then they won't. And that's different from the leadership experience I've had in the past" (*q. v.*).

Team members also differed in their degree of extracurricular and leadership experiences at the collegiate level. Several participants stated that ECT was their only extracurricular collegiate activity. For these students, the contribution of ECT to leadership development was clear: Extended, immersive participation in a large-scale engineering project provided opportunities to experience a range of challenges, both human and technical. Two of these students' stories are told below. Mark "was involved in a lot of things" in high school but deliberately chose a different approach in college. Luke's story illustrates the strong impact of ECT in moving a Stage 3 follower to a Stage 5 leader.

Students who had participated in other collegiate organizations could differentiate between lessons learned in various contexts. In particular, the technical aspect of ECT expanded their understanding of leadership. Technical leadership in which a product must be collaboratively conceived, designed and delivered is different from philanthropic and event-oriented leadership. One Sharks officer, who also held a leadership position in an engineering professional society, described the difference this way: "I think if somebody wants to try and be a leader they should probably join one of these [competition teams or] organizations and work their way up… Joining anything will help you… [but] the competition [team] would probably be a little better because

it's tougher. It's tougher than meeting up and being like, okay, let's go do some volunteer work here."

Curricular experiences in the field of leadership varied among the participants as well. One student had taken a graduate-level course in organization systems. Five ECT members had taken or were enrolled in an elective engineering leadership course taught by an esteemed instructor, and several others had attended lectures by this instructor during a required professional development course. Four students mentioned the application of course concepts to the teams. In particular, one student cited the instructor's talk as confirming practices already exercised within the team, supporting Komives's assertion that Stage 4 students are learning the leadership vocabulary to apply to their actions.

Whether the interviewee held a hierarchical, collectivistic, or hybrid view of leadership, the primary difference they observed between ECT and other organizations was the idea of leadership based in action. As a Jets officer put it, "the people who get their stuff done… in a timely manner and with good quality… they're going to be the ones making the key decisions on the team." Knowledge and technical skill were associated with leadership by every team member interviewed. A Jet who called himself "an educator" situated his leader identity in his ability to teach others and "[get] manufacturing done." He stressed technical competence as evidence of leadership. A veteran Jet said he had not learned how to lead "without using my knowledge base". One Shark believed that he was not a leader on the competition team because his knowledge of concrete was limited. Another Sharks officer observed that team members

will follow a person's lead "if they think you know what you're talking about… and that's different from the leadership experience I've had in the past" (*q. v.*).

The influence of ECT on team members' overall leadership identity development varied. For some, the influence of the ECT experience was small. For the majority, participating on an engineering team promoted their understanding of leadership as a relational process as they moved from the Leader Identified stage to higher levels. Three students believed that the ECT experience had contributed to their leadership development but resisted being called a leader. And although some students still retained a somewhat hierarchical view of leaders and leadership, team participation had helped others develop an appreciation for collectivistic leadership.

6.3 Profiles in Leadership Identity Development

The range of influence of the ECT experience can be illustrated through the stories of six students: Connor, the Scout; Mark, the Coordinator; Luke, the Collaborator; Tom, the Liaison; Danna, the Reluctant Leader; and Patrick, the Big Man.[1] At the time of the interview, Connor exhibited a Level 6 leadership identity. Connor entered college with a strong leadership identity and a "get it done" approach; through the competition team, he developed better relational leadership skills and an understanding of leadership as a developmental process. Mark and Luke had Level 5 identities. Mark said he was not a "natural-born leader." The variety of situations he experienced through ECT had helped him develop both interpersonal and project-management skills. Luke had formerly been content to follow instructions and let others

[1] All names are pseudonyms, and some identifying details have been changed. Pseudonyms do not necessarily correspond to the participants' gender identifications.

take the lead. Once he was asked to start coaching younger ECT members, his self-image rapidly changed from contented follower to collaborative leader. Tom exemplified a Level 4 identity. His actions looked like those of a Level 5 leader, but he did not realize that his excellent relational skills were true indicators of leadership. Danna was experiencing the Key transition from Level 3 to Level 4. Her leadership identity was almost a mirror image of Tom's: She sometimes talked in terms consistent with Level 5, but her actions were more indicative of Level 3. Patrick was one of the most intriguing participants. Despite extensive positional leadership role experience, his leadership identity development was stalled at Level 3.

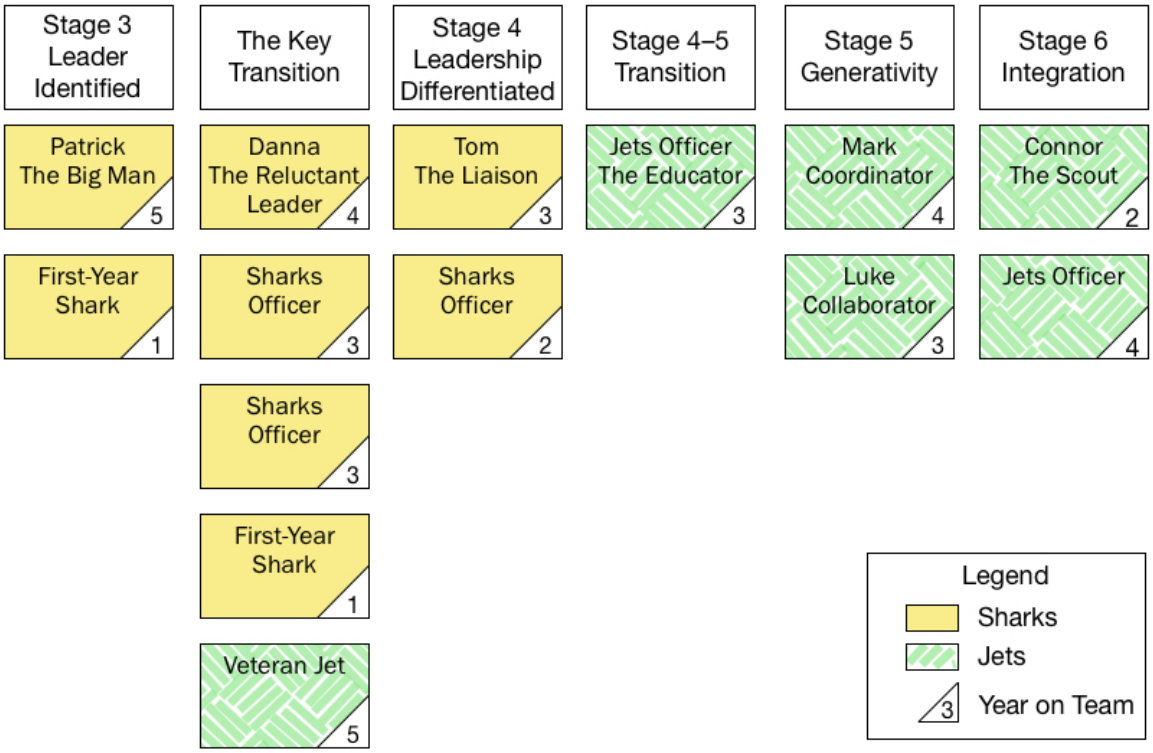


Figure 6.1. Leadership identity development stages of engineering competition team members.

6.3.1 The Scout

Connor, the Scout, had considerable pre-collegiate leadership experience: leadership workshops, co-owning a small service business, and scouting. He learned about goal-setting during a junior-high workshop, but he did not think highly of such workshops in general: "A lot of it I felt like was teaching [people who were] already leaders how to be better leaders, or maybe understanding leadership qualities and capitalizing on them if you had them. As far as these conferences go… I don't think I got much value out of them." Connor believed that scouting was most influential to his leadership education: "When it comes to practical leadership… making mistakes as a leader, the Boy Scouts was it… Any leadership qualities I have, I would attribute to that."

Connor's responses indicated that he entered college with a Stage 4 leadership identity. He understood how to work in a group, recognized "that you don't have to be in a designated role to be a leader," and trusted his fellow scouts.

Connor joined the Jets during his sophomore year and was named an officer within a few months. According to Connor, the Jets recognized that leadership could be exercised by anyone on the team: "I set out on the team to be a [technical] guy… and apparently I was doing something right that people thought that I was… leading in the right direction… [and they] elevated me to a designated role."

Although he already had a strong leadership identity, his time with the Jets had made considerable impact. Connor contrasted the effects of scouting and ECT. Through scouting he learned about "the logistics of leadership—planning and project management and… making sure everyone moves in the right direction to get the job

done." The engineering competition team, on the other hand, required more attention to "people, their motives, tactfulness, [communication]…. I've had to learn as a leader on the race team… [In] previous leadership roles, I probably never even thought about that stuff.

In Connor's view, scouting had a transactional nature; motivating other people to participate was not difficult because assisting fellow scouts with projects was a cultural expectation. "You had a group of people that were Boy Scouts. You grew up with them… and whenever they had a project you helped them, and when you had a project they helped you." In contrast, building a racecar required a greater degree of person-oriented skills: "Definitely the number one thing [I learned from the engineering competition team] is people skills… I can't do everything by myself. To see that vision come true… I need to get others on board. And to get others on board I need to exercise these skills." Connor learned that building a car required true collaboration and an extended commitment of a group of people. As he described it, "We really don't know what we're doing. We don't know how to build a car. Not one of us could build a car by ourselves. But we all have that characteristic of figuring things out and being dedicated to it."

Connor's leadership identity exhibited clear Stage 6 markers. Although he still believed that some attributes of leaders, such a willingness to take initiative, are innate, he saw leadership as a developmental journey —"something that I'm good at and can work at and can be better at, developing skills." Although his experiences as a team officer had been stressful—"I hate so much about it"—Connor envisioned himself continuing as a leader in his future career: "I think it's just in my nature… to run the

project… No question about it, if I'm working at a company, then I'll be managing of some sort, whether I like it or not."

6.3.2 The Coordinator

Mark, the Coordinator, had been "involved in a lot of things" in high school. Because he "wasn't able to just hang onto something, truly call it my own," he decided to choose one extra-curricular activity in college. "[Jets] was my opportunity to do one thing and keep working hard… so I could hang onto it as my own."

Mark saw his role on the team as "the voice of reason with the design process… trying to hold other people accountable." One of three team executives, Mark described the triad as sharing leadership: "There's not a specific hierarchy… It's not like one of us is president or anything. We're all just in charge of [our] specific areas. And then we have system leads." Like Connor, he believed that exercising leadership preceded the attainment of an office. "I feel like everyone who's in a leadership position was put there because everyone on the team already holds them as a leader and they're already basically a leader on the team… Without a title they'd probably be doing the exact same thing."

Mark's recognition of leadership as a collaborative process indicated a Stage 5 identity. Having devoted all of his undergraduate years to the Jets, he clearly had a passion for the team. He expressed concern for his teammates, helped others meet their objectives, and spent time developing new members. "If you don't teach someone else your system, then when you leave no one's going to know how to do it." He viewed the faculty advisor as a mentor: "In the past I've never really gone to [the advisor] with

problems, but this year it seems like I got to know him a lot more. If there's a conflict he helps me figure out the best way to deal with it, and I try my best to use this advice."

Mark's decision to focus on one activity in college, rather than participating in many activities as he had done in high school, suggests a Stage 3 identity at matriculation. According to the LID model, students in this stage are beginning to "narrow [their activities] down to meaningful experiences" (Komives et al., 2006, p. 404). Because Mark had intentionally chosen FSAE as his only collegiate extracurricular activity, he found it easy to describe the contributions of the ECT experience to his development. Unlike Connor, who had learned to manage a project through scouting, Mark credited FSAE with developing his project-management skills, such as adding a buffer to schedules: "There's going to be issues [you can't predict]." FSAE's technical focus meant that Jets leadership "is a lot different than just being a leader in a club." Like Mark, he saw the Jets experience as particularly helpful with regard to person-oriented behaviors. As a member of the Jets, he learned how to be patient, assertive, and emotionally controlled. He learned to collaborate and to "lean on others' strengths." Through ECT, he says, "I've developed into a leader. I wasn't a natural-born leader; I'm not very aggressive… I've developed a lot as a person, as a leader, because of my exposure and dealing with situations…. All the different types of people I've dealt with [on the Jets], all the different types of stuff, I felt like I would have never had to deal with [if I hadn't joined the team]."

6.3.3 The Collaborator

Of all the students interviewed, Luke's leadership identity experienced the greatest degree of development as a result of the ECT experience, moving from Stage 3 to Stage 5 in just over two years. He entered college as a declared follower. "I never saw myself as a leader in high school," he explained. "I was always a guy that was fine with being told what to do and was able to go do it, and didn't, you know, complain about anything... and even as a freshman on the team I was okay with saying, hey, what do you need me to do today? I can do it. It wasn't like I was complaining about being told what to do or having to follow somebody who knew more about it than I did."

The other Jets eventually realized Luke's gift for coaching. As one teammate explained, Luke "is great at teaching people how to do things… [He] remembers that whenever we were new we didn't know how to do anything. And he really has a lot of patience." Coaching new team members was Luke's first leadership experience: "This year [they told me] you need to mentor a couple of guys… and I've never done that before, I have no idea what I'm doing." Luke's understanding of leadership changed as a result. "How I looked at it in years past is, he leads the team because he knows how to do everything. That's not necessarily the case. He leads the team because he's good at communicating, he's good at taking advice, he's good at being open-minded... So that's the biggest thing for me, just realizing that it's not about what you know as much as who you know, who's around you, who you trust, how open you are to new ideas and direction."

