THE MYTHOS OF ENGINEERING CULTURE:

A STUDY OF COMMUNICATIVE PERFORMANCES AND INTERACTION

by

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ABSTRACT

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The Mythos of Engineering Culture: A Study of Communicative Performances and Interaction

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Across a wide variety of literatures, researchers consistently identify similar values and practices that characterize "engineering culture." Engineers themselves are aware that they belong to a professional culture that sets explicit guidelines for what it means to be an engineer. The amazing coherence and persistence of engineering culture suggests that there is a certain mythos surrounding it.

Recently, professional engineering associations and engineering scholars have pointed to the importance of group work in the field of engineering and have suggested that engineers are not adequately prepared to work well with others. As Barley (1996) contends, the nature of work in the U.S. is changing dramatically and the most serious barriers to adapting successfully to these changes are likely to be cultural. Moreover, in passing, recent engineering scholars have suggested that the culture of engineering may impeded the collaborative process of a team (Ingram & Parker, 2002).

This thesis explores the intersections between engineering culture and group interaction by examining the ways in which the mythos of engineering culture plays out in communicative performance. Through interviews and participant observation of engineering students at the University of Colorado, I adopt a cultural communicative performance perspective (Pacanowsky & O'Donnell-Trujillo, 1983) to study how the mythos of engineering culture is performed in engineers' interactions with one another. This study shows that the mythos of engineering culture does shape the communicative performances constitutive of engineering culture and although many of these performances may constrain effective group interactions, there are others that clearly promote it.

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CHAPTER I

INTRODUCTION

> A recent survey of employers of graduates with bachelor's degrees in engineering found that of eight employee attributes, the one which the greatest number of employers valued highly was teamwork – and engineering graduates were less prepared in this area than in math and science. Furthermore, more than three-fifths of respondents said that in a revised engineering curriculum it would be most important to give more time to the development of student's communication skills. (From the National Society of Professional Engineers as quoted in Bucciarelli & Kuhn, 1997 p. 220)

> Learning how to work in teams is not a natural process for many students, but it is nonetheless extremely important. Students should learn to work in both small and large teams so that they acquire planning, budgeting, organizational, and interpersonal skills. Ample course material should support the students in their teamwork. (*Computing Curricula 2001: Computer Science*, 2001, p. 59)

> The Accreditation Board of Engineers and Technology (ABET) and its counterpart, the Canadian Engineering Accreditation Board (CEAB), have argued that engineering schools should be developing students' communication skills, their interpersonal and teamwork skills, and their project management skills. (Ingram & Parker, 2002, p. 7)

As numerous scholars have argued, engineers are distinctly aware that they belong to a specific culture that has very clear guidelines about what it means to be an engineer (Brooks, 1982; Florman, 1987; Hacker, 1981; Kunda, 1992; McIlwee & Robinson, 1992). Research on engineers by social scientists and engineers themselves acknowledges that engineers do believe in a uniform engineering culture. In a well cited study, McIlwee and Robinson (1992) contend that this engineering culture consists of three main components that are recognized by most engineers: (1)

An ideology that stresses the centrality of technology, and of engineers as producers of technology; (2) the acquisition of organizational power as the base of engineering success; and (3) a self-centered "macho" belief in the value of engineers. Numerous studies of engineers in the workplace and in educational settings agree that engineers understand these characteristics to be key features of engineering culture.

Setting aside the question of whether this depiction is accurate, the concept or the metaphor of engineering culture is amazingly coherent. Across a wide variety of literatures, scholars consistently identify similar values and practices of engineering culture. Regardless of its truth, engineering culture is a pervasive and persistent concept. The professional myth has lasting power.

Although engineering culture is said to preference individuality and non-communication, as the quotations that open this thesis demonstrate, every major professional engineering association now says that engineers must learn how to work effectively with one another, and from all corners the call is being made to engineering schools to teach students how to interact in teams. Additionally, the burgeoning corpus of literature on engineering management says that whether engineers like it or not, the need for group work and team based assignments will continue to grow more common in the workplace (Carlson, 2001; Hilburn & Humphrey, 2002; Lovgren & Racer, 2000; Workman, 1995). In organizations that employ engineers, teamwork is on the rise because of its ability to help spark innovative ideas and allow participants to produce higher quality projects (Ancona & Caldwell, 1992; Jassawalla & Sashittal, 1999; LaFasto & Larson, 2001; Sutton, 2002).

This thesis explores the intersections between “engineering culture” and group interaction by examining the ways in which culture plays out in communicative performance. Through interviews and participant observation of engineering students at the University of Colorado, I adopt a cultural communicative performance perspective (Pacanowsky & O'Donnell-Trujillo, 1983) to study how the mythos of engineering culture is performed in engineers’ interactions with one another. Before I discuss the importance of this study on both theoretical and practical levels, I define my object of analysis: Engineering Culture.

Engineering Culture as Organizational Culture

Just as countries and organizations have their own culture, so too do occupational communities (Van Maanen & Barley, 1984). Although engineers often have varied orientations and work with distinct technical and analytical tools, scholars have argued the importance that “engineering culture” plays in the formation and maintenance of engineering practices and values (Hacker, 1981; Kunda, 1992; McIlwee & Robinson, 1992; Sharp, Robinson, & Woodman, 2000). The idea of engineering culture is important because most engineers orient their identities and careers to their occupation rather than to their organizational communities (Whalley & Barley, 1997). For engineers in particular, paying attention to engineering culture may be more telling about engineering practices and values than examining the companies for which the engineer works.

Throughout this thesis I describe engineering culture as an organizational culture. I agree with Weick (1979) that in the process of organizing individuals continually activate a repetitive series of interlocked behaviors and, in so doing, form a collective structure. As a community of practitioners, engineers do just that. Occupational communities, such as engineering, represent bounded work cultures populated by people who share similar identities and values that transcend specific "organizational" settings (Van Maanen & Barley, 1984). From their first days in an engineering school, engineers are indoctrinated with the values and beliefs of the engineering community. They are taught how to work and think as an engineer (Bucciarelli & Kuhn, 1997). As they move into the world of professional practice their identity as engineers is continually shaped by the culture of the occupation. Interactions with other engineers tightly script their behaviors and communication practices. Professional organizations such as the National Society for Professional Engineers and the Institute of Electrical and Electronics Engineers (IEEE) serve to institutionalize and further homogenize the practices of engineering culture.

The mythos of engineering culture is pervasive and persistent. As such, engineering culture does not operate at any single level of analysis. Instead, the coherent themes stressed in engineering culture are present in individuals, groups, organizations, and society. Even if the qualities that are said to "make a good engineer" are not uniformly accepted, they are, as Brooks (1982) observes, widely recognized. Therefore, we can see engineering culture permeate all institutions with which engineers are involved. In their interactions with others, engineers carry distinct traces of engineering culture with them.