Luke expressed a willingness to listen to other members of the team, including freshmen. "I've been telling [the freshmen] lately, don't be afraid to say anything

because we will definitely listen to you. We don't know enough to not. We can't afford not to listen to good ideas." He explained how he puts this approach into practice. "I was showing [a freshman] how to use the machine, and he mentioned to me... why don't you do it this way, it seems like it will save five or ten minutes. And I said that's a good idea."

As is common among Jets members, the Jets team was Luke's only collegiate extracurricular activity. He cited a talk by an esteemed instructor as another factor in his developing understanding of leadership: "[He] talked a lot about empowering as opposed to just communicating. So it's not about, how are you doing on this goal? It's, what can I do to help you with the goal?" Luke's application of this advice provided further evidence of his Stage 5 leadership identity. "It's a team effort so if I help you here, you're going to help me there, and we're going to get things done… It's not, why haven't you got your system done? If you can't do your system, let me help… I know you're struggling in this area. I'm not going to dog you for it; I'm going to help out" (*q. v.*). Luke's teammates concurred; several mentioned that he was always willing to help lighten the load for others on the team.

Luke's openness to ideas, regardless of the source, reflected an understanding of leadership as a fluid process rather than a status to be attained. "It's not about knowing everything; it's admitting that you don't know everything, and telling the people that you're leading that you are also following somebody... and they could potentially be leading you in certain areas and you'd be leading them in certain areas." Luke also expressed an understanding of leadership as a collaborative process of influence rather than a dictatorial one: "[Being asked for advice] is every bit as much of a leader as

knowing what to do. It's being able to give your advice and say, this is the direction I want to go, and now the choice is up to [the group]."

Luke was one of the few participants to strongly articulate a collectivistic, relational view of leadership. "Leadership is not about one person. It's much more a group effort than one person being a leader… maybe one guy is organizing it, and he's necessarily a leader in that instance, but I think it's more the communication between the group as far as working together for one goal."

6.3.4 The Liaison

Tom's leadership identity is complex. Like some of the students in the Komives study (2005, 2006), he operated a higher stage (5) than his expressed identity would suggest (3, 4). This internal conflict is characteristic of a Stage 4 leadership identity.

Tom cited his large family as the most influential source of leadership development, particularly in the areas of assertiveness, negotiation, communication, and supportiveness: "You have to learn to negotiate and vie for your parents' time… I feel like that's the best leadership training, to be thrown into craziness and just go for it."

Student council provided an additional venue for the development of leadership skills. In addition to serving as a representative "all through high school," Tom worked as a member of the organizing committee when his school hosted the state student council convention. Tom gained experience in recruiting event participants, a skill he later applied to the Sharks team. "[Promoting the convention required] reaching out to schools and making sure schools got there and pushing it. And so through that I was

able to not be deterred from calling people [to help with Sharks activities] tons and tons and tons of times."

In college, Tom actively participated in a number of organizations. At the time of the interview, he held leadership positions in the Sharks and several other organizations. Within the Sharks, Tom identified boundary-spanning as his primary leadership contribution, an assessment shared by other Sharks interviewed. "Everyone comes to me with stuff they want to take to the captain… I'm able to… talk to her about things without making her feel bad… but still letting her know that things really need to be done." In addition to serving as the liaison between the team members and the captain, Tom also acted as a bridge between the team and the advisor—particularly when the team believed the advisor was overstepping his bounds: "I'm really the go-between between [the captain] and the [advisor]. Because [the advisor] is a little bit intimidating, and so I'm very much one who doesn't shy from confrontation. I think I handle it very well. I'm not a bully about it but I'm not scared to address things… [Sometimes] he'll come and stomp on Danna's toes without realizing it. And I'll [tell him], you can't undermine Danna in front of the team… If you have an issue… talk to us one-on-one… He'll be like, oh, okay. He doesn't mean anything bad by it but he's a very strong personality and if you don't watch him he'll walk all over [you]."

Tom expressed commitment to a relational approach, similar to that described by Luke. "We want to create a team environment where everyone's opinion matters… If you come in not knowing anything, your opinion's still going to be valid." Tom also discussed efforts to foster a welcoming environment within the team. "We [are] building a relationship [with new members] from the start… When we go to team

meetings for the general team, [the leads] don't sit next to our friends who are leads. We all separate and… go talk to new people… We want [the team] to be inclusive" (*q. v.).*

Despite considerable experience as both a member and an officer, Tom did not consider himself a leader. When asked if others consider him to be a leader he replied, in a questioning tone, "I guess so? Everyone comes to me with the stuff they want to take to the captain. So I guess I'm the through-person, I don't know. I don't think of myself that way." Intrigued by the mismatch between Tom's self-perception and his leadership behaviors as described by himself and others, I probed further: "So you don't think of yourself as a leader, and yet you're an officer in multiple organizations." He replied, "I don't. I'm very much of a person-to-person. I don't think I have the ability to move mountains, but I can make a difference in one person's life. So that's what I focus on. Individual people." This emphasis on personal relationships, and the hesitancy in describing this type of behavior as leadership, is characteristic of Tom's Stage 4 leadership identity (Komives, 2006).

Tom's tendency to associate his own leadership with a particular group is also typical of Stage 4 identity. As he explained, "I just think of myself as someone on the team. I have assets that are used, but I don't really see myself as a leader on the team." Tom's lack of confidence in his technical abilities may have contributed to this self-perception. "I don't think my [technical] skills are the most valuable… I really wish I knew more about mix design because I feel like that's a huge asset to the team."

Tom's Stage 4 status was further evidenced by his deference to the Sharks captain and his concern for following established team processes. One of the captain's duties is ordering the plastic foam from which the canoe hull is milled. A company in a

neighboring state provides the foam at a discount. To ensure timely delivery, the foam must be ordered early in the fall semester. Because Tom possessed more thorough knowledge of the project timeline than the captain, "I would be sending her email reminders [about project milestones]. We need to get this done. We need to call the foam place. We need to call the CNC place." Despite reminders by Tom and others, the captain procrastinated. But Tom did not feel empowered to handle the problem himself. When asked if he could have done something differently, Tom said, "Not without going behind Danna's back… I thought that would undermine [the captain] and hurt the team more than it would help us…"

Tom considered the delay a "learning experience for next year… I think it's important for the team to see, if we don't get it done earlier, this is what we're going to have to do… next year, I guarantee you we'll have it done earlier. Because it's super stressful right now, not having our foam milled."

Because Tom was involved in several collegiate organizations, the specific contribution of ECT to his LID was more difficult to elucidate. One comment suggested that ECT participation has broadened his understanding of leadership: "[In high school] the most outgoing people… would be considered the ones who were the leaders. But I guess that's changed a little bit, because now I look a lot more to the quiet person, because they usually aren't as overbearing in their ideas, so it's more of a collaborative process instead of you're doing this, you're doing that."

Tom's experiences contrast interestingly with those of two other Sharks: Danna, the Reluctant Leader; and Patrick, the Big Man. Although both Danna and Patrick had

been members of the Sharks for several years and held high leadership positions, the leadership identity of both remained at Stage Three, but for markedly different reasons.

6.3.5 The Reluctant Leader

Danna joined the Sharks as a freshman. At the time of the interview, she was in her fourth year on the team and had just completed her first semester as captain. The Sharks had chosen to consider for the captaincy only seniors with several years of team experience. As a result, Danna and Patrick were the only candidates. Patrick had already been elected president of another organization, so the advisor and outgoing officers selected Danna as the next Sharks captain. She began training for the captaincy in the spring prior to assuming the role. Unfortunately, the graduating captains apparently did not apprise Danna of the work they had conducted during the preceding fall—an omission that would prove detrimental both to Danna's performance and to the team at large.

Danna had been a volleyball player in high school but did not see herself as a leader. "In high school I wasn't a very outgoing person. So I always saw [a] leader [of a club] as just somebody who was able to get the word out... They were always higher than me. I was afraid to approach them… While they were always very nice, friendly people, it was my insecurity about leadership." She credits her participation with the university's volleyball team as a turning point in her leadership identity development. "You really got to know [the captains], which started breaking down my wall… [I realized that] they're [leaders of the] team but they're not unapproachable. And that's when I started to think maybe I can be a leader. Maybe my quiet side will contribute to

making that wall break down for other people." Through her volleyball experience, Danna began the transition from a follower identity to a leader identity.

Despite her longstanding Sharks participation and her leadership position, Danna's primary extracurricular collegiate activity was volleyball. "Volleyball takes over my life in the fall and everything I do is related to that," she explained. The other Sharks frequently remarked that Danna used her volleyball responsibilities as an excuse for not completing tasks for the Sharks team. As a result of her volleyball involvement, she was not present when many important project management tasks, such as ordering materials, were conducted. As one member explained, "I don't think our current captain realized what [the previous captains] were doing, because she wasn't around for that part… So she didn't realize that he had to [delegate certain activities], because it was just taken for granted that it got done." Danna described the experience this way: "When I started my apprenticeship [for the captaincy] last year… I started in the spring semester. So I didn't see all that prep work they had going… I didn't see them do anything at all [in the fall]. I saw them run meetings but I didn't see the foam show up until the spring semester. I didn't see the concrete mixes start until the spring semester. So when I got here, I was like, okay, we have the full fall semester just get a theme idea out and start thinking about mix design… Completely wrong."

Volleyball gave Danna the courage to try leadership and reinforced her understanding of the responsibility to exhibit personal excellence as a member of a group. Through leadership workshops sponsored by the athletics department, she learned about trust and teambuilding. The ECT experience furthered her development. Being on the Sharks "taught me the management side of leadership." In addition to

learning about “paperwork [and] fundraising,” she also gained boundary-spanning experience: “We had to deal with the issue of the foam price, getting in contact with people. It gave me the experience of getting outside my comfort zone when it comes to talking to people outside the university.”

The Sharks experience also showed Danna the importance of actively developing younger members. Danna belatedly realized the gap in her training and was working to help her likely successor avoid a similar fate. “I’m making sure [he] knows… all the information… so he can get the experience.” She also saw the effects of limited training on other team roles: “I’m trying to make sure we have more people up for [all] the jobs.”

The engineering team helped Danna develop a relational view of leadership. “I’ve slowly learned that leadership isn’t all about being that guy in the front who can just talk and get her point across, but it’s somebody who can also relate to the person you’re leading, making sure that they exactly know what you’re doing, why you’re doing it, and getting the hands-on experience doing it well.”

Danna expressed an intention to have younger members take more responsibility with team tasks so that they could do the same thing in turn—“[I'm] making sure they’re doing everything they can this year so that next year they can take that step back and… allow the younger members to work it out on their own.”—but the extent to which she followed through on this intention is unclear. Another experienced member remarked that Danna did not trust younger members to conduct certain activities, such as contacting companies.

Among the team members interviewed, Danna exhibited a remarkable ability to reflect on her own mistakes and to connect those mistakes to leadership lessons. “You learn from your mistakes. And while we might not end up with our fifth-place team this year, just because we made a lot of mistakes... with our processes… next year they’ll know to start earlier. They’ll know to choose a different path.”

When asked about communication within the team, Danna acknowledged her failings and described how she attempted to compensate by relying on others’ strengths. “I’m a horrible communicator… when it comes to spreading the word on things… I would say that’s my biggest weakness… It’s very difficult… I’ve asked [the secretary] to bug me. I’ve asked him… to do anything he can to make sure I get him the information to send out to the team.”

Danna “struggle[d] with delegation” (Komives et al., 2006, p. 405), a common feature of Stage 3 leadership identity development. “That’s a big weakness for me… I’m one of those people that hate bugging people. I hate it. I don’t mind being bugged—like I told you, I asked [the secretary] to bug me. But I don’t like interrupting people so when I don’t know what we’re doing… until the day before we’re going to have to do, just because of [delivery delays or] winter weather, I don’t want to contact them the day of and go, hey, you need to be here tonight. Because that throws off their schedule.” Danna’s view was starting to shift, but she had not overcome the discomfort with asking for help. “I’ve started to learn that—I’m just going to send [the request] out and if they can’t show up they won’t.” Danna also regretted the Sharks’ insistence that the captaincy be restricted to seniors. “We actually considered [a junior] to be co-captain this year. We were a little too worried on how much experience he had with it. Looking

back I kind of wish we did just select him and dealt with his inexperience. He's very likely going to be [a captain or co-captain] next year.

Despite these progressions, Danna remained in the transition between Stages 3 and 4 at the time of the interview. She still talked in leader-differentiated, hierarchical terms, as evidenced by statements such as "the captain… mak[ing] all the decisions," "your people," and "people below them." And yet, she was ready to advance to the next stage. A number of comments indicated that she could be at the generative stage of leadership development (Stage 5) if she would just let go and trust others to do their jobs—a concept she verbally expressed: "Leadership doesn't mean you stand up there and monitor everybody. They need to trust that their people know what they're doing"—but had difficulty putting into practice. Despite her stated intentions to provide younger members with significant responsibilities, she wrote the entire technical paper herself and did not let younger members contact companies.

Danna was also reluctant to call herself a leader. While she acknowledged that other people consider her a leader, she refrained from owning that identity. "I try and not perceive myself a leader. I try and think I'm just another member of the team who has a little more experience…" When asked to explain the drawback to seeing herself as a leader, she evoked his pre-collegiate view. The drawback, she said, would be "setting myself apart… the thing I was most afraid of when I started college… was the leader is above me and I'm afraid to approach him. That would be my biggest drawback. Well, I don't know if anybody on the team will see me that way if I become… a full-out leader [but] there might be somebody like me on the team that does see me as that, and I don't want that to happen."

6.3.6 The Big Man

Of all the team members interviewed, Patrick, the Big Man, had held the largest number of collegiate organizational leadership positions. But counter to what one might expect, he had experienced the least degree of leadership identity development. At the time of the interview, Patrick was a senior and the president of a large organization. Yet his leadership identity remained stubbornly at Stage 3, Leader Identified.

Although Patrick had held a number of leadership positions, he had not received much formal leadership training. He attributed most of his leadership education to observation. "I've never really had a good leadership workshop. I've just been watching over people." He had taken an engineering leadership course, but unlike most students, he did not find it enlightening. When asked if he had applied lessons from that class to the team, he responded, "Not really… I remember a lecture on not setting people up to fail… I remember thinking about it at one point in relationship to [the Sharks]… it had something to do with how you ask people to do things. Obviously I've forgotten a lot of what I learned in that class."

Patrick's understanding of leadership was typical of a Stage 3 student. He emphasized the leader-follower distinction, saying that "Leadership is about having people follow you," and stressed the leader's role in "get[ting] work done." Patrick equated official positions with leadership. When asked to name leaders on the Sharks team, he replied, "Obviously the leads are generally going to be leaders." He quoted his long list of positional roles as evidence that others considered him to be a leader. And while some Sharks and Jets recognized that certain team members were, in the words of Connor the Scout, "leading in the right direction" before they received a title, Patrick

viewed leadership behaviors such as "show[ing] up regularly, [taking] on tasks, and get[ting] work done" as precursors to leadership: "That's how all leaders are developed within our organization. People who actually show up and do things will ultimately *become* leaders" (emphasis added).

Patrick talked about his accomplishments as a leader in various organizations, but he focused on his own efforts and rarely discussed working through others to accomplish group goals. He expressed little confidence in the Sharks' ability to set goals and make decisions: "If you can't get people together and tell them what the goal is and when we're going to do things, it simply won't happen… The goals of the team are always going to be set by the captain." He doubted the general membership's internal motivation: "A lot of members, honestly most of the members show up to do something fun or to put something on their resume. It's the captain and maybe a few of the leads who really have to actually push if we want to really reach for something."

Despite being stalled at the Leader-Identified stage, Patrick had experienced some leadership development through his varied experiences. Patrick described how his leadership ideas had changed during his collegiate career: "When I was young I always thought leaders were kind of, either really charismatic people, or people who got tapped, got lucky. But I really came to understand just how much goes into it." He credited his Sharks experience with some important lessons, particularly the experience of completing a large-scale technical project. "[Being on an engineering competition team has] taught me that to be a leader people have to have faith in what you're doing. You have to show that you've thought things out, you have a plan, and that you're going to execute it. You're not just going to attempt to do something. You're actually going to

do something." He also credited the Sharks team with helping him develop communication skills. "I've found that communication is the heart of all leadership… There's the whole side of motivating people and then actually communicating to get them to do it." However, another statement revealed how Patrick understood communication: "Most communication I guess is going to be from the captain to the other members." This statement suggests that Patrick saw communication as unidirectional messaging rather than a collaborative exchange, further evidence of his Stage 3 leadership identity.

Like Mark, the Coordinator, and Connor, the Scout, Patrick understood the challenges of having responsibility without true authority. "It surprises me, how difficult it actually is to coordinate people. Just aside from their skills, their level of effort. I guess it's primarily an issue here because all the stuff is volunteer. You can't just fire people. So that makes it always a problem. There's so much that goes into motivating people, coordinating things, organization, that it really takes a set of skills."

Patrick seemed more comfortable with delegation than Danna, the Reluctant Leader, but he did not fully trust others to follow through on commitments. When tasks went undone, he blamed other students' lack of dedication rather than his own management skills. He struggled to identify "team player[s]… I've had so many people say they'll do things, and at the last minute I'll ask them if it's done, and it's not."

Despite his apparent lack of confidence in engineering students in general, Patrick did recognize that some students "are waiting, just waiting, for more responsibilities." He understood the importance of giving members meaningful work as a way of helping them develop—something he thought Danna had failed to do. "Some

of the younger members are kind of awkward… They don't necessarily have much experience working with older people in professional settings," he explained. "So I can see the hesitancy in throwing them into calling someone on the phone and asking about a donation, but at some point you have to throw people in the fire and get them used to that kind of thing."

Patrick's numerous leadership positions may have actually hindered his leadership identity development. Recall that he cited his own elected offices as evidence of his identity as a leader. A person whose organization makes progress may be unaware of the need to change anything and may attribute the organization's success to his own behaviors. Patrick indicated no understanding of leadership as a group process, of something than can come from anyone in an organization, or of the need to develop leadership skills in a larger number of people. He attributed organizational struggles to failures of people in official positions to execute their responsibilities. "What kills a lot of leaders… I think is just a lack of commitment and lack of caring about what they're doing. There's a lot of people who sign up for officer positions or even president positions… and they'll do the bare minimum… just so they can get it on their resume. By the end of the year, no one is following them, their organization is falling apart, it's treated as a joke."

Patrick was not self-congratulatory. He saw leadership as developmental process and recognized that he had not always been effective. "The more leadership responsibilities I take on, the less I understand how to do it right." Patrick had learned how to get things done, but he had not learned how to lead through others.

6.4 Discussion

The students' stories indicate that engineering competition team participation can have positive effects on leadership identity development. These effects are moderated by several individual- and team-level factors, including team members' experiences with other organizations, project complexity, team culture, and advisor influence.

6.4.1 Individual Differences

For most of the participants, the engineering team positively contributed to what Komives and colleagues call "a broadening view of leadership" (2005, p. 605). But the extent of this contribution depended in part on team members' other organizational and leadership experiences. The stories of Luke, Tom, and Patrick illustrate this continuum. Luke made a big jump from Stage 3 to Stage 5, perhaps because he had no prior positional leadership experience. In contrast, Patrick's extensive positional leadership experience may have hindered his progression through the stages.

Patrick had participated in the Sharks throughout college, had held leadership positions in several large organizations, and was president of an organization at the time of the interview. Yet his most salient lesson seems to have been that people are hard to motivate and that officers must get the job done in spite of other people's lack of dedication. His experiences had reinforced the idea that the positional leader had to "tell [people] what the goal is and when [to] do things," that most students "were just participating to get something on their resumes," and that delegating responsibilities was often not worth the risk. He considered himself a successful leader and cited

several examples of organizational improvements he had implemented, but he believed those accomplishments to be largely the result of his own individual efforts.

Luke, on the other hand, had held no prior leadership positions and was "always… fine with being told what to do." He was surprised when the Jets told him "this year you need to mentor a few new guys." The experience of coaching others in technical tasks and participating in problem-solving discussions with teammates had helped him develop a collaborative, relational view of leadership. Luke's leadership identity matured from that of a Stage-3 follower to a Stage-5 generative leader within a few months. The fact that the engineering team was Luke's only extracurricular activity supports Komives's finding that LID is enhanced through prolonged and fully engaged membership within a group.

Tom's experience occupies the middle ground between those of Patrick and Luke. Tom had held a number of leadership positions beginning with high school student council. His collegiate experiences had helped him develop an interdependent view of leadership. Not having held the top office in any collegiate organization, he believed his primary contributions to be focusing on "individual people" and acting as liaison between Sharks team members, the captain, and the advisor. Like many Stage 4 students, Tom was not sure that these behaviors constituted *leadership* and expressed some cognitive dissonance: Even though he acknowledged that others probably did see him as a leader, he said "I don't see myself that way."

The stories of Patrick, Tom, and Luke illustrate experiences along the continuum of leadership identity development. Extensive participation within hierarchical leadership structures may hinder a student's advancement through the

stages. It may be that students with considerable leadership and organizational experience have to unlearn hierarchical and individualistic views of leadership before they can adopt a relational, process-oriented perspective. In contrast, students with little prior organizational experience who immerse themselves in a collaborative engineering competition team may advance rather quickly through the stages of leadership identity development.

Komives and colleagues (2006) found that immersive experiences facilitated leadership identity development, and a similar pattern was evident in this study. Both Mark and Luke had chosen ECT as their only collegiate extracurricular activity, and both experienced considerable development as a result. Danna and Patrick, on the other hand, had not immersed themselves in ECT. Volleyball was Danna's priority during the fall, and her Sharks responsibilities were often neglected. Patrick split his time and attention among leadership positions in multiple organizations and complained that he could rarely rely on other members for assistance. Patrick and Danna's experiences suggest that spreading oneself too thin can also hinder leadership identity development.

Perceptions of technical competence also affected students' LID. Tom (quoted above) said, "I don't think my [technical] skills are the most valuable," and cited that lack of expertise as one reason for not considering himself a team leader. In contrast, a Jet cited technical competence as evidence for seeing himself as a leader. The Sharks used team experience, a proxy for technical competence, as a filter for identifying candidates for captain. And all students in the study cited technical competence as a characteristic of leaders.

Prior experiences may have contributed to reluctance of some ECT members to call themselves leaders. In addition to Danna of the Sharks, two members of the Jets expressed similar hesitation. A veteran Jet who had recently started "learning about management and leadership" recalled years in which a few members had dominated the team. As a result, he did not want to be seen as "the big guy in the room… just because I had four years on the team." Another Jet preferred to think of himself as a "teacher and influential" team member rather than a leader. Even though he was a member of the executive triad, he stated, flatly, "I'm a leader in terms of getting [the car built]… I'm not a leader in terms of team management."

In addition to contributing to a broadening view of leadership, engineering teams also helped participants learn specific leadership skills and approaches. Several team members described how the engineering team had filled a hole in their leadership development—but the hole was not necessarily the same for everyone. Some students learned relational skills through ECT. Connor, for example, had learned project management and individualistic leadership from the Boy Scouts; ECT helped him develop "people skills" such as "tactfulness" and "understanding [team members'] motives." A Sharks officer said that leadership on an engineering team was a matter of team members' perceptions rather than position and was enhanced by being "assertive but nice," something that had not been as important in high school organizations. Other students credited ECT with enhancing their business and project-management skills. Danna, for example, had learned some person-focused skills through volleyball; ECT taught her "the management side of leadership." Another Sharks officer thought that the

opportunities for technical project management made ECT "a little better than… one of those regular organizations" for developing leadership.

6.4.2 Team-Level Differences

With regard to participants' leadership identity development, a clear difference between the two teams emerged. Regardless of age, years of team participation, or prior developmental influences, the Jets exhibited greater levels of leadership identity development than the Sharks (Figure 6.1). Project complexity and team culture likely contributed to the difference.

Project Complexity. As mentioned earlier, a race car is fundamentally more complex than a canoe. A vehicle powered by an internal-combustion engine has many interdependent parts, and successful design and construction requires interdependent work by the team members. These interdependencies create many opportunities for students to communicate, collaborate, argue, and iterate. In contrast, most of the canoe-building work can be accomplished by individuals or small groups, and the work of one subteam may have little or no effect on the work of other subteams. For example, if the display team's design is unattractive, or if the paddling team is out of shape, the canoe's seaworthiness is unaffected. The students' statements support this analysis. Sharks recalled no team meetings about goal-setting or project schedules, and they discussed working with others primarily in terms of their own sub-teams. The full team had only one meeting in which a major decision was made (choosing the design theme). Even constructing the canoe did not require a large number of people. Due to scheduling delays, most team members did not participate in tasks that normally involve the full

team. In the season under study, Casting Day was held during Spring Break, and the canoe was removed from the mold over a holiday weekend. In both cases, only a few Sharks were present. In contrast, the Jets emphasized teamwork. They recalled a series of goal-setting meetings, beginning immediately after competition and continuing through the summer. Several Jets talked about helping each other complete their responsibilities. All the Jets interviewed related stories of collaboration and problem-solving in both formal and informal settings, describing their decision-making process as "constantly bouncing ideas off each other" and "coming together to put those systems together." As Mark said, "there's no system on the car that you can design without thinking of anyone else's system. You really have to communicate with everyone."

Project strategies adopted by the local team can also affect the leadership development opportunities afforded by the ECT experience. For example, while some other Concrete Canoe teams design and build a new hull each year, the Sharks rarely redesign their hull, and they outsource the foam milling. This may result in a higher-quality product, as several members claimed, but it limits the opportunities for team members to engage in engineering design. Although the advisor was quoted by a Shark as saying "I'm not here to teach paddlers or teach concrete placers. I'm here to teach engineers, and engineers are problem-solvers," responses suggested that the general membership spends most of its time placing concrete, or sanding, painting, or paddling the canoe. And because they are not doing as much design work as the Jets, the Sharks do not have as much opportunity to practice collaboration and problem-solving. On the other hand, doing too much individual design work can also get in the way of

collaboration. Among the Jets, failure to complete design work in a timely fashion was a common complaint and was cited as a key reason for production delays. In order to have enough time to collaborate and advance in the design and construction process, engineering team members need to know, as Connor explained, "when to call it good enough and not over-engineer it."

Team Culture and Practices. Team culture and practices also shaped students' views of leaders and leadership. Some team members retained, to varying degrees, a hierarchical view of leaders and leadership. This was particularly evident among the Sharks. While Patrick was the most extreme example, even those Sharks with a hybrid view of leadership tended to see the captain as having greater authority than the other officers. One new member reflected Patrick's view, stating that engineers need a leader because they are "directionless" and "need to be pulled along."

The Sharks' deference to the hierarchy affected members' abilities to work effectively with each other and sometimes resulted in a mismatch between expectations and execution. A misunderstanding between Danna and Tom illustrates this problem well. Danna and Tom considered each other to be leaders on the Sharks. But their ideas regarding leadership were in conflict. Tom was familiar with the project schedule and knew that Danna was not executing some of her responsibilities at the proper time. Yet Tom was reluctant to assume those tasks without the captain's consent. In a surprising counterpoint, Danna complained in the interview that Tom lacked initiative and would only do what he was told. Danna did not like to "bug people," but she apparently wanted team members to take on responsibilities without being asked. It appeared that

she would have appreciated Tom's calling the foam company and would not have viewed it as usurpation.