In sum, engineering culture is a distinct type of organizational culture because, like all organizational cultures, it is created and maintained through daily patterns of interaction shared among members of the entire community. And, as Van Maanen and Barley (1984) suggest, an occupational culture such as engineering culture might be an even stronger organizing force than workplace cultures because occupational communities transmit a shared culture from generation to generation by blurring the distinction between work and leisure activities in a way that workplace culture cannot.

Rationale for Researching Engineering Culture

Contribution to Theory

The major theoretical contribution of this study is an increased understanding of the intersections between culture and group interaction. Scholars have suggested that paying attention to cultural performances is one way we can begin to understand how cultures operate (Pacanowsky & O'Donnell-Trujillo, 1983; Putnam, Phillips, & Chapman, 1996; Taylor, 1999). Aiming for more than a mere understanding of cultural communicative performances, this study examines the performances of engineering culture in order to begin to understand how culture plays out in interactional settings such as work groups. Accordingly, this study addresses two bodies of literature.

The first is the literature on organizational culture from a communicative performance perspective. Since Michael Pacanowsky and Nick O’Donnell Trujillo made the first definitional statement of this perspective in 1983, many scholars have undertaken cultural analyses under this rubric. These accounts have tended toward description, examining communicative performances in different organizational cultures. The current study hopes to advance the theory of communicative performance in organizational culture by helping to identify the functions that culture serves in group interaction.

This study also has the potential to advance our understanding of how and why engineers interact with one another they way they do. Much of the research on engineering teamwork has looked to the structure of teamwork to explain why engineers do not work well with others. For example, Hilburn and Humphrey (2002) claim that one of the major problems engineering professors face when trying to teach students how to work in teams is that the teachers themselves have not been trained to work in teams. The authors suggest that in order to teach students to work in teams engineering professors should be taught how to select team members, assign team roles, build cohesive unity, assess progress, and provide meaningful advice and guidance. Such an analysis relies on the structure of teamwork itself to help engineers work together in teams. The analysis in the present study agrees that structures of teamwork are important for helping individuals to interact in meaningful ways. However, understanding how culture is *performed* might enable us to see how interaction among engineers really works.

Contribution to Practice

Scholars, practitioners, and employers alike are noticing that engineers are not well equipped to work with other individuals to bring a project to fruition, even though the scope of most projects is such that they require multiple engineers to work on them simultaneously. Currently, many pedagogical methods within engineering curricula simply instruct teachers to place students together in groups and have them figure it out (Bucciarelli & Kuhn, 1997; Ingram & Parker, 2002; Margolis & Fisher, 2001). However, we do not currently know enough about how engineering culture intersects with interaction to make recommendations for how individuals could work together more effectively. As Bucciarelli and Kuhn (1997) observe, "Engineering as a social process must be integrated into the science-based curriculum, not tacked onto it. The changes we believe necessary are deep and fundamental: They are changes in culture, in ways of seeing, in ways of relating to the tasks of engineering and to its scientific content" (p. 222). For engineers to work effectively together they must not only work together, or even simply learn how to work together; instead, the cultural practices that intersect with group interaction should be identified. This study has the potential to enumerate points of agreement and conflict between engineering culture and group interaction and make recommendations for strategies engineers can adopt to work better with one another.

Agenda

The following chapters begin an exploration into how the specific practices of engineering culture affect the way engineers work in teams. This chapter has set forth the rationale for the study. The second chapter establishes a theoretical framework for examining organizational culture from a communication perspective. This chapter focuses in on one particular strand of organizational communication research on organizational culture that is particularly well suited to identify specific communicative performances in engineering culture. The third chapter reflects on the mythos of engineering culture and provides examples of specific features of the culture. The fourth chapter details the research setting and population and outlines the methodological framework I use to analyze the data. Chapter five presents the results of the study. The final chapter presents an analysis of the communicative performances prevalent in engineering culture and explores the theoretical and practical implications of this study.

CHAPTER II

THEORETICAL FRAMEWORK: ORGANIZATIONAL CULTURE AND COMMUNICATIVE PERFORMANCE

This chapter establishes a theoretical framework for studying organizational culture. I begin by examining issues of organizing from a cultural perspective in which researchers treat organizational culture as a symbolic variable. Second, I discuss how communication scholars attempt to move our understanding of culture from one in which culture is something an organization *has* to something an organization *is*. Third, I trace a particular line of research within the literature on organizational communication and culture to articulate how communicative performances in organizations constitute culture. Fourth, I discuss the limitations of the performance perspective by considering what this perspective leaves out in its analysis of organizational culture.

Organizational Culture as a Symbolic Variable

As Meryl Reyes Louis (1985) notes, concern with workplace cultures is nothing new. Early organization scholars including Barnard (1968), Selznick (1969), and Katz and Kahn (1966) observed that organizational members often organize themselves informally and establish norms, symbols, and codes of conduct for how one should act in the organization. In the late 1960's, scholars began to take seriously the informal codes of conduct occurring in organizational settings and developing theories of socialization in order to understand, as Schein (1968) put it, how members "learn the ropes."

Andrew Pettigrew (1979) was arguably the first to coin the term "organizational culture." Much like his predecessors, he was interested in understanding the role of norms and rituals in organizational contexts. His brief statement about how to study organizational cultures differed from previous research on norms and rituals in two important ways. First, rather than simply studying organizations as entities, he was interested in understanding groups that had organized. Although he does not develop this idea sufficiently in his work, it is clear that his understanding of organizations was very similar to, and perhaps influenced by, the work of Karl Weick. Weick (1979) proposed that organizations were not static. Rather, he saw them as dynamic and urged scholars to pay attention to the processes of organizing and to examine how individuals form a collective structure by activating "repetitive series of interlocked behaviors" (p. 90). Second, Pettigrew suggested that the norms and rituals that made up an organizational culture were *symbolic* and observed that "symbolic construction serves as a vehicle for group and organizational conception" (1979, p. 574). Pettigrew suggested that organizational cultures were created symbolically through the use of language, rituals, myths, and "organizational sagas." He pointed to the symbolic acts performed by organizational members as a useful tool for studying transition processes in beliefs, values, and structures as they created organizational cultures.

Early organizational scholars in the management tradition attempted to isolate symbolic meaning as a cognitive construct shared among members of an organization in order to explain how organizational culture worked. Accordingly, many early studies of organizational culture attempted to account for the ways culture was embodied and transmitted symbolically among members of an organization (Barley, 1983; Dandridge, Mitroff, & Joyce, 1980; Martin, Feldman, Hatch, & Sitkin, 1983; Pfeffer, 1981). Barley (1983) commented that "organizations are speech communities sharing socially constructed systems of meaning that allow members to make sense of their immediate, and perhaps not so immediate environments" (p. 393), but simultaneously proclaimed that "'culture' is somehow implicitly tied to notions of social cognition and contextual sense making" (p. 393). These management scholars examined how organizational members enacted cultural codes by studying how culture was developed continually from an individual's encounter with others. More specifically, these scholars attempted to isolate the shared meaning of the signs and symbols through which human communication and interaction is achieved.