In contrast, Jets were more likely express an appreciation for shared leadership than Sharks. Most of the Jets thought of positional roles as defining areas of responsibility rather than being part of a "set hierarchy." As the self-identified Educator explained, "You can't have just one leader. When you have that, everything does start falling through the cracks" (*q. v.*).

The adoption of an interdependent view of leadership underpins Stages 4, 5, and 6 of the LID model and is a key marker for a maturing leadership identity. Collaborative decision-making and an understanding that leadership "can come from anywhere in the organization" are evidence of this interdependent view (Komives et al., 2006, p. 405). As a Jet, Luke had learned that "leadership is not one guy." A Sharks officer in his first positional leadership role had learned that, within the Canoe team, "leadership is more of a group thing" rather than "one person… in charge of everything." A longtime Jet had reached a Stage 6 identity by integrating his team experiences with classroom studies and personal leadership learning; he strongly believed that "Having a lot of people who will lead in various areas… is helpful to team development and personal development."

Leader selection also differed between the teams. The Jets were open to identifying candidates for leadership positions based on demonstrated and relevant skills. Team tenure was less important, as evidenced by the team's selection of Connor as captain. In contrast, the Sharks placed high value on team experience as a filter for leader selection. Only members who had been to a regional competition were

considered for officer positions. And only seniors were considered for the position of captain, even when other members might have been better suited for the post. Following this tradition unnecessarily limited Sharks' opportunities for positional advancement, endowed the captain with too much perceived authority, and likely hampered the Sharks' individual leadership development.

Advisor Influence. While the role of the team advisors was not an initial focus of this research, their influence was apparent in the team members' interviews. Both advisors behaved in ways that seem to have promoted team members' leadership development. The Sharks advisor's advocacy of inclusion was reflected in the team's demographics, in the way they spoke about recruiting and retaining members, and in their use of a charrette[2] to involve all members in making a major decision. The Jets advisor's participation in team performance reviews and scheduling decisions helped team members practice some important project management skills. But by exercising too much control in some areas and not enough in others, the advisors also acted in ways that may have blocked members' development.

The Sharks mentioned their advisor 22 separate times and described him as "powerful" and "intimidating." (All of the members mentioned the advisor at least once, and three members mentioned him four or more times.) While the advisor wanted to teach the Sharks to be "engineers… and problem-solvers," some of his practices may have hindered both their leadership development and their engineering development. The Sharks advisor attempted to protect the team from activities he considered distractors, such as "worrying about money" and ordering materials. Yet this approach

[2] A charrette is a design process typically used to solicit citizen input on large development projects. The systematic process captures for discussion all proposed ideas, "allow[ing] everyone who participates to be a mutual author of the plan" (The Town Paper, 2015).

limited their opportunities for managing their own resources and may have contributed to their scheduling problems. Managing material resources, including money, is a major component of functional leadership (Fleishman et al., 1991). But as Danna remarked, the advisor did not "allow [the team] to worry about money." National competition rules require teams to include a budget and financial analysis in their report, suggesting that the sponsoring organization also believes financial management to be an important engineering skill. But the advisor revealed the team's budget and expenditures after the fact, just in time for writing the report. Danna also observed that the team was behind schedule in testing their concrete mixes because "we're still missing both our microspheres and [another material]. [The advisor] orders them and so it's just a matter of, he's a very busy person so it's just how fast he can order them." While the members chafed under this control—Tom, Patrick, and Danna all complained about it—the team seemed resigned. As Danna explained: "While I don't always like that, that's the way he's always seemed to run it..."

Despite the advisor's control of certain aspects of the team, he was less involved with scheduling, knowledge transfer, and project management. As one officer explained, "He has a lot of input on things we do, but he as an advisor really tries to stand back away from things." That same officer hinted at a desire for more active coaching. "If we have a question he's always there for us... If we don't have a question he'll leave us alone and let us do our thing… which can be really scary, especially when you're dealing with a team that has the success that we have, over the course of our history."

The Jets mentioned their advisor much less frequently—only 11 times—and with none of the awe expressed by the Sharks. (Only two members mentioned the

advisor at all.) In contrast to the Sharks advisor, who controlled the budget, handled much of the procurement, and provided frequent consultation on the concrete mix design, the Jets advisor did not "really monitor design or anything. He literally gives us what we want." Yet the Jets advisor was influential in his own way. He encouraged the Jets to "make mistakes" as part of the learning process, something Connor "caught on to." He participated in the team's post-competition reviews and summer conference calls. And when asked, he helped team members navigate conflicts. Mark particularly relied on the advisor's counsel. "Whenever there's a conflict, he kind of helps me figure out the best way to deal with it."

6.5 Conclusion

Leadership development is frequently advertised as a benefit of engineering competition team participation. Certainly the potential for leadership development exists. Yet as the team members' stories reveal, the degree to which ECT contributes to development, and the specific lessons learned, depend on the interplay between individual experiences, team culture, and team practices.

Overall, ECT participation helped students further their relational, technical, and project-management skills. The teams offered members the opportunity to exercise leadership in diverse ways, exposing them to new situations with challenging restraints and requiring a higher level of performance than they had experienced through other types of organizations. The influence of ECT on individual leadership development was most notable in the student with considerable pre-collegiate project-management experience (Connor) and the student with little pre-collegiate leadership experience

(Luke). The team's internal environment and project complexity also influenced members' leadership development. The Jets provided more opportunities for team members to collaborate and participate in decision-making. This likely contributed to the more mature leadership identity exhibited by the Jets overall. The Sharks did not make many decisions (other than the theme) as a team and had fewer opportunities to collaborate. Without the chance to practice participative leadership, the Sharks' leadership identity development was hindered.

The interviews demonstrate that membership in engineering competition teams can enhance individual leadership development. But how is individual leadership development related to team-level leadership development (Day et al., 2004)? The membership of a collegiate leadership team is often completely replaced every two to four years. When individual members graduate, their leadership learning leaves with them. The challenge, then, is to transmit some of this knowledge to the remaining team members, so that future teams can build on the lessons of their predecessors. Enhancing team-level leadership capacity could result in a progression of team success, rather than simply helping individual participants develop as leaders.

Chapter 7

Conclusion

The engineering competition team experience has the potential to help students develop as leaders in technical environments. Through participation in ECT, students in this study learned both practical and relational leadership skills, and most developed a more mature sense of themselves as leaders. While college students can learn and practice leadership skills through a variety of experiences, the specific emphasis on technical competence and functional leadership within engineering competition teams distinguish these teams from other avenues of student leadership development. Despite the current emphasis on social-change and related approaches in collegiate leadership development programs (e. g., Dugan & Komives, 2010; Hoy & Meisel, 2008; Posner, 2004; Astin & Astin, 2000), functional leadership should not be neglected in the consideration of leadership development among engineering students.

7.1 Addressing the Research Questions

Research Question 1a: How do members of student engineering competition teams perceive leadership?

When asked to define leadership, all but one member started by defining a leader. This subtle shift suggests that the team members have internalized the Western cultural concept of leadership as a set of attributes possessed by an individual. Only one respondent—Luke the Collaborator—initially defined leadership as process. When asked, "What is leadership?" he replied, "Number one is communication... But I also think leadership is more, it's not about one person. It's much more a group effort than

one person being a leader… I think it's more the communication between the group as far as working together for one goal." As the interviews progressed, the students expressed more nuanced views, but that initial response to the question "What is leadership" revealed—as the Leadership Identity Development model predicted—that the conception of leadership as an individual attribute is common among engineering competition team members, just as Komives and colleagues (2006) found among student leaders within the general collegiate population.

The idea of leadership as getting a group of people to work together toward a goal (Bresnen, 1995; Yukl, 2013) was the most common theme expressed by the students in this study. Other strong themes included leadership as a form of guidance and the existence of followers as a necessary condition for leadership. A few students revealed a more mature understanding of the nonpositional and collectivistic aspects of leadership.

The ECT members in this study acknowledged the value of nonpositional leadership. Several participants noted that the exercise of leadership behaviors often preceded the attainment of a leadership position.

Research Question 1b: What behaviors, skills, and characteristics do members of student engineering competition teams associate with leaders and leadership?

Team members' descriptions of leadership behaviors were richer than their definitions of leadership. ECT members understood leadership from a functional perspective (Fleishman et al., 1991), a finding consistent with Bryman's (2004) observation regarding the types of leadership behaviors identified in qualitative studies. Their views of leadership behaviors also aligned with paradigms identified in the

professional technical domain (Pelz, 1963; Barnowe, 1975; Elkins & Keller, 2003). Members of both teams strongly associated five types of behavior with leadership: Ideal Behavior, Individual Consideration, Project Management, Technical Competence, and Communication. Some leadership behaviors were more commonly recognized by one team than the other. Collaboration, Training & Mentoring, and Problem-Solving were highly valued by the Jets, while Motivating Others and Delegation were more important to the Sharks. Boundary-Spanning was associated with leadership by only a few members of each team.

Research Question 2: How do members of student engineering competition teams see themselves as leaders?

The team members interviewed exhibited the full range of collegiate leadership identities described by the Leadership Identity Development model. Two students had a Stage 3 identity, five were in the Key transition between Stages 3 and 4, three had a Stage 4 identity, and two occupied Stage 6. Two students, one with three years of team experience and one with four, held Generative (Stage 5) leadership identities. The evidence suggests that they entered college at Stage 3, one as an occasional positional leader and one as a dedicated follower. Both of these students had chosen ECT as their only extracurricular collegiate activity and clearly described how team participation had helped them develop as leaders. As Komives and colleagues (2006) also found, prolonged and immersive participation in the engineering competition team had enhanced their leadership development.

Interestingly, positional leadership role experience did not predict a student's LID stage. The Sharks captain—like several of her teammates—was experiencing the

Key transition; Tom was in Stage 4; and Patrick occupied the least mature stage, despite having held more collegiate officer positions than any other interviewee.

Research Question 3: How does the engineering competition team experience contribute to this leader identity development?

ECT participation helped students further their technical, relational, and project-management skills. Technical competence is an important attribute of technical leaders (Elkins & Keller, 2003). The team members in this study believed that they had improved both their own technical skills and their abilities to coach others. Team members learned the value of individual consideration. Across the board, the study participants had found that successful project completion required identifying and "leaning on [individual] members' strengths," helping each other in times of stress, "understanding [individual] people's motives" and "respect." Engineering team members also gained practice in non-authoritarian management. As both a Shark and a Jet observed, motivating a volunteer workforce required skill in being "assertive but nice." This combination of attributes had been less important in other organizations they had joined.

The degree of leadership development experienced by the team members was moderated by characteristics specific to each team. Although there was little difference in the average age or team tenure of the participants interviewed, the Jets' LID stages were higher overall than those of the Sharks. Both teams offered members the opportunity to exercise leadership in diverse ways, exposing them to new situations with challenging restraints and requiring a higher level of performance than they had experienced through other types of organizations. But the differences in project

complexity, team culture, and team practices likely contributed to the difference in overall LID between the teams.

By promoting an inclusive environment, the Sharks had a good foundation for developing leaders with an appreciation for relational and shared leadership. Unfortunately, other characteristics of the team stood in the way. While not everyone thought that "[the team] is a dictatorship," all the Sharks interviewed exhibited deference to the hierarchy. The team sociograms (Figures 4.1 and 4.2, reproduced below as Figures 7.1 and 7.2) support this finding. Six of seven core team members saw the captain, Danna, as a source of personal influence (Figure 7.1) and five strongly believed that the team saw her as a leader (Figure 7.2). In contrast, Danna was not strongly influenced by any member and gave only three people (Jasmine, André, and Tom) high team leadership readings. The deference to the hierarchy was evident even among those team members (such as Rob and Tom) who expressed some appreciation for collectivistic leadership. The captain was in charge, and her authority was not usurped even when team members knew that she was not fulfilling her responsibilities. Interestingly, Tom—the member who most strongly verbalized deference—did not rate Danna highly on either personal influence or team leadership. This suggests that Tom's deference to Danna was due to Danna's position and not to her personal skill as a leader.

The Sharks' culture also limited opportunities for developing functional leadership skills. Technical leadership requires a strong functional focus. In addition to exercising relational skills, good technical leaders must also have strong technical knowledge, know how to manage financial and material resources, and understand how to develop and adhere to a schedule. By re-using an existing hull design, the Sharks lost

the opportunity to practice CAD skills, learn how to design a floating vehicle, and test alternative shapes. Because the advisor controlled the purse and kept the team's account balance secret, the Sharks did not learn how to work within financial constraints.

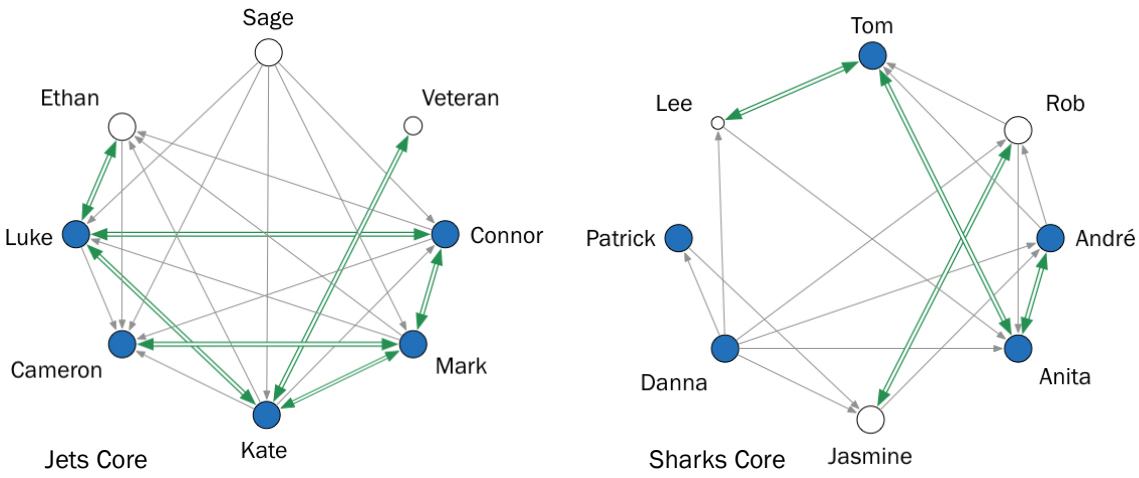


Figure 7.1. Core-group influence sociograms. Shaded circles represent high within-core eigenvector centralities. Arrows indicate the direction of influence. Only within-core influence ratings of 4 or higher are shown.

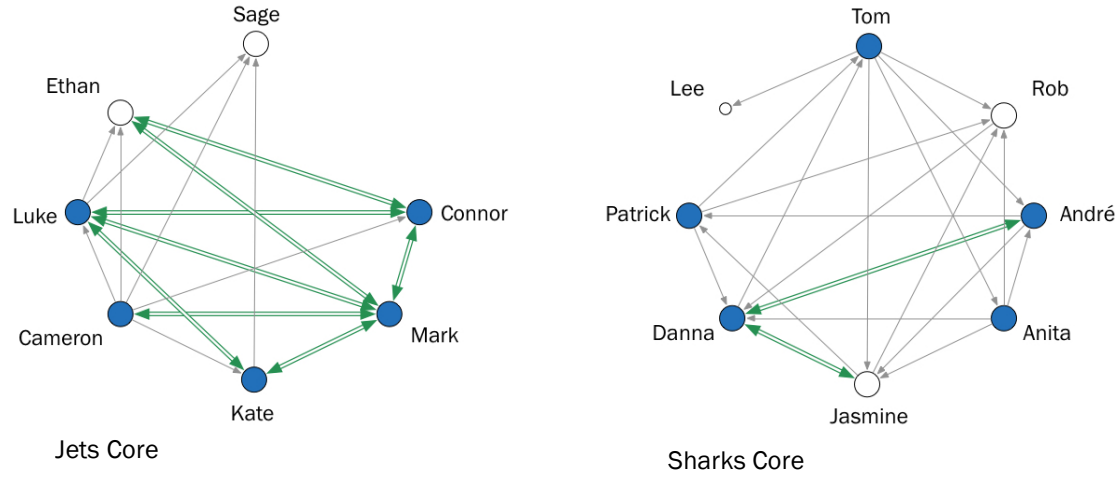


Figure 7.2. Core-group leadership sociograms. Shaded circles indicate high within-core eigenvector centralities. Arrows represent leadership ratings and indicate that the sender considers the receiver to be a source of leadership for the team. Only ratings of 4 or higher are shown.

The captain's failure to delegate resulted in serious delays, a problem worsened because the team did not hold regular meetings to set the schedule and monitor progress. In short, the Sharks had almost no opportunity to collaborate on a technical design or practice true project management, both fundamental skills in engineering leadership.

The Jets' sociograms reveal a much denser web of mutual strong influence and leadership ratings, graphically illustrating Luke's observation that leadership is "more a group effort than one person being a leader." Within the Jets core, there were eight strong mutual team leadership ratings, and seven strong mutual influence ratings. But despite understanding the importance of project management and collaboration, the Jets fell short when putting their ideas into practice. Whereas the Sharks had a lot of willing members without much to do, the Jets had the opposite problem. Most of the experienced members, including the officers, had more than one primary responsibility. For years, Jets have bemoaned their inability to retain a critical mass of new members. To put it in athletic terms, they had no depth at any of the positions and could not field a full team. They also struggled to "hold people accountable." If a member failed to complete a design or task on time, the rest of the team had little recourse.

The complexity of the Jets' project granted many different types of opportunities for team members to design systems, and the interdependencies encouraged—even required—teammates to collaborate. The Jets had charter to make most of their own decisions regarding fundraising, budgets, and procurement, so members could practice managing financial resources and boundary-spanning. The Jets also exhibited little deference to hierarchical positions. Individual members had responsibility for certain systems, but most decisions were made as a group, at least among the core team

members. And because members were encouraged keep each other apprised of progress, they could share the load when one member dropped behind schedule.

The conclusions drawn from Phase 1 (the questionnaire) and Phase 2 (the interviews) corroborated each other. The teams' sociograms and core-group leadership densities (Table 4.2) suggested a greater degree of mutual influence and shared leadership among the Jets than among the Sharks, a conclusion that was supported by the interviews.

The dense web of mutual influence and leadership ratings within the Jets core supports their stated emphasis on collaboration (Table 5.2). The Sharks, who placed less importance on collaboration, had fewer mutual influence and leadership connections. Conversely, the Jets mentioned delegation less often than did the Sharks, possibly because the close working relationships among the Jets reduced the need for formal delegation.

Results from the team environment questionnaire (Table 4.1) were less conclusive, primarily because a follow-up questionnaire was not administered. The questionnaire was administered during the fall semester, a low-stress period for both teams. At the time, the teams' overall internal team environment scores were nearly identical. But among returning team members, the Sharks scored higher than the Jets on the dimensions of Social Support (4.4 and 3.9, respectively) and Voice (4.5 and 4.0). Possible reasons for these differences emerged in the interviews. The Sharks' higher Social Support rating may have been due to the team's emphasis on fun and friendship, a common theme expressed by the Sharks. On the other hand, the high rating on the Voice dimension was difficult to square with the Sharks' complaints about problems

with delegation and communication. Some interviewed members positively discussed the charrette during which the team selected the canoe's visual design theme. The questionnaire was administered after the charrette took place, so perhaps the respondents were thinking about that process when they answered the questions about Voice.

Initially, I had chosen to use social network measures to identify candidates for the interviews and to get a rough picture of the leadership landscape within the teams. Post-hoc analyses revealed some interesting relationships between team members' social network measures and their LID stages. The leadership density of the Jets core group was 0.57. Of those core-team members who were interviewed, leadership identities ranged from the Stage 4–5 transition to Stage 6, with an average LID stage of 5.3.[3] The Sharks core group, on the other hand, had both a lower leadership density (0.48) and a lower average LID stage (3.6). Because shared leadership is a hallmark of a mature leadership identity (Komives et al., 2006), these findings support the use of leadership density as a measure of shared leadership (Carson et al., 2007).

At the individual level, betweenness centrality predicted team members' advancement to positions of greater responsibility. Recall that betweenness centrality indicates a person's service as a connection between members of a network. A person with high betweenness is often promoted faster than others in the organization (Hansen et al., 2011). This was true for the students in this study. Of those who remained in

[3] To compute the average LID stage, I assigned transitions a value halfway between the stage numbers (e.g., the transition between Stages 3 and 4 was assigned a value of 3.5). The LID average is intended only as a general indicator of prevailing leadership identities within a team. The model's originators (Komives et al., 2006) made no claims regarding mathematical properties and relationships.

school the following year, the highest-scoring Jet and the top four Sharks were named to high officer positions, either within ECT or in another engineering organization.

These results show that ECT participation can have a positive contribution on students' leadership development. However, the benefits should not be assumed. The interviews also revealed that there is considerable room for improvement. The teams struggled to manage their projects, failed to document important information, and overemphasized ideal behavior as the key to project success. Advisor involvement also affected leadership development, with mixed results.

Both the Jets and the Sharks struggled with setting clear goals, establishing a schedule, and monitoring progress. While members of both teams wanted to finish their projects earlier than in the past, neither team succeeded. In fact, they barely finished their projects before the competitions. According to a Shark, "We were putting on the last coat of sealant in the parking lot" at the regional competition site. A university employee close to the teams said that the Jets had not successfully driven their car before taking it to the first competition. Establishing structure and monitoring progress are important elements of team leadership (Burke et al., 2006; Morgeson 2010). Even though the members understood this idea intellectually, they apparently did not know how to effectively manage the project.

Members of both teams expressed intentions to record relevant information for future use, but informal follow-up conversations with team members indicated that neither team succeeded. Knowledge capture was not actively managed, probably because the team members did not consider knowledge transfer to be critical to the upcoming competition. The pressures of completing the project left little time for

activities that would benefit future teams but would have little perceived effect on the present. Within ECT, much expertise is held "in the head" (Norman, 2013, p. 109) and leaves the team when a member graduates. An individual student's leadership learning may increase, but unless lessons are captured in a way that future team members can benefit, the team's leadership capacity may not improve (Burke et al., 2006).

While both teams identified the need for improved processes, better teamwork, and earlier completion, neither team truly understood that good project management made everything else possible. Instead, the teams over-emphasized ideal behavior. The Sharks valued "passion," dedication, and hard work. The Jets also believed that sacrifice and hard work distinguished the successful teams from the rest. In the words of Mark, "It's how much effort you put into the team that makes it how well you do at competition… [If] the whole team wants to sacrifice… then that's how you become a top-ten team." As Hackman and Wageman (2005) noted, effort and skill are important to success, but they are insufficient. In order for a team to work effectively, the team also must employ appropriate performance strategies.

Although I did not set out to investigate the team advisor's role in the leadership development process, advisor influence emerged as a theme in the interviews. Both advisors acted in a consulting role, providing input when requested. Both advisors behaved in ways that seem to have promoted team members' leadership development. But by exercising too much control in some areas and not enough in others, the advisors also acted in ways that may have blocked members' development.

7.2 How Can Institutions Improve the Leadership Development Opportunities for Students via the Engineering Competition Team Experience?

An intentional approach to student leadership development will enhance the educational value of the engineering competition team experience. Institutions can foster leadership development in a number of ways:

1. Build a foundation of technical and project-management skills upon which the teams can build.

a. Provide a technical elective course in which students can learn to use machine tools and gain experience with skills such as welding, soldering, and basic circuitry. This would help students gain confidence and relieve some of the training responsibilities currently borne by the teams.

b. Conduct project-management workshops at the beginning of the fall semester. As we have seen, trying to learn and implement project-management skills at the same time limits both learning and execution. To enhance retention and application of lessons taught during the workshops, team advisors should encourage good project management practices throughout the competition season.

2. Establish appropriate boundaries within which the teams are allowed to direct their own activities. In addition to designing and building, students should conduct all activities included under the umbrella of functional leadership, including budgeting, procurement, and contacting sponsors.

Hackman (2002) suggests that administrators define activities that teams should "always do" or "never do." A similar philosophy is followed by the Fortune 500 company W. L. Gore & Associates, which allows work teams to direct their own activities as long as the team's decisions do not affect the company "below the

waterline" (Manz et al., 2009, p. 241). This approach would allow team members to practice leadership while not being given so much latitude that they sabotage the project.

3. Educate the advisors about effective coaching practices. Even leaders need leadership, and advisors can contribute to students' leadership development by modeling good leadership themselves. Advisors are often a repository of wisdom; an experienced advisor can help bridge the leadership gap even when the individual team leaders have moved on. Advisors should act as active coaches rather than consultants. Hackman & Wageman (2005) recommend that team coaches actively intervene at three times during the course of a team work cycle. For ECT, the season naturally divides itself into two work cycles corresponding to the fall and spring semesters. At the beginning of the work cycle, the advisor should act as a motivator, helping team members learn about the work environment, the task, and their respective roles and responsibilities. Explaining the basic timeline is appropriate at this point, but the advisor should avoid in-depth discussions of the schedule. The focus should be on helping the team have a "good launch" (p. 270). At the midpoint of the team cycle, the advisor should act as a consultant by helping the team discuss its strategy, refine the timeline, and address problems. And at the end of the cycle, the advisor should as an educator, helping the team review performance and "capture and internalize the lessons… learned from the experience" so that the team can build its capacity (p. 278). As Kozlowski and colleagues (1996a, b) and Day (2011) have noted, leadership development does not happen during periods of extreme stress and high activity, but in the intervening time of reflection between periods of engagement.

7.3 Concluding Remarks

The engineering team experience clearly enhanced the leadership development of most students in this study. Some gained confidence to accept greater leadership responsibilities. Others learned that relational skills were valuable leadership attributes, and that a collaborative approach was often more effective than a directive style.

One longtime member remarked, "You hope just by being around people, it will rub off, they'll understand you, how we work, but it never works out that way." While this team member was talking about knowledge of team processes, that comment also illustrates this college's perspective on team learning in general: Historically, the college has expected that team members will learn project management and leadership just by working on the project. Unfortunately, the reality always falls short. In order to help students develop as leaders, institutions must approach leadership development more intentionally. We must teach basic technical skills early, so that, in the words of a staff member, "the practice and the practical are not happening at the same time." Because project management problems are often the source of team interpersonal problems (Hackman and Wageman, 2005), we should actively teach and reinforce good project management. And we should teach advisors to act more as coaches than consultants, providing strategic interventions at developmentally appropriate times within competition season (Hackman & Wageman, 2005).

Students' leadership development is enhanced when they have opportunities to practice leadership and when that practice is accompanied by affirmation, education, and coaching. Building a leadership identity is one part of the leadership development process; improving leadership effectiveness is the other. Although leadership skill

development should progress as a person moves through the LID stages, leadership identity should not be confused with leader effectiveness. A person with a strong leadership identity may still be faced with situations that exceed his or her abilities to effect change or ensure positive outcomes. In these cases, advisors and peer mentors can and should intervene, thereby helping the team members avoid catastrophic failures.