Because management scholars defined culture in terms of its symbolic qualities, and located it within individual organizational members, they could now look to culture as a key construct for explaining why certain social practices took shape and constantly reconstituted themselves in the process of organizing. Cultural studies of organizations from this symbolic perspective were common in the early 1980s and researchers applied this symbolic approach to a variety of tasks. Van Maanen and Barley (1984) examined how the culture of organizations such as occupations and work groups were transmitted over time and worked to construct members' identities. Schein (1992) examined how the values of the founder influenced the creation of organizational cultures and Martin (1992) theorized about the incommensurability of culture on organizational members.

It soon became clear to practitioners, such as business executives, that the symbolic nature of a culture could be *used* to increase performance in organizations. Studies from the "strong culture" perspective (Deal & Kennedy, 1982; Ouchi, 1981; Peters & Waterman, 1982) emphasized the profound effects that building a "strong" organizational culture could have on the organization's bottom line. As academic writings on organizational culture began to look more like practitioner's writings (Barley, Meyer, & Gash, 1988), management scholars of culture started to pay attention to the ways in which culture could indeed be used as a positive variable. As one example, Schein's (1992; 1996) tremendously influential work on organizational culture was one of the first scholarly efforts to tie together the notion of "strong culture" with symbolism. He emphasized that culture was a symbolic variable organizations could manipulate in order to achieve desired outcomes. In this tradition, the symbolic nature of culture has been important both in explaining why organizations function the way they do and have provided management with practical tools for changing and improving organizational culture. Although the cultural analyses by management theorists were helpful in understanding the effects of culture in organizations, they did not give communication a central role in their creation and reification.

Communication and Organizational Cultures

One of the first theoretical essays on communication and organizational culture to appear in the field of communication was introduced by Pacanowsky and O'Donnell-Trujillo (1982). Drawing on Geertz's (1973) influential work on culture, Pacanowsky and O'Donnell-Trujillo argue that meaning is central to culture and suggest that the metaphor of culture is important to organizational communication analyses because it shows how culture is (1) both confining and facilitative, (2) exists and is created by individual's communication activity, and (3) a context not a cause. The authors agree with management theorists that organizational culture is the product of symbolic processes, but they disagree on one fundamental point: Culture is not a variable, it is constituted by communication. That is to say, a communication perspective does not look at how a person's own meanings come to bear on social situations, but rather looks at how meaning is produced through communication among individuals. This point separates the management perspective on organizational culture from the communication perspective. Where the management theorists studied the former, how an individual's interpretation of the symbolic features of organizational life served to create and perpetuate a culture, communication theorists have looked at the latter by examining how the ways individuals communicate with one another, what they say and do and how they say and do it, constitute and continually reconstitute culture.

As a result, from a communication perspective on organizational culture, scholars have been interested in how organizational life is accomplished communicatively (Deetz, 1982; Pacanowsky & O'Donnell-Trujillo, 1982). Scholars in this tradition draw on the works of Berger and Luckmann (1967) and Hawes (1974) who argued that communication creates and constitutes what we tacitly accept as social reality. Culture, as a feature of organizational life, is thus created and maintained through specific repetitive communication practices enacted by organizational members. In short, a communication perspective on culture holds that there is not something "out there" called culture, nor is culture something individuals keep in their heads. Rather, communication serves to create and recreate culture through the practices of everyday interaction among organizational members.

Scholars who adopt a communication perspective on organizational culture share among them the following assumptions. In line with traditional research on culture in the field of communication, a communication perspective holds that culture is not a variable; rather it is a process of communication that continually recreates itself in the context of organizations. Scholars who adopt a communication perspective also share the assumption that organizations are more than structures or artifacts; they are real people doing real things. Finally, a communication perspective on organizational culture recognizes that culture provides rules for action that both guide individual members and stymie their volition. Communication plays a central role in constructing and reifying the social patterns of interaction that become trapped in the web of culture.

Although most Organizational Communication scholars generally agree that all of the social practices woven into the web of an organization's culture are transmitted from member to member through communication (Bantz, 1993; Carlone

& Taylor, 1998; Deetz, Tracy, & Simpson, 2000; Eisenberg & Riley, 2001; Stohl, 2001; Trujillo, 1992; Weick & Ashford, 2001), those same scholars make varying claims for what it means to actually do research on an organizational culture from a communication perspective.

One well cited typology for the study of organizational cultures from a communication perspective was developed by Bantz. In his description of Organizational Communication Cultures, Bantz (1993; 2001) contends that characterizing organizations as cultures yields four corollaries. The first is that the student of organizations is interested in all the activities of organizational members. Bantz suggests that researchers must pay attention to the speech acts of organizational members as well as written documents and other artifacts of the organization because they all communicate information about the culture. The second corollary is that organizations are processes as well as things and that researchers should pay attention to practices as well as artifacts. Third, Bantz urges students of organizations to see symbols and meaning as basic to organizational life. The fourth and final corollary is that organizations are socially constituted. Bantz also draws on Weick's use of the term "organizing" to suggest that organizational culture is not a variable, but a process that is constituted by communication.

In another typology, Eisenberg and Riley (2001) hold that "organizational culture consists solely of patterns of human action and its recursive behaviors (including talk and its symbolic residues) and meaning" (p. 294). They proffer five guidelines for researching an organizational culture from a communication perspective. First, researchers adopting a communication perspective should pay attention to the ways in which cultural meanings are constructed in everyday activities including conversations, texts, and the nonverbal, semiotic field. The second guideline is that students of organizational culture should recognize that "of all human activities, human communication is the one in which interpretation and action most clearly coexist" (p. 295). Reflecting on the problem of structure vs. agency, Eisenberg and Riley suggest that although social and organizational structures may constrain an individual's ability to communicate, research on culture from a communication perspective also acknowledges that communication has the potential to spark "innovation and novelty" within a culture. Third, the researcher should be attentive to how the broader patterns of communication in society, such as those found in the family, national culture, and government, are adopted and appropriated by organizational members and consequently affect the patterns of communication found in organizations. Fourth, the researcher should be aware that a communication perspective offers new and exciting possibilities for positioning the researcher. The researcher must be cognizant of his/her own role and make deliberate decisions on the action/non-action he/she will take during the research process. Finally, students of organizational culture should bear in mind that from a communication perspective all motives for the study of culture are legitimate. Whether studied from a management or a member's perspective, the authors assume that research on culture will enhance dialogue about the very culture under the researcher's lens.