This study evaluated the effects of engineering competition team participation on students' individual leadership development. Further research should examine the development of team-level leadership capacities within engineering competition teams. Building strong team-level leadership could result in a progression of team success, rather than simply helping the individual participants learn leadership lessons.

References

Alabart, J. R., Özgen, S., and Brull, E. A. (2008). *The Alabart Competency Dictionary*. Tarragona, Spain: Universitat Rovira i Virgili.

Antes, A. L., & Schuelke, M. J. (2011). Leveraging technology to develop creative leadership capacity. *Advances in Developing Human Resources, 13,* 318–365.

American Society of Civil Engineers (2013). *2014 ASCE National Concrete Canoe Competition Rules & Regulations*. Retrieved from http://www.asce.org/uploadedFiles/Concrete_Canoe/Rules_and_Regulations/2014%20ASCE%20NCCC%20Rules%20and%20Regulations.pdf on 30 September 2014.

American Society of Civil Engineers (2014). *Concrete Canoe*. Retrieved from http://www.asce.org/concrete_canoe/ on 29 December 2014.

American Society of Civil Engineers (2013). Sponsorship. In *ASCE National Concrete Canoe Competition*, www.asce.org/concretecanoe/sponsors-contact.

American Society of Civil Engineers (2013). Why have a concrete canoe competition? In *ASCE National Concrete Canoe Competition*, www.asce.org/concretecanoe/basicsidebar.aspx?id=23622324580.

Antonakis, J. (2011). Predictors of leadership: The usual suspects and the suspect traits. In Bryman et al. (eds.), *The Sage Handbook of Leadership*, pp. 269–285.

Arena, M. P., Ferris, S. P., & Unlu, E. (2011). It takes two: The incidence and effectiveness of co-CEOs. *The Financial Review, 46,* 385–412.

Arnone, M., & Stumpf, S. A. (2010). Shared leadership: From rivals to co-CEOs. *Strategy & Leadership, 38,* 2, 15–21.

Astin, A. W., & Astin, H. S. (2000). *Leadership Reconsidered: Engaging Higher Education in Social Change*. Battle Creek, MI: W. K. Kellogg Foundation.

Atwater, L. E., Dionne, S. D., Avolio, B., Camobreco, J. F., & Lau, A. W. (1999). A longitudinal study of the leadership development process: individual differences predicting leader effectiveness. *Human Relations, 52*, 12, 1543–1562.

Barnowe, J. T. (1975). Leadership and performance outcomes in research organizations: The supervisor of scientists as a source of assistance. *Organizational Behavior & Human Performance, 14,* 264–280.

Barry, B. E., Meyer, K. F., Arnett, K. P., Spittka, B. (2013). Competition-based learning activities within civil engineering education. In *Proceedings of the 120th ASEE Annual*

Conference & Exposition, Atlanta, Georgia. American Society for Engineering Education.

Bass, B. M. (1985a). *Leadership and Performance Beyond Expectations*. New York: The Free Press.

Bass, B. M. (1985b). Leadership: good, better, best. *Organizational Dynamics, 13,* 26–40.

Bass & Riggio (2006). *Transformational Leadership*. Mahwah, NJ: Lawrence Erlbaum Associates.

Bennis, W. (2009). *On becoming a leader*, 20th anniversary edition. New York: Basic Books.

Bigelow, B. F., Glick, S., & Aragon, A. (2013). Participation in construction management student competitions: perceived positive and negative effects. *International Journal of Construction Education and Research, 9,* 272–287.

Bonacich, P. (2007). Some unique properties of eigenvector centrality. *Social Networks, 29*, 555-564.

Borrego, M., Karlin, J., McNair, L. D., & Beddoes, K. (2013). Team effectiveness theory from industrial & organizational psychology applied to engineering student project teams: a research review. *Journal of Engineering Education, 102,* 4, 472-512.

Bowers, D. G., & Seashore, S. E. (1966). Predicting organizational effectiveness with a four-factor theory of leadership. *Administrative Science Quarterly, 11*, 2, 238–263.

Bresnen, M. J. (1995). All things to all people? Perceptions, attributions, and constructions of leadership. *The Leadership Quarterly, 6*, 4, 495–513.

Brewer, W. D. (2009). Leaders of the pack: Responsibilities and experiences of collegiate drum majors. *Research & Issues in Music Education, 7,* 1. Retrieved from http://www.stthomas.edu/rimeonline/vol7/brewer.htm on 4 January 2015.

Bruner, J. (2004). Life as narrative. *Social Research, 71*, 3, 691–710. Originally published in *Social Research, 54*, 1, Spring 1987.

Bryman, A. (2004). Qualitative research on leadership: A critical but appreciative review. *The Leadership Quarterly, 15*, 729–769.

Bryman, A., Collinson, D., Grint, K., Jackson, B., & Uhl-Bien, M., eds. (2011). *The Sage Handbook of Leadership.* London: Sage Publications Ltd.

Bryman, A. (2011). Research methods in the study of leadership. In Bryman et al. (eds.), *The Sage Handbook of Leadership*, pp. 15–28. London: Sage Publications Ltd.

Burke, C. S., DiazGranados, D., & Salas, E. (2011). Team leadership: A review and look ahead. In Bryman et al. (eds.), *The Sage Handbook of Leadership*, pp. 338–351. London: Sage Publications Ltd.

Burke, C. S., Stagl, K. C., Klein, C., Goodwin, G. F., Salas, E., & Halpin, S. M. (2006). What type of leadership behaviors are functional in teams? A meta-analysis. *The Leadership Quarterly, 17,* 288-307.

Burns, J. M. (1978) *Leadership*. New York: Harper & Row.

Buschlen, E., & Dvorak, R. (2011). The social change model as pedagogy: Examining undergraduate leadership growth. *Journal of Leadership Education, 10,* 2, 38–56.

Cameron, K. S., Dutton, J. E., & Quinn, R. E., eds. (2003). Positive organizational scholarship: Foundations of a new discipline. San Francisco: Berrett-Koehler.

Carson, J. B., Tesluk, P. E., & Marrone, J. A. (2007). Shared leadership in teams: an investigation of antecedent conditions and performance. *Academy of Management Journal, 50*, 1217–1234.

Chan, K., & Drasgow, F. (2001) Toward a theory of individual differences and leadership: Understanding the motivation to lead. *Journal of Applied Psychology, 86,* 481–498.

Chickering, A. W., & Reisser, L. (1993). *Education and Identity*, 2nd ed. San Francisco: Jossey-Bass.

Christopherson, J. A. (1979). Influence concentration analysis and the Middle East 1949–1966. *Political Methodology, 6,* 1, 75–121.

Collinson, D. (2011). Critical leadership studies. In Bryman et al. (eds.), *The Sage Handbook of Leadership*, pp. 181–194. London: Sage Publications Ltd.

Creswell, J. W. (2009). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, 3rd ed. Los Angeles: Sage.

Crevani, L., Lindgren, M., & Packendorff, J. (2010). Leadership, not leaders: On the study of leadership as practices and interactions. *Scandinavian Journal of Management, 26,* 77–86.

Dansereau, F., Yammarino, F. J., & Markham, S. E. (1995). Leadership: The multiple-level approaches. *The Leadership Quarterly, 6*, 3, 251–263.

Dannason, P. D. (2007). The effect of band director leadership style and student leadership ability on band festival ratings. Research & Issues in Music Education, 5, 1, retrieved from http://www.stthomas.edu/rimeonline/vol5/davison.htm on 4 January 2015.

Day, D. V. (2001). Leadership development: a review in context. *The Leadership Quarterly, 11,* 581-613.

Day, D. V. (2011). Leadership development. In Bryman et al. (eds.), *The Sage Handbook of Leadership*, pp. 37–50. London: Sage Publications Ltd.

Day, D. V., Gronn, P., & Salas, E. (2004). Leadership capacity in teams. *The Leadership Quarterly, 15,* 857–880.

Day, D. V., Harrison, M. M., & Halpin, S. M. (2009). *An Integrative Approach to Leader Development: Connecting Adult Development, Identity, and Expertise.* New York: Routledge.

Day, D. V., & Sin, H.-P. (2011). Longitudinal tests of an integrative model of leader development: Charting and understanding developmental trajectories. *The Leadership Quarterly, 22,* 545–560.

Denis, J.-L., Langley, A., & Sergi, V. (2012). Leadership in the plural. *The Academy of Management Annals, 6,* 1, 211–283.

DeRue, D. S., Ashford, S. J., & Cotton, N. C. (2009). Assuming the mantle: Unpacking the process by which individuals internalize a leader identity. In L. M. Roberts & J. E. Dutton, eds., *Exploring Positive Identities and Organizations: Building a Theoretical & Research Foundation*, pp. 217–236.

DeRue, D. S., Nahrgang, J. D., Wellman, N., & Humphrey, S. E. (2011). Trait and behavioral theories of leadership: An integration and meta-analytic test of their relative validity. *Personnel Psychology, 64,* 1, 7–52.

DeRue, D. S., & Wellman, N. (2009). Developing leaders via experience: The role of developmental challenge, learning orientation, and feedback availability. *Journal of Applied Psychology, 94,* 4, 859–875.

Díaz-Sáenz, H. R. (2011). Transformational leadership. In Bryman et al. (eds.), *The Sage Handbook of Leadership*, pp. 299–310. London: Sage Publications Ltd.

Dolan, D., Batchelder, M., McReynolds, J. Osberg, K., Koontz, R., Mahon, P., Keegan, M., & Weiss, J. (2011). Student development in the co-curriculum through values-based teaming. *Proceedings of the 41st ASEE/IEEE Frontiers in Education Conference,* T3C-1.

Drath, W. H., & Paulus, C. J. (1994). Making common sense: Leadership as meaning-making in a community of practice. Center for Creative Leadership, Report No. 156. Retrieved from http://www.leadingeffectively.com/interdependent-leadership/wpcontent/uploads/2012/10/Making-Common-Sense-Drath-and-Palus-1994.pdf.

Dupuis, M., Bloom, G. A., & Loughead, T. M. (2006). Team captains' perception of athlete leadership. *Journal of Sport Behavior, 29,* 1, 60–78.

Dugan, J. P. (2006). Explorations using the social change model: Leadership development among college men and women. *Journal of College Student Development, 47*, 2, 217–225.

Dugan, J. P., & Komives, S. R. (2010). Influences on college students' capacities for socially responsible leadership. *Journal of College Student Development, 51,* 5, 525–549.

Edmondson, A. C. (2003). Speaking up in the operating room: How team leaders promote learning in interdisciplinary action teams. *Journal of Management Studies*, 40, 6, 1419–1452.

Elkins, T., & Keller, R. T. (2003). Leadership in research and development organizations: A literature review and conceptual framework. *The Leadership Quarterly, 14,* 587–606.

Eys, M. A., Loughead, T. M., & Hardy, J. (2007). Athlete leadership dispersion and satisfaction in interactive sport teams. *Psychology of Sport and Exercise, 8,* 281–296.

Fairhurst, G. T. (2011). Discursive approaches to leadership. In Bryman et al. (eds.), *The Sage Handbook of Leadership*, pp. 495–507. London: Sage Publications Ltd.

Fleishman, E. A., Mumford, M. D., Zaccaro, S. J., Levin, K. Y., Korotkin, A. L., & Hein, M. B. (1991). Taxonomic efforts in the description of leader behavior: A synthesis and functional interpretation. *The Leadership Quarterly, 4*, 245–287.

Fletcher, J. K. & Käufer, K. (2003). Shared leadership: paradox and possibility. In C. L. Pearce & J. A. Conger, eds., *Shared Leadership: Reframing the Hows and Whys of Leadership,* 21–47. Thousand Oaks, CA: Sage.

Follett, M. P. (1924). *Creative Experience*. New York: Longmans, Green.

Follett, M. P. (1928). The teacher-student relationship. Presented at Boston University. Reprinted in 1970 in *Administrative Science Quarterly, 15,* 2, 137–148.

Foor, C. E., Walden, S. E., Trytten, D. A., & Shehab, R. L. (2013a). "We weren't intentionally excluding them… Just old habits.": Women, (lack of) interest, and an

engineering student competition team. In *Proceedings of the 2013 Frontiers in Education Conference*.

Foor, C. E., Walden, S. E., Trytten, D. A., & Shehab, R. L. (2013b). "You choose between TEAM A, good grades, and a girlfriend—you get to choose two!": How a culture of exclusion is constructed and maintained in an engineering design competition team. In *Proceedings of the 120th ASEE Annual Conference & Exposition*, Atlanta, GA.

Freeman, L. C. (1979). Centrality in social networks conceptual clarification. *Social Networks, 1,* 215-239.

French, R., Simpson, P., & Harvey, C. (2006). Downplaying leadership: Researching how leaders talk about themselves. *Leadership, 2,* 4, 469–479.

Friedrich, T. L., Vessey, W. B., Schuelke, M. J., Ruark, G. A., & Mumford, M. D. (2009). A framework for understanding collective leadership: The selective utilization of leader and team expertise within networks. *Leadership Quarterly, 20,* 933–958.

Gibb, C. A. (1954). Leadership. In G. Lindsey (ed.), *Handbook of Social Psychology*. Reading, MA: Addison-Wesley, pp. 877–917.

Greene, B. (2014). Hanging by a string. *Smithsonian, 45,* 9, 21–27 and 88–90.

Grint, K. (2011). A history of leadership. In Bryman et al. (eds.), *The Sage Handbook of Leadership*, pp. 3–14.

Gronn, P. (2002). Distributed leadership as a unit of analysis. *The Leadership Quarterly, 13,* 423–451.

Gruner, A. (no date). Organizing a Formula SAE Team. Retrieved from http://students.sae.org/cds/formulaseries/fsae/reference/orgteam01.htm on 30 September 2014.

Haber, P. (2011). Peer education in student leadership programs: responding to co-curricular challenges. *New Directions for Student Services*, Spring 2011, 65–73.

Hackman, J. R. (2002). *Leading teams: Setting the stage for great performances*. Boston: HBS Press.

Hackman, J. R., & Wageman, R. (2005). A theory of team coaching. *Academy of Management Review, 30,* 2, 269–287.

Hackman, J., & Walton, R. E. (1985). *The Leadership of Groups in Organizations*: Technical Report #6, Research Program on Group Effectiveness. New Haven, CT: Yale School of Organization and Management.

Hanneman, R. A., & Riddle, M. (2005). *Introduction to Social Network Methods*. Riverside, CA: University of California, Riverside. Published in digital form at http://faculty.ucr.edu/~hanneman/.

Hansen, D.L., Shneiderman, B., & Smith, M. A. (2011). *Analyzing Social Media Networks with NodeXL: Insights from a Connected World.* Burlington, MA: Elsevier.

HERI (1996). *A Social Change Model of Leadership Development, Guidebook III*. Los Angeles, CA: Higher Education Research Institute.

Hillebrand, D. G. (2013). SAE president's message. *2013 Formula SAE Michigan Event Guide*.

Hiller, N. J., Day, D. V., & Vance, R. J. (2006). Collective enactment of leadership roles and team effectiveness: A field study. *Leadership Quarterly, 17,* 387–397.

Hirst, G., Mann, L., Bain, P. Pirola-Merlo, A., & Richver, A. (2004). Learning to lead: The development and testing of a model of leadership learning. *The Leadership Quarterly, 15,* 311–327.

Hodgson, R. C., Levinson, D. J., & Zaleznik, A. (1965). *The Executive Role Constellation: An Analysis of Personality and Role Relations in Management*. Boston: Harvard University.

Hoy, A., & Meisel, W. (2008). *Civic engagement at the center: Building democracy through integrated cocurricular and curricular experiences*. Washington, DC: Association of American Colleges and Universities.

Janson, A., Popper, M., Blyde, P., Markwick, L., & Ranatunga, C. (2008). Extracting leadership knowledge from formative experience. *Leadership, 4,* 1, 73–94.

Jones, T., Boettner, D., Dillon, J., Ivey, S., Lambert, A., Novoselich, B., & Suhr, S. (2009). Organizational leadership and effective team problem-solving strategies in engineering design projects: An analysis of student perceptions. In *Proceedings of the ASEE Annual Conference*, AC 209-907.

Judge, T. A., & Piccolo, R. F. (2004). Transformational and transactional leadership: A meta-analytic test of their relative validity. *Journal of Applied Psychology, 89,* 5, 755–768.

Judge, T. A., Piccolo, R. F., & Ilies, R. (2004). The forgotten ones? The validity of consideration and initiating structure in leadership research. *Journal of Applied Psychology, 89,* 1, 36–51.

Katz, D., & Kahn, R. L. (1978). *The social psychology of organizations* (2nd ed.). New York: Wiley.

Kets de Vries, M., & Balazs, K. (2011). The shadow side of leadership. In Bryman et al. (eds.), *The Sage Handbook of Leadership*, pp. 380–392. London: Sage Publications Ltd.

Klenke, K. (2008). *Qualitative research in the study of leadership*. Bingley, UK: Emerald Group Publishing Ltd.

Komives, S. R., Owen, J. E., Longerbeam, S. D., Mainella, F. C., & Osteen, L. (2005). Developing a leadership identity: A grounded theory. *Journal of College Student Development, 46,* 593–611.

Komives, S. R., Longerbeam, S. D., Owen, J. E., Mainella, F. C., & Osteen, L. (2006). A leadership identity development model: Applications from a grounded theory. *Journal of College Student Development, 47*, 401–418.

Komives, S. R., Longerbeam, S. D., Mainella, F. C., Osteen, L., Owen, J. E., & Wagner, W. (2013). Leadership identity development: Challenges in applying a developmental model. *Journal of Leadership Education, 8,* 1, 11–47.

Komives, S. R., Wagner, W., & Associates (2009). Leadership for a better world: Understanding the social change model of leadership development. San Francisco: Jossey-Bass.

Kozlowski, S. W. J., Gully, S. M., McHugh, P. P., Salas, E., & Cannon-Bowers, J. A. (1996a). A dynamic theory of leadership and team effectiveness: Developmental and task-contingent leader roles. *Research in Personnel and Human Resources Management, 14,* 253–305.

Kozlowski, S. W. J., Gully, S. M., Salas, E., & Cannon-Bowers, J. A. (1996b). Team leadership and development: Theory, principles and guidelines for training leaders and teams. *Advances in Interdisciplinary Studies of Work Teams, 3,* 253–291.

Laguette, S. (2013). Team leadership on capstone design project teams. In *Proceedings of the ASEE Annual Conference*, Paper 5904.

Ligon, G. S., Hunter, S. T., & Mumford, M. D. (2008). Development of outstanding leadership: A life-narrative approach. *The Leadership Quarterly, 19,* 3, 312–334.

Likert, R. (1961). *New Patterns of Management*. New York: McGraw-Hill.

Locke, E. A. (2003). Leadership: Starting at the top. In C. L. Pearce & J. A. Conger, eds., *Shared Leadership: Reframing the Hows and Whys of Leadership,* Chapter 13. Thousand Oaks, CA: Sage.

Lord, R. G., & Hall, R. J. (2005). Identity, deep structure and the development of leadership skill. *The Leadership Quarterly, 16,* 591–615.

Loughead, T. M., Hardy, J., & Eys, M. A. (2006). The nature of athlete leadership. *Journal of Sport Behavior, 29,* 142–158.

Manz, C. C., Shipper, F., & Stewart, G. L. (2009). Everyone a team leader: Shared Influence at W. L. Gore & Associates. *Organizational Dynamics, 38,* 239-244.

Mayo, M., Meindl, J. R., & Pastor, J.–C. (2003). Shared leadership in work teams: a social network approach. In C. L. Pearce & J. A. Conger, eds., *Shared Leadership: Reframing the Hows and Whys of Leadership*. Thousand Oaks, CA: Sage.

McGrath, J. E. (1962). *Leadership Behavior: Some Requirements for Leadership Training.* Washington, DC: U. S. Civil Service Commission, Office of Career Development.

Morgeson, F. P., DeRue, D. S., & Karam, E. P. (2010). Leadership in teams: A functional approach to understanding leadership structures and processes. *Journal of Management, 36,* 5–39.

Mumford, M. D., Connelly, S., & Gaddis, B. (2003). How creative leaders think: Experimental findings and cases. *The Leadership Quarterly, 14,* 411–432.

Mumford, M. D., Friedrich, T. L., Vessey, W. B., & Ruark, G. A. (2012). Collective leadership: Thinking about issues vis-à-vis others. *Industrial & Organizational Psychology, 5,* 408–411.

Mumford, M. D., Hunter, S. T., Eubanks, D. L., Bedell, K. E., Murphy, S. T. (2007). Developing leaders for creative efforts: A domain-based approach to leadership development. *Human Resources Management Review, 17,* 402–417.

Mumford, M. D., Marks, M. A., Connelly, M. S., Zaccaro, S. J., & Reiter-Palmon, R. (2000). Development of leadership skills: Experience and timing. *The Leadership Quarterly, 11,* 87–114.

Mumford, M. D., Robledo, I. C., & Hester, K. S. (2011). Creativity, innovation, and leadership: Models and findings. In Bryman et al. (eds.), *The Sage Handbook of Leadership*, pp. 405–422. London: Sage Publications Ltd.

Mumford, M. D., Scott, G. M., Gaddis, B., & Strange, J. M. (2002). Leading creative people: Orchestrating expertise and relationships. The Leadership Quarterly, 13, 705–750.

Mumford, M. D., Zaccaro, S. J., Harding, F. D., Jacobs, T. O., & Fleishman, E. A. (2000). Leadership skills for changing world: Solving complex social problems. *The Leadership Quarterly, 11,* 11–35.

Norman, D. (2013). *The Design of Everyday Things: Revised and Expanded Edition*. New York: Basic Books.

O'Toole, J., Galbraith, J., & Lawler, E. E., III (2003). When two (or more) heads are better than one: the promise and pitfalls of shared leadership. In C. L. Pearce & J. A. Conger, eds., *Shared Leadership: Reframing the Hows and Whys of Leadership,* Ch. 12. Thousand Oaks, CA: Sage.

Özgen, S., Sánchez-Galofré, O., Alabart, J. R., Medir, M., & Giralt, F. (2013). Assessment of engineering students' leadership competencies. *Leadership & Management in Engineering, April*, 65-75.

Pan, R., Shehab, R. L., Foor, C. E., Trytten, D. A., Walden, S. E., (2015). Building diversity in engineering competition teams by modeling industry best practice. In *Proceedings of the 2015 ASEE Annual Conference & Exposition*. Seattle, WA: American Society of Engineering Education.

Pearce, C. L. (2004). The future of leadership: Combining vertical and shared leadership to transform knowledge work. *Academy of Management Executive, 18,* 1, 47–59.

Pearce, C. L. & Conger, J. A., eds. (2003). *Shared Leadership: Reframing the Hows and Whys of Leadership.* Thousand Oaks, CA: Sage.

Pearce, C. L., & Sims, H. P. Jr. (2002). Vertical versus shared leadership as predictors of the effectiveness of change management teams: An examination of aversive, directive, transactional, transformational, and empowering leader behaviors. *Group Dynamics: Theory, Research, and Practice, 6,* 172–197.

Pearce, C. L., Manz, C. C., & Sims, H. P. (2008). The roles of vertical and shared leadership in the enactment of executive corruption: Implications for research and practice. *The Leadership Quarterly, 19*, 3, 353–359.

Pearce, C. L., & Wassenaar, C. L. (2014). Leadership is like fine wine: It is meant to be shared, globally. *Organizational Dynamics, 43,* 1, 9–16.

Podsakoff, P. M., MacKenzie, S. B., Moorman, R. H., & Fetter, R. (1990). Transformational leader behaviors and their effects on followers' trust in leader, satisfaction, and organizational citizenship behaviors. *The Leadership Quarterly, 1,* 2, 107–142.

Posner, B. Z. (2004). A leadership development instrument for students: Updated. *Journal of College Student Development, 45,* 4, 443–456.

Roberts, L. M., & Dutton, J. E., eds. (2009). *Exploring Positive Identities and Organizations: Building a Theoretical & Research Foundation.* New York: Routledge.

Rube Goldberg Inc. (2014). *Contest History*. Retrieved from http://rubegoldberg.com/Contest?page=contest_history on 29 December 2014.

Rucker, W. (1969). A value-oriented framework for education and the behavioral sciences. *The Journal of Value Inquiry, 3,* 4, 270–280.

SAE International (2013). *2014 Formula SAE Rules*. Retrieved from http://students.sae.org/cds/ formulaseries/rules/2014_fsae_rules.pdf on 30 September 2014.

SAE International (2014). *CDS Events History*. Retrieved from http://students.sae.org/cds/formulaseries/cdshistory.htm on 29 December 2014.

Salas, E., Dickinson, T. L., Converse, S. A., & Tannenbaum, S. I. (1992). Toward an understanding of team performance and training. In R. W. Swezey, & E. Salas (eds.), *Teams: Their training and performance* (pp. 3–29). Norwood, NJ: ABLEX.

Salas, E., Sims, D. E., & Burke, C. S. (2005). Is there "big five" in teamwork? *Small Group Research, 36,* 555–599.

Schein, E. H. (1992). *Organizational Culture and Leadership*, 2nd ed. San Francisco: Jossey-Bass.

Schuster, P., Davol, A., & Mello, J. (2006). Student competitions: the benefits and challenges. In *Proceedings of the 2006 American Society for Engineering Education Annual Conference & Exposition.*

Scribner, J. P., Cockrell, K. S., Cockrell, D. H., & Valentine, J. W. (1999). Creating professional communities in schools through organizational learning: An evaluation of a school improvement process. *Educational Administration Quarterly, 35*, 130–160.

Sergi, V., Denis, J.–L., & Langley, A. (2012). Opening up perspectives on plural leadership. *Industrial & Organizational Psychology, 5,* 403–436.

Shamir, B., Dayan-Horesh, H., & Adler, D. (2005). Leading by biography: Toward a life-story approach to the study of leadership. *Leadership, 1*, 1, 13-29.

Shamir, B., & Eilam, G. (2006). What's your story? A life-stories approach to authentic leader development. *The Leadership Quarterly, 16,* 395–417.

Sinclair, A. (2011). Being leaders: Identities and identity work in leadership. In Bryman et al. (eds.), *The Sage Handbook of Leadership*, pp. 508–517.

Sirianni, V. L., Lee, K. E., LeFevre, M. D., Lindholm, J. W., Aghayere, A., Valentine, M. (2003). Assessing the impact of the concrete canoe and steel bridge competitions on

civil engineering technology students. *Proceedings of the 2003 American Society for Engineering Education Annual Conference & Exposition.*

Smith, D. W. (2013). Phenomenology. *The Stanford Encyclopedia of Philosophy* (Winter 2013 Edition), Edward N. Zalta (ed.), URL = <http://plato.stanford.edu/archives/win2013/entries/phenomenology/.

Smith, M., Milic-Frayling, N., Shneiderman, B., Mendes Rodrigues, E., Leskovec, J., & Dunne, C., (2014). NodeXL: A free and open network overview, discovery and exploration add-in for Excel 2007/2010, http://nodexl.codeplex.com/ from the Social Media Research Foundation, http://www.smrfoundation.org.