Organizational Culture: The Communicative Performance Perspective

The perspective that I adopt for my theoretical framework in this study of organizational culture follows a strand of communication research on organizational culture identified as the *communicative performance perspective* (Eisenberg & Riley, 2001; Putnam et al., 1996). In setting out the boundaries for this perspective, Pacanowsky and O'Donnell-Trujillo (1983) observe,

> If culture consists of, as Geertz suggest, 'webs of significance that man himself has spun' (1973, p. 5), and if, as we have suggested elsewhere, spun webs imply some act of spinning (Pacanowsky and O'Donnell-Trujillo, 1982, p. 123), then we need to concern ourselves not only with the structures of cultural webs, but with the process of their spinning as well. (p. 128)

This particular perspective on organizational culture adheres to the same tenets laid out in the broader communication perspective on organizational culture: It adopts a constitutive model of communication and applies it to cultural analysis. Research in this perspective emphasizes that culture is constructed and maintained through communication. The communicative performance perspective also follows a broader communication perspective on organizational culture in its interest in all the activities of organizational members. Additionally, Alvesson (2002a) has recently urged scholars using culture as a root metaphor to consider culture as something an organization *is* rather than something an organization *has* by paying attention to the specific symbolic and performative actions of its members. Drawing on the performance concept, he suggests that culture should be examined on a deeper level, the level where members themselves construct meaning.

Pacanowsky and O'Donnell-Trujillo base their explication of performance on the works of Goffman (1959) and Turner (1980). From Goffman, the authors borrow the notion of "theatricality" in organizational life. They suggest that organizational members are choice-making individuals who either choose to go along with, or flout, the scripts provided to them as members of an organization. Drawing on Turner, the authors argue that performances are the actions organizational members use to constitute and reveal their culture to themselves and to others. These two notions of performance specifically direct culture researchers to pay attention not only to the fact that organizational members communicate, but also to the things members do to bring organizational reality to life. Although it shares the same ontological and epistemological commitments of the broader communication perspective on organizational culture, this perspective moves one step further in its analysis to highlight *performance* as a key theoretical and empirical focal point.

From a theoretical standpoint, paying attention to performances is important because rather than generically credit communication for the creation and reification of culture, researcher from this perspective looks to specific moments in which communication acts are performed – social interaction becomes the focal point when using this metaphor. As Putnam et al. (1996) observe, "in the performance metaphor, organizations emerge as *coordinated actions,* that is, organizations enact their own rules, structures, and environments through social interaction" (p. 384). Through communicative performances, organizational members create and maintain organizational scripts that direct how one should act as a member of that particular culture. The performance perspective pays close attention to the enabling and constraining features of communication not only in the creation of organizational culture, but also in the perpetuation and expansion of existing cultures. Pacanowsky and O'Donnell-Trujillo (1983) contend that interactions always occur within an existing context and the performative features of that context must be given heed if scholars are to understand the mutual shaping that occurs between context and communicative performance.

More concretely, Pacanowsky and O'Donnell-Trujillo (1983, pp. 131-133) and Trujillo (1983, pp. 78-80) note several characteristics of communicative performances. They argue that performances are interactional, meaning that they are enacted socially by multiple participants. Members play both the role of the performer and the spectator in a cultural setting and thereby influence and are influenced by the types of performances that come to define the organization. Performances are also embedded in the very reality they bring to completion. This means that context always emerges as both a constraining and enabling force in the production of performances. Organizational members can create new performances or revise old ones, but are always subject to preceding scripts that determine which performances are acceptable to change. Another key feature of performances is that they are episodic, yet nameable as distinct events. Organizational culture is not characterized by one overarching performance. Rather, different situations call for different performances and organizational members look to their performance scripts to tell them whether an existing performance should be used in a given situation or whether a new performance should be scripted. Finally, performances are improvisational in that the actions of organizational members are never tightly scripted; members always have a certain amount of leeway in their interpretation of a particular performance.

Applying the performance concept to empirical analysis, Pacanowsky and O'Donnell- Trujillo (1983) show how researchers can study organizational culture. In the creation of a heuristic for the analysis of performances, the authors identify five cultural performances that have been analyzed in the literature: Ritual, passion, sociality, politics, and enculturation. The authors argue that through these types of performances scholars can examine how communication has brought culture into being and how it is influenced by existing cultural performances.

The first type of performance that the authors identify is *ritual*. A communication perspective on organizational culture holds that culture is constituted through practices in which members regularly engage. When members perform certain rituals, they are communicating the relative importance of actions to other members of an organization. As one example of a ritual that occurs in organizations, Rosen (1985) describes an annual breakfast at an advertising agency at which members learn about what it takes to succeed at their particular company. Through the choice of cuisine and the order of the speeches presented, the importance of social structure and status is communicated to organizational members, and as Rosen observes, this ritual "promises continuity of employment and ego definition" (p. 48).

A second type of performance often performed in an organization is the *passion* performance. Often, the day-to-day activities that organizational members perform are dull and monotonous. Yet, "members of most organizational cultures frequently talk about their work in a way that transmutes the commonplace into passion" (Pacanowsky & O'Donnell-Trujillo, 1983, p. 138). One of the primary ways that organizational members engage in passion performances is through the process of storytelling. Trujillo (1992) observes how part-time workers at a baseball stadium, workers with less than desirable jobs, talk about the important work they do in preparing the stadium for "the show." In organizational settings workers often find features about their job that they are passionate about and the communication of this passion enlivens the culture with a certain notion about what one should value as a member of that culture.

Sociality is a third type of performance common in organizations. Each organization has a different set of norms for how people will interact with one another. Sociality refers to formalized codes of acceptable interaction with others. Most of the time these norms go unnoticed and it is not until someone breaks one that these cultural norms are noticed. Trujillo (1983) documents how a manager of an automotive dealership personally interacts with his employees. Communication among the organizational members is expected to be direct and even aggressive. Members communicate features of the organizational culture by their norms for sociality. In the dealership examined by Trujillo, members often quipped with each other and told abrasive stories. Consequently the culture was often cutthroat and uncompromising.

The fourth type of performance in organizations is the performance of *politics.* Quite simply, many performances in organizations are aimed at influencing others. In order to get the job done, organizational members often have to win others over by showing personal strength, cementing allies, and bargaining with others. In his study of the computer manufacturing company "Tech," Kunda (1992) depicts how members engaged in performances of politics. Members at the lower level of the organizational hierarchy would often work later than their managers in order to show their commitment to their job and their dedication over other employees. Such political performances communicated personal strength and were successful in influencing managers and other mid-level employees to assign workers to certain projects and give them certain benefits.

The final type of performance identified by Pacanowsky and O'Donnell-Trujillo is the performance of *enculturation.* "Enculturation refers to those processes by which organizational members acquire the social knowledge and skills necessary to behave as competent members" (1983, p. 143). Alvesson (2002b) discusses how members of two different consulting firms taught newcomers how to be part of the organizational culture. In one firm, members taught the newest recruits about the "culture of delivery" by pressuring them to work overtime and requiring them to demonstrate their technical competence early on.

As the examples in the descriptions of the types of organizational performances above demonstrate, researchers use the cultural communicative performance perspective in a variety of ways. By examining how organizational members perform organizational culture, researchers show how culture can enable organizations to adapt easily to some new challenges and can inhibit them from successfully completing others. By examining one or more of the communicative performances constitutive of organizational culture, such researchers elucidate specific interactional moments were culture affects the process of organizing.

Limitations of the Performance Perspective

The cultural communicative performance perspective is an interpretive approach to cultural analysis in organizations. As such, it attempts to provide a thick description of culture (Geertz, 1973) in order to understand the actual patterns of communication in which members participate. It also focuses on the symbolic aspects of human organizational life by attempting to reveal how interactants use symbols to make sense of their everyday experiences (Martin & Nakayama, 1999; Trujillo, 1992).

The strength of the communicative performance perspective is its ability to understand the actual practices that constitute culture. By examining concrete communicative performances, this perspective examines how culture is transmitted and maintained among members of a specific culture. Paying attention to actual communication performances allows researchers to see how culture works and the ways that it is perpetuated through interaction. Such an analysis is well suited to this study because it will allow me to examine how engineering culture is manifested in the daily interactions among members of the culture.

Yet the communicative performance perspective does not lend itself well to certain types of analysis, particularly those involving the creation of cultures, how individuals justify or analyze a culture, or the role of power within a culture. Certain interpretive analyses of organizational culture study how culture is created. For example, Martin and her colleagues (1992; Martin & Frost, 1999; Martin &

Meyerson, 1988) study how organizational culture is brought into being by examining the paradigms of integration, differentiation, and fragmentation. This study does not speak to how cultures themselves are formed or perpetuated in an organization. Instead, I focus on how a known culture is communicated in everyday interactions.

Second, the communicative performance perspective emphasizes the relation between actions and cultural training. As such, it does not attend well to how members justify their actions or how they reflect upon and analyze their behaviors. For example, in other perspectives concerned with how members reflect upon cultural practices and create accounts of their activities that make sense of their existence (Brown & McMillan, 1991) researchers examine both the written and metaphorical texts produced in an organization. By paying attention to members' own reflections on organizational narratives, stories, and documents, scholars have been able to examine how organizational members frame their cultures, highlighting what they choose to include and what they choose to leave out.

Finally, communicative performance perspective does not explicitly attend to the role of power in organizational culture. Power is another interesting feature of organizational culture that scholars have examined from an interpretive approach (Alvesson, 1993; Deetz, 1992; Mumby, 1989). I agree with those scholars who argue that culture can be used to subjugate and control members. Power will be addressed in this study to the extent that it is revealed in the intersection of culture and group interaction.

The performance perspective does not take into account the relationship between organizational practices and outside factors that affect organizations such as the economy, war, or national culture. Although the performance perspective certainly recognizes that external factors are important determinants of internal performances, the performance perspective does not attend to the ways in which such factors specifically affect them.

Summary

Early studies of organizational culture examined culture as a shared symbolic variable in organizations. Communication scholars introduced to culture studies the idea that communication is constitutive of culture and thus culture was created and maintained in the everyday interactions of organizational members. Under the broad umbrella of the communication perspective on organizational cultures, researchers in the communicative performance strand began to look specifically at the ways in which organizational members performed culture through a variety of communicative performances. I adopt the cultural communicative performance perspective in this thesis and adhere to its commitment to examine the actual communication practices in which organizational members engage to construct and reify organizational culture.

CHAPTER III

THE MYTHOS OF ENGINEERING CULTURE

> It is a great profession. There is the fascination of watching a figment of the imagination emerge through the aid of science to a plan on paper. Then it moves to realization in stone or metal or energy. Then it brings jobs and homes to men. Then it elevates the standards of living and adds to the comforts of life. This is the engineer's high privilege. (Whinnery, 1965, p. v)

As Whinnery observes, engineering is a noble profession. The ultimate goal or privilege of the engineer is to use his or her skills to better life for humanity. Yet as observers of engineers have noticed, "engineering" is much more than simply a set of skills: "It is embedded in a social system consisting of shared values and norms, a special vocabulary and humor, status and prestige ordering, and differentiation of members from non-members. In short, it is a culture" (Kiesler, Sproull, & Eccles, 1985, p. 453).

As I observed in Chapter 1, engineering culture is astoundingly coherent, pervasive and persistent. Engineers know what it means to be an engineer, and so does everyone else. As Alvesson (2002a) observes, however, whenever a culture appears to be extremely coherent, researchers should call into question the mechanisms through which that culture maintains its aura of coherency. Recently, Margolis and Fisher (2001; 2003) have attempted to do just that by addressing the "Geek Mythology" that pervades engineering culture. The authors argue that engineering culture profoundly affects how engineering students feel about their purported profession. More importantly, Margolis and Fisher present Geek mythology as a paradox. They claim that although the mythos of engineering culture is profound enough to influence students into believing that most of their peers embody the myth of the engineer, many students do not believe that the culture accurately depicts their own personalities. What is important for the purposes of this study is not whether the mythos of engineering culture accurately portrays the reality of the culture, but rather how that myth intersects with the ways in which engineers interact with others.

They Mythical Engineer

As Brooks (1982) proposed over 20 years ago, the aura of the engineer has been propelled to mythical proportions. Since that time engineering culture has been well studied by both social scientists and engineers themselves. These researchers agree that there are several distinguishing features of the culture that separate it from the cultures of specific workplaces and other occupational communities. In this chapter I outline the various components that constitute the well defined mythos of engineering culture by discussing the various characterizations of the mythical engineer.

The Maverick

The practices of engineering culture uphold the importance of the individual and of autonomy, and such rituals appear in two important places: On the job and in the engineer's education. Engineering rituals that occur on the job are typically rituals associated with the engineer's craft orientation, or what Whalley and Barley (1997) call manual work. Engineering work centers heavily upon a lone engineer tinkering with technology. Engineers routinely spend long hours at a work station and form intimate relations with the technologies they are tasked to create. Because work is so often done individually, engineers engage in seemingly strange rituals to protect the sanctity of their work time. For example, it is typical for an engineer to stay at the office or laboratory late into the night or to bring work home with them just so they can work in solace and without distraction (Perlow, 1999).

One of the reasons that these rituals exist is because the emphasis on the technical and practical applications of work within the engineering profession has positioned the engineer as a maverick. Because a project is only successful if the object or application created works, engineers are rewarded for their ability to think practically and work skillfully. Consequently, focusing on the application of work has exalted the individual to the level of technical guru (Sharp et al., 2000). Engineers are often chosen for special projects only if they demonstrate the requisite technical competence (Perlow, 1997). As a result, rewards for engineers are often based on individual rather then team work and achievements on specific projects hailed above sustained performance (Ross, 2000).

One of the explicit goals of engineering education is to prepare students for the profession by instilling in them a sense of what it means to be a practicing engineer. Therefore, engineering rituals can also be found in the engineer's education. Engineers often work on school projects alone and are required to demonstrate their competence individually even if they have worked in a group to complete an assignment. The ability to perform complex mechanical tasks is a requirement and expectation for graduation from engineering schools and for employment. The ethos of individual work has become so entrenched in engineering culture that group work often seems impossible. A recent study by MIT's Industrial Liaison Program Corporate Advisory Panel noted, "MIT Graduate: Not as perfect for industry as before. Typical product of MIT education – and excellent individual performer but often considers it just about unethical to use results of other people's work. This attitude must change" (quoted in Bucciarelli & Kuhn, 1997, p. 216). One of the reasons that individual work has become so prevalent is because such work is easier to evaluate than group work. In schools, evaluation takes the form of individual scores in classes and on projects, and in the working world the individual who masters technical skill and can perform specific operations on assignments becomes the most valued in the organization (Davis, 1998). Because of the nature of most rituals in engineering culture, rituals that emphasize technical skill and individual work, engineers often understand themselves to be autonomous individuals and regard themselves as mavericks.

The Expert

The relationship between science and engineering is a well discussed topic. Often, engineering is argued by outsiders as distinct from science – even subordinate to science (Layton, 1971). From within the profession, however, engineers see themselves as scientists; as Florman (1987) contends, "In seeking the essence of the engineering view it seems appropriate to begin with the scientific view. All contemporary engineers enter their profession by passing through the portals of science" (p. 68). As a result of responding to doubt from the outside that engineering is really a science, passion for engineering as a science has become even more meaningful. The entrenchment of engineering as a science has had an important consequence for engineering culture in that it has posited the engineer as en expert. Sociologists of knowledge (see for example Knorr Cetina, 1999) have discussed the close relationship between scientific knowledge and the ability to claim expertise. Consequently, engineers often display an ethos of expertise by pronouncing the science of their work. Despite the routine performance of hands-on type rituals, it is common for engineers to talk about their work as science. Although technical craft work occupies most of the engineers time, engineers often talk about the science of their profession and degrade other engineers who appear nonscientific: "Engineers take great pleasure in explaining why a colleague's approach or suggestions does not make sense or is unsound or nonscientific – the harshest of all criticisms" (Frankel, 1993, p. 95).

More than in any other route, the positioning of engineering as a science, and thus overtures to the engineer as the expert, has occurred through engineering education. Engineering programs in colleges and universities describe engineering as a profession that draws on scientific principles (Bucciarelli & Kuhn, 1997) and require students to take numerous science classes. More importantly, as Ingram and Parker (2002) observe, in engineering school attributes including hands-on competence and prowess at scientific engineering talk are respected.

Quite simply, by pointing to the scientific qualities of their work, engineers have posited themselves as experts (Finch, 1951; Winsor, 1988). As an expert who draws upon science for the basis of his/her knowledge, the engineer alone claims the right to do engineering and make design and implementation decisions. As a consequence, engineers have tended to separate "real engineering," work requiring scientific principles, independent creativity, and the skills that one acquires in school, from the other activities they perform at work (Perlow & Bailyn, 1997). The idea of "real engineering" as a type of work that requires intense theoretical training has transformed the engineer from a simple craftsperson into a knowledge worker. Engineering culture, then, is one in which expertise is *sine qua non*. Bucciarelli (1994) shows how engineers invoke the discourse of science when interacting with one another to pronounce their expertise and make claims about the essence of design. Expertise, however, often leads to problems when communicating with other groups. As evidence, Workman (1995) observes that engineering departments often have trouble communicating with other departments, such as marketing, because the engineers revel in their expertise about technical matters and will not concede to other points of view. Even more blatantly, Workman finds that engineers do not trust marketers because they believe they do not have the necessary expertise to make informed decisions. Additionally, and more frighteningly, Winsor (1988) explains how the fact that engineers had a need to overtly display their expertise in technical matters may have contributed to the tenuous conditions that provided for the Challenger space shuttle accident. Such displays of expertise are common in engineering culture because engineers passionately communicate and engage their work as *science*, and engineers believe that they cannot invoke scientific practices if they are not experts.

The Macho

In engineering culture showing strength is often linked to masculine ideals that create a culture of "the right answer." The invocation of the term *machismo* is a helpful lens for understanding engineering culture. The word, which finds its roots in Hispanic culture and refers to the subjugation of men by women through the enactment of socially constructed gender roles, has been picked up by those who study engineering culture such as Carter and Kirkup (1990), who suggest that engineering can be distinguished from other technical professions by the machismo myth that surrounds it and the aura of masculinity with which it is associated. In studying the machismo myth in Hispanic cultures, Strong, McQuillen, and Hughey (1994) identify several characteristic tenets of machismo, among them: Male dominance, possessiveness, aggressiveness, gender-role rigidity, and a constant need for respect. These characteristics resound in the qualities of the engineer. As McIlwee and Robinson (1992) note, "competence as an engineer is a function of how well one presents an image of an aggressive, competitive, technically oriented person" (pp. 20-21). Thus, aggressive displays of technical self-confidence and hands on ability are criteria for success in engineering culture (Ingram & Parker, 2002; Kunda, 1992). For example, Frankel (1993) observes that engineers "seem to thrive on putting each other down and to criticize their work or opinion particularly in the company of nonengineers" (p. 95). On a related note, much of the recent scholarship on engineering culture has focused on the barriers of entry to the profession for women (Carter & Kirkup, 1990; Hacker, 1981; Margolis & Fisher, 2001; McIlwee & Robinson, 1992; Wajcman, 1995), centering on the effect of masculine ideals on cultural practices. This discussion is important because it is particularly illustrative of the cultural qualities endemic to engineering.

Out of the machismo of engineering culture is born the desire to excel. Often, this desire is competitive and cut-throat, but more often than not, it simply highlights the engineers' need to always have the right answer. Brooks (1982) explains that this way of thinking comes from a very simple premise: Because the machine performs perfectly, so must its user. In engineering culture there is a certain arrogance, characteristic of machismo, that the engineer has the power to control technology, and in turn, society (Henderson, 1998). Yet the ability to do so always hinges upon another characteristic of machismo: Getting the answer right. As such, engineering work is understood by engineers to be challenging intellectual work with a large component of tinkering and making something work right (Robinson & McIlwee, 1991), and engineers will work an inordinate number of hours to make sure that they can come up with that right answer (Perlow, 2001).

In taking such care to get the answer right, engineers will occasionally step on one another or engage in nasty battles over who has the better answer. The nature of engineering culture is competitive and concerned with technical results (Kunda, 1992). Holding true to these ideals, engineers work in what Bucciarelli (1994) calls the object-world. He argues that engineers do not always adequately reflect on the process of design, but are usually more concerned with the success of the finished product. This aggressive, outcome focused orientation also has effects for how engineers work with others. Lovgren and Racer (2000) show how teams of engineering students focused so much on the object they were tasked to create that they could not adequately function as a team. The authors reveal that the greatest difficulty encountered when trying to facilitate teamwork among the students was teaching them how to work in groups. With each student vying for the correct answer, students were not following the goals set forth for the assignment and, consequently, all working on unique projects. Similarly, Ingram and Parker (2002) observe that engineers had relatively cavalier attitudes toward group assignments precisely because each student was trying to get the answer right for his or herself.

The Technophile

As Whalley and Barley (1997) observe, there is an inherent tension in having to simultaneously be craft and knowledge workers. For example, an Electrical Engineer is expected to be both an electrician (have the technical skill to solder two wires to together) and a scientist (understand the theories of current and be able to accurately determine which wires to solder together), where in most other professions the hands-on work and the scientific background for it do not go together – an architect rarely swings a hammer on a construction site. When engineers enter the profession, as early as their student years, they experience a tension between being craft and knowledge workers. At the same time, engineers are expected to design adroitly, build technological artifacts, and have an expert knowledge of the theories and scientific phenomena constituting their effectiveness.

Numerous reviews have recognized this dual identity as a hallmark of engineering culture (Barley, 1996; Bucciarelli, 1994; Florman, 1987; Tang, 2000; Whalley & Barley, 1997) and many have suggested that the primary way that engineers resolve the different requirements placed upon them by each role is to identify with and build an affection for the technology with which they work (Brooks, 1982; Feldman, 1989; Robinson & McIlwee, 1991; Whalley, 1986). From electrical, to computer, to mechanical engineering, day in and day out engineers interact with technology. Engineers view themselves in command of technology and the creators of technological advancement in society. The prestige associated with working with high-technology enhances the engineer's love affair with it (Henderson, 1998). Yet for engineers, it is not enough to simply enjoy working with technology, one must be obsessed with it (McIlwee & Robinson, 1992). As a result, the notion of the engineer as technophile pervades the culture of engineering. As Robinson and McIlwee (1991) observe, "Coffee break conversations revolve around cars and tools. To be anything less than similarly obsessed it to be less serious as an engineer" (p. 412).

Technology-centered views of work and occupation reinforced by engineering culture make it acceptable for engineers to work in ways that would seem strange to less technically oriented professions. Perlow (1999) shows how engineers often come to work in the middle of the night to avoid having to work with others, and to be able to concentrate fully on their technology. Other studies concur with these findings and detail how isolationism is important to the work of engineers because it means that they can focus on the technology and do not have to permit themselves to be distracted by other interactions (Feldman, 1989; Hacker, 1981). On a broader level, the culture of engineering stresses the importance of technology over personal relationships and even over formal abstract knowledge (Robinson & McIlwee, 1991). Management's allowance for engineers to work alone with technology rather than together with others even becomes a way for organizations to achieve high employee buy-in (Kunda, 1992). As a result of bypassing collegial interactions through isolated work on technology, engineers are often perceived to have poor communication skills (Ford, Voyer, & Gould-Wilkinson, 2000) and to not work well in group settings. For these reasons, working with technology is not only a requirement of the job of the engineer, but also something that he/she is expected to enjoy above all else.

The Non-Communicator

In every organization there are certain established norms that guide how people communicate with one another. In most organizations, cultural practices have implications for how members communicate with one another. In engineering culture, however, there are explicit norms for how engineers should communicate. More accurately, engineering culture teaches engineers that they should not communicate. As Darling and Dannels (2003) recount, practicing engineers often reflect on how good communication among engineers is stigmatized. Although one might say that engineering culture's rule for communication is "less is better," the one caveat, however, is that talk related to technology, whether task or relationally based, is not looked down upon provided that it too is kept to a minimum (Ingram &

Parker, 2002). Certainly these observations exaggerate the situation a bit. Engineers do often work in teams and do talk to one another. Yet the cultural norm is that less talk is better both in terms of task and socio-emotional factors.

Many scholars have argued that the lack of communication characteristic of engineering culture is due to the fact that engineers work very closely with technology (Henderson, 1998; Robinson & McIlwee, 1991). Engineering culture is one in which obsession with technologies is not only accepted but encouraged and social interaction – as it detracts from time spent with the technology – is discouraged. In engineering culture it is preferable to have a detailed knowledge of, and affection for, the technologies with which one works rather than of social interactions with co-workers. Even more importantly, it is common for engineers to have little knowledge of human communication processes, and an often misleading view that human interaction is a routine, systematic process akin to the operation of certain technologies (Wenk, 1995). Therefore, regular and open communication among engineers often does not occur, and when it does it is mostly related to task objectives.

Although engineers revel in their intimate relationship with technology, the omission of interpersonal interactions in daily work often prevents engineers from working effectively with others; this problem has been well documented (Frankel, 1993; Ingram & Parker, 2002; McIlwee & Robinson, 1992; Tang, 2000). Because of the nature of such work, engineers often have a difficult time understanding people. Engineering scholars have recognized this problem and have devoted a fair amount of time to trying to provide strategies with which engineers can improve interpersonal relations. For example, a recent skill book for professional engineers opens with a chapter entitled “Human Behavior: Understanding Yourself and Others.” Along with an explanation of the “birth order phenomenon,” there is an entire section devoted to models of people. A short excerpt follows:

> People react in two ways: from emotions and from rational analyses… This natural behavior of people is probably governed by the part of their brain more nearly analogous to the ROM’s (read-only memories) in a microcomputer… Again, drawing on the analogy to the microcomputer, the Child’s behavior is a response to the part of the brain which can be represented by a PROM (programmable read-only memory); the Adult’s response is analogous to the part of the brain which can be represented by the ALU (arithmetic logic unit). (Martin, 1993, p.13)

As is clear from this passage, the author is attempting to describe the way people behave by drawing analogies to the way computers are constructed. This is an interesting strategy. Typically, when people interact with computers they tend to anthropomorphize them (Nass & Moon, 2000; Reeves & Nass, 1996), that is, they invoke human characteristics when attempting to make sense of the technology. This passage represents an opposite strategy common for engineers. The engineer is supposed to make sense of humans by invoking the characteristics of technology. If nothing else, this passage is instructional in that it demonstrates the clear affinity for technology over human interaction in engineering culture and lends support for Schein’s (1996), perhaps slightly exaggerated, observation that if given the choice, engineers would replace people with machines and routines.

Research Question

In this chapter I explained how the mythos of engineering culture has a tremendous impact on the engineer's understanding about what it means to be an engineer. Then I detailed how the coherency of this culture has produced various characterizations of the mythical engineer. As Margolis and Fisher (2003) argue, this "Geek Myth" may not adequately reflect all engineers own understanding of themselves. Regardless of its accuracy, the evidence presented in this chapter suggests that this myth has currency within the engineering profession and acts as a persistent and pervasive force in the everyday actions of engineers. The goal of this study is to begin an effort to understand how the coherent mythos that characterizes engineering culture intersects with group interaction among engineers. Therefore I propose the following research question to guide this study:

> RQ: How do the communicative practices of engineers either contribute to or become shaped by the mythos of engineering culture?

CHAPTER IV

RESEARCH METHODS

Methodology

Research Setting

The research setting for this study was the engineering school at the University of Colorado at Boulder. Participants in this study were earning a variety of degrees in engineering, including specializations in electrical and computer engineering, mechanical engineering, and computer science. Over a three year period, a team of researchers was involved in a project to revise a sequence of programming language courses in the engineering school's curriculum. I joined the study in the third year as a research assistant. My duties were to observe group interaction in several undergraduate engineering courses and to provide feedback to instructors on how to create more conversational classrooms (Waite, Jackson, & Diwan, 2003), as well as to provide group mediation and training sessions for the students themselves. Participants were solicited from random selection of all students enrolled in the courses included in the study. For all but one semester, this process yielded less than 30% response; consequently, the solicitation was increased to all students, and participants were enlisted in soliciting the participation of other students (snowball method). However, continued effort was directed to enlisting the students selected randomly. The sample is, therefore, a modified convenience sample (Frey, Botan, & Kreps, 2000).

Participants

This study included the participation of 128 engineering students. Although the participants represent various sub-disciplines within the field of engineering, and although the majority of students were pursuing degrees in software and computer engineering, I refer to these participants throughout as engineers. There are two important reasons for referring to my participants in this way.

First, following the precedent set by scholars researching engineers (Bailey, 2000; Barley, 1996; Bucciarelli, 1994; Downey & Lucena, 1995; Florman, 1987; Hacker, 1981; Kunda, 1992; McIlwee & Robinson, 1992; Whalley & Barley, 1997) there is sufficient evidence to suggest the presence of meaningful commonalities among engineers of different sub-disciplines. Although engineering culture is by no means monolithic, the overarching communicative performances constitutive of it have been shown to be markedly similar across sub-disciplines by such researchers. Additionally, the engineering sub-disciplines represented in this study all fall under the umbrella of the Institute of Electrical and Electronics Engineers (IEEE), the foremost international organization that represents technical areas ranging from computer engineering, biomedical technology and telecommunications, to electric power, aerospace and consumer electronics, among others. Finally, these sub-disciplines represent the most common and rapidly growing forms of engineering and have been studied by other researchers for similar reasons (McIlwee & Robinson, 1992; Whalley, 1986; Zussman, 1985).

Second, following previous research on engineering students (Bucciarelli & Kuhn, 1997; Ingram & Parker, 2002; Lovgren & Racer, 2000), I refer to the student participants in my study as engineers. Bucciarelli and Kuhn (1997) have made the strongest argument for studying engineering students as engineers. The authors contend that at no time in their career are engineers more strongly influenced by the culture of engineering than when they are students at a formative stage. The cultural practices of engineering are deeply ingrained in the standard engineering curricula and, as I discussed in Chapter 3, engineering students begin their enculturation there. Thus students of engineering are engineers (albeit in training) and can provide particularly useful insights into the culture of engineering due to their intense immersion in it.

Although numerous studies have shown that the seeds of engineering culture are sewn while engineers are in school (Bucciarelli & Kuhn, 1997; Ingram & Parker, 2002; Perlow & Bailyn, 1997), engineering students are distinct from practicing engineers. Although this study has operationalized engineering culture at a fairly macro level so as to include both engineering students and practitioners, there are sure to be differences between engineering students and practicing engineers. Further, these findings may not be applicable for all engineering students. The engineering students who participated in this study represent particular engineering sub-disciplines. Because engineering student are different than practicing engineers, and because engineering is a much broader field than this sample represents, one must be careful when making claims about the generalizability of these results on those grounds.

Participants ranged in education level from college sophomores to doctoral students. In terms of professional experience, they ranged from none to over 25 years. All participants had completed at least two introductory courses in software and computer engineering, and the average number of engineering courses completed was five. 32% of all participants indicated that they had worked professionally as an engineer, either as an intern or full time. Of the students who participated in this study, 87% acknowledged having participated as a member of a group in an engineering course. Of those who had previously participated in a group, 46% claimed to have a positive experience.

There is always the possibility that this study suffers from selection bias. It is possible that those who participated in the study do not represent accurately the majority of engineering students, even with these sub-disciplines. However, the scope of the data suggests this is unlikely. The data used in this study were collected during a two and a half year period across four separate courses and ten different classes and involved individuals with distinct emphases, knowledge bases, and comfort levels. Additionally because all of the data were collected at one institution, the possibility exists that the culture of this specific institution is reflected in the sample rather than the more general culture of engineering.   As a partial check against this bias, general findings will be compared with prior studies of engineering education and engineering students.

Procedures for data collection

Data for this project were collected through interviews with, and observation of, engineering students at the University of Colorado. The interviews were begun in the fall of 2000 and were collected in the final third of each semester. All interviews within a semester used a standard semi-structured interview protocol (Appendix A). The protocol itself evolved in minor ways over the course of the project, as needed to improve wording of items or to elicit responses to specific interventions used for that course. The participant observation began in August of 2002 and extended through December of 2002.

Interviews. The primary method of data collection for this project was the respondent interview (Lindlof, 1995). Respondent interviews are aimed at eliciting open ended responses that seek to accomplish five goals: "(a) to clarify the meanings of common concepts and opinions, (b) to distinguish the decisive elements of an expressed opinion, (c) to determine what influenced a person to form an opinion or act in a certain way, (d) to classify complex attitude patterns, and (e) to understand the interpretations that people attribute to their motivations to act" (Lindlof, 1995, p. 172.) The respondent interview was chosen for this study for its ability to elicit cultural understanding from the participants. As Lindlof further suggests, the respondent interview is an effective way to understand "behaviors that derive from the cultural and ideological identities of the speaker" (1995, pp. 165-166).

The interviews used in this study were semi-structured interviews (Kvale, 1996) inquiring about participants' familiarity and experience with group work and their general reactions to the courses in the engineering curriculum. The use of a standard protocol allowed systematic comparison across all three years of the study. 128 interviews conducted in this time span were used in the present study. The interview protocol was constructed by members of the research team in the Department of Communication and cross-checked for applicability and cultural sensitivity by members of the research team in the Electrical and Computer Engineering Department. Participants were asked a series of open ended questions that comprised four general categories: (1) Education and work experience, (2) experience working in groups with other students, (3) studying and preparation practices for engineering courses, and (4) opinions about the assignments and teaching style of the specific course in which the student was enrolled and in which the researchers were intervening. Interviews ranged from 30 minutes to nearly two hours, averaging approximately 45 minutes in length. All interviews were audio recorded with the permission of the participants and later transcribed. Approximately 100 hours of interview data were obtained.

Participant Observation. In addition to the interviews, I spent over 60 hours observing students interacting in groups in engineering courses. Through participant observation the researcher seeks to understand a social scene or a culture from the perspective of the participants that he/she is studying (Lofland & Lofland, 1995). I observed two classes during this study. The first was a large lecture class in which the students were required to participate in some type of group activity every class period. The second class was an upper