Sorenson, G., Goethals, G., & Haber, P. (2011). The enduring and elusive quest for a general theory of leadership: Initial efforts and new horizons. In Bryman et al. (eds.), *The Sage Handbook of Leadership*, pp. 29–36.

Sparrowe R. T., Liden, R. C., Wayne, S. J., & Kraimer, M. L. (2001). Social networks and the performance of individuals and groups. *Academy of Management Journal, 44,* 316–325.

Spector, B. (2014). Flawed from the get-go: Lee Iacocca and the origins of transformational leadership. *Leadership, 10,* 3, 361–379.

Stice, J. M. (2011). *A Leader's Introduction of Rapid and Radical Change into an Organization: A Case Study of Jack Welch and General Electric.* Dissertation (unpublished). Graduate School of Education and Human Development of The George Washington University.

Stodgill, R. M. (1950). Leadership, membership, and organization. *Psychological Bulletin, 47,* 1–14.

Sulzbach, C. (2007). Enhancing engineering education? Concrete canoe competition. *Proceedings of the 2007 American Society for Engineering Education Annual Conference & Exposition,* Session 3649.

Tonso, K. (2006a). Student engineers and engineer identity: Campus engineer identities as figured world. *Cultural Studies of Science Education, 1,* 2, 273–307.

Tonso, K. (2006b). Teams that work: campus culture, engineer identity and social interaction. *Journal of Engineering Education, 95,* 1, 25–37.

The Town Paper. (2015). What is a charrette? http://www.tndtownpaper.com/what_is_charrette.htm.

Trytten, D. A., Pan, R., Foor, C. E., Shehab, R. L., Walden, S. E. (2015) Inclusion or Exclusion? The Impact of the Intersection of Team Culture, Student Identity and

Pathway on Team Diversity. *In Proceedings of the 2015 ASEE Annual Conference, Paper 11763.*

Tyree, T. M. (1998). *Designing an instrument to measure socially responsible leadership using the social change model of leadership development.* Doctoral dissertation. College Park, MD: University of Maryland.

Uhl–Bien, M., Marion, R., & McKelvey, B. (2007). Complexity leadership theory: Shifting leadership from the industrial age to the knowledge era. *The Leadership Quarterly, 18,* 298–318.

Van Knippenberg, D., van Knippenberg, B., De Cremer, D., & Hogg, M. A. (2004). Leadership, self, and identity: A review and research agenda. *The Leadership Quarterly, 15*, 825–856.

Walden, S. E., Foor, C. E., Shehab, R. L., & Trytten, D. A. (2013). Student, Experiential-Learning, Engineering Competition Teams (SELECT): Early results. Poster presented at the Annual STEP Grantees' Meeting, Washington, DC. Available online at stepcentral.net/posters/700/#.VLfINIrF_rg.

Wankat, P. C. (2005). Undergraduate student competitions. *Journal of Engineering Education*, 94, 3, p. 343–347.

Wankat, P. C. (2013). Personal communication.

Wasserman, S., & Faust, K. (1994). *Social Network Analysis: Methods and Applications*. Cambridge, UK: Cambridge University Press.

Yammarino, F. J., Dionne, S. D., Chun, J. U., & Dansereau, F. (2005). Leadership and levels of analysis: A state-of-the-science review. *The Leadership Quarterly, 16,* 879–919.

Yammarino, F. J., Salas, E., Serban, A., Shirreffs, K., & Shuffler, M. L. (2012). Collectivistic leadership approaches: Putting the "we" in leadership science and practice. *Industrial & Organizational Psychology, 5*, 382-402.

Yin, R. K. (2013). *Case Study Research: Design and Methods*, 5th ed. Los Angeles: Sage.

Yukl, G. (2011). Contingency theories of effective leadership. In Bryman et al. (eds.), *The Sage Handbook of Leadership*, pp. 286–299.

Yukl, G. (2013). *Leadership in Organizations*, 8th ed. Boston: Pearson Education, Inc.

Zaccaro, S. J., Rittman, A. L., & Marks, M. A. (2001). Team leadership. *The Leadership Quarterly, 12,* 451–483.

Zafft, C. R., Adams, S. G., Matkin, G. S. (2009). Measuring leadership in self-managed teams using the Competing Values Framework. *Journal of Engineering Education, 98,* 3, 209-303.

Zimmerman-Oster, K., & Burkhardt, J. C. (1999). *Leadership in the Making: Impact and Insights from Leadership Development Programs in U.S. Colleges and Universities*. Battle Creek, MI: W. K. Kellogg Foundation.

Appendix: Data Collection Instruments

Social Network Questionnaire

1. Is this your first semester to participate on this competition team? ____ Yes ____ No

2. Have you participated on any other engineering competition teams? ____ Yes ____ No

If yes, which team(s)? _____

3. For the next set of questions, think about your experience working with the current team members. Mark the box that indicates your level of agreement with the following statements, where *1* means you strongly disagree and *5* means you strongly agree. If you do not know, write "do not know" across the answer boxes.

	1	*2*	*3*	*4*	*5*
1. The members of my team spent time discussing our team's purpose, goals, and expectations for the project.					
2. The members of my team discuss our team's main tasks and objectives to ensure that we have a fair understanding.					
3. The members of my team devise action plans and schedules that allow for meeting our team's goals.					
4. The members of my team talk enthusiastically about our team's progress.					
5. The members of my team recognize each other's accomplishments and hard work.					
6. The members of my team give encouragement to team members who seem frustrated.					
7. People in this team are encouraged to speak up to test assumptions about issues under discussion.					
8. As a member of this team, I have a real say in how this team carries out its work.					
9. Everyone on this team has a chance to participate and provide input.					
10. My team supports the active participation of everyone in decision making.					
11. The team's faculty advisor expresses confidence in the capabilities of our team.					
12. The team's faculty advisor effectively motivates and guides our team toward accomplishing challenging goals for this project.					
13. The team's faculty advisor is sensitive to the needs of our team and tries to help us however he or she can.					

4. Now think about the current individual members of this team. Which current team members influence you? List their names in the blanks below. You do not have to fill each blank. Do not list the faculty advisor.

A. _____
B. _____
C. _____
D. _____
E. _____
F. _____
G. _____
H. _____

5. Copy the name of each person above in the corresponding blank below. For example, if you listed "Kim Wolfinbarger" in Blank A, then write "Kim Wolfinbarger" on the line for Team Member A.

Below each team member's name, there are two questions. On a scale of 1 to 5, where 1 means "not at all" and 5 means "to a great extent," answer the questions for that team member.

	1	*2*	*3*	*4*	*5*
Team Member A:					
To what extent does Team Member A influence you?					
To what extent does your team rely on this person for leadership?					
Team Member B:					
To what extent does Team Member B influence you?					
To what extent does your team rely on this person for leadership?					
Team Member C:					
To what extent does Team Member C influence you?					
To what extent does your team rely on this person for leadership?					
Team Member D:					
To what extent does Team Member D influence you?					
To what extent does your team rely on this person for leadership?					
Team Member E:					
To what extent does Team Member E influence you?					
To what extent does your team rely on this person for leadership?					
Team Member F:					
To what extent does Team Member F influence you?					
To what extent does your team rely on this person for leadership?					

	1	*2*	*3*	*4*	*5*
Team Member G:					
To what extent does Team Member G influence you?					
To what extent does your team rely on this person for leadership?					
Team Member H:					
To what extent does Team Member H influence you?					
To what extent does your team rely on this person for leadership?					

Thank you. Turn this questionnaire face-down when you are finished.
Please check your Informed Consent form to ensure that you have answered all questions and included a signature.

Preliminary Questionnaire for ECT Leadership Interview Participants

1. Is this your first semester to participate on this competition team?
   ____ Yes ____ No

2. Have you participated on any other engineering competition teams at [university]? ___ Yes ____ No

   a. If yes, which team(s)? _____

3. How many semesters have you completed at [this university]? _____

4. What year and semester do you expect to graduate? _____

5. What is your major? _____

6. Do you have a minor(s)? If so, in what field(s)? _____

7. List any other majors you have declared or pursued at [this university]:
   _____

8. Year and place of birth: _____

9. Graduating high school and location: _____

10. Did you come straight to [this university] from high school? ____ Yes ____ No

    a. If no, what did you do between high school and [coming here]?

11. Is English your first or primary language?
    a. first
    b. not first, but primary language spoken at home
    c. neither, please describe: _____

12. What is the highest level of education for each of your parents?

Mother	Father	Education
		Some high school
		High School diploma or GED
		Some college
		Technical certification (e. g. career tech)
		2-yr degree
		4-yr degree
		Graduate or Professional school (e. g. law, medicine, MA/MS/PhD)

13. Which best describes the race or ethnicity you identify with most?
    a. African-American
    b. Asian-American
    c. Native American; please list your tribal affiliation(s) or enrollment(s): _____
    d. Hispanic-American, white
    e. Hispanic-American, black
    f. Hawaiian or Pacific Islander
    g. white
    h. mixed or other; please describe: _____

14. With which gender do you identify? ____ Female ____ Male

15. Do you have a job(s) now? ____ Yes ____ No

    If yes, complete:

    Total hours per week: _____

    Is your job related to engineering or technology? ____ Yes ____ No

    Describe briefly:

    _____

    _____

Interview Protocol A: Returning Members

Teamwork within ECT

1. What is the purpose of your team?

2. What is your team's goal this year?
    a. How did your team decide on that goal?

3. How is the team structured?
    e. g., work groups, subteams, officers, managers

4. Which subteam are you a member of?
    a. How are tasks assigned within your [sub] team?
    b. Who decides?

5. About how many hours per week have you spent working on the [project]?
    a. When do you usually work?
    b. With whom do you usually work?
    c. How do you decide when to work?
    d. How do you know what to work on?

6. How would you describe the team chemistry?

7. Describe communication within your team. Is it good, okay, poor?
    a. What makes someone a good communicator? Do you notice that some teammates are better at communication than others?
    b. What do they do to facilitate team communication?
    c. How does the team communicate with new members?

8. Tell me coaching within the team. Who coaches? What do they do? Who receives coaching?
    a. *Coaching* specifically refers to helping members learn technical and other project-related skills.

9. How does the team handle member errors, conflicts or disputes?
    a. What happens when a team member makes a mistake?

10. How do team members support each other? Can you give an example?
    a. *Support* is broader than *coaching*. Can refer to assistance with workload, encouragement, cooperation, flexibility in scheduling, etc.

Individual Perceptions of Leadership and Teamwork

11. What do you think leadership is?
    a. How has that changed over the years?

12. Other than [team], what groups are you involved in?
    b. Level of involvement, activities, positions

13. In general, do others consider you a leader? How do you know?

14. Have you had any particular leadership training? Tell me about that.

Leadership within the Team

15. Who are the leaders on [team]?
    a. Don't prompt too much—want to know if the respondent lists only officers or also recognizes nonpositional leaders.

16. [For each leader mentioned in Q15] What makes this person a leader, in your opinion?
    a. Don't prompt too much—want to know what skills the respondent associates with leadership.

Individual Contributions to the Team

17. How do you contribute to the team? Think beyond your particular job/role.

18. You mentioned earlier that others [consider/do not consider] you a leader. Do you view yourself as a leader on the team? How?
    a. What makes you [not] a leader? What experiences inform that assessment?

19. What has your experience on the team taught you about leadership?
    a. Avoid prompting.

20. Describe a situation within [team] where you applied leadership training, or applied some knowledge you had gained from previous experience.

21. Is there anything you'd like the team to do differently this year?
    a. What are you planning to do to make that happen?
    b. Could be technical, task-oriented, or person-oriented changes—looking for the respondent's goal-setting perspective.

22. Is there anything else you'd like to share about leadership?

Interview Protocol B: New Members

Teamwork within ECT

1. What is the purpose of your team?

2. What is your team's goal this year?
    a. How did your team decide on that goal? Were you a part of that discussion?

3. Are you part of a particular subteam? [chassis, powertrain, etc.]

4. About how many hours per week have you spent working on the [project]?
    a. When do you usually work?
    b. With whom do you usually work?
    c. How do you decide when to work?
    d. How do you know what to work on?

5. How would you describe the team chemistry?

6. Now let's talk about communication within the team.
    a. As a new member, how do you find out about meetings? What about work days? How do the current members keep you in the loop?
    b. What makes someone a good communicator? Do you notice that some teammates are better at communication than others?
    c. What do they do to facilitate team communication? With you as a new member?

7. As a new member, do you feel free to ask questions or make suggestions? Can you give an example of a time when you did so?

8. Sometimes new members receive coaching from former members. Would you tell me about coaching that you or other new members have received?

Individual Perceptions of Leadership and Teamwork

9. Other than [team], what groups are you involved in?
    a. Level of involvement, activities, positions

10. What do you think leadership is?
    a. How has that changed over the years?

11. In general, do others consider you a leader? How do you know?
    Have you had any particular leadership training? Tell me about that.

Leadership within the Team

12. Who are the leaders in [team]?
    a. Don't prompt too much—want to know if the respondent lists only officers or also recognizes nonpositional leaders.

13. [For each leader mentioned in Q12] What makes that person a leader, in your opinion?
    a. Don't prompt too much—want to know what skills the respondent associates with leadership.

Individual Contributions to the Team

14. How do you contribute to the team? Think beyond your particular job/role.

15. You mentioned earlier that others [consider/do not consider] you a leader. Do you view yourself as a leader on the [team]? What makes you say that?

16. Is there anything else you'd like to share about leadership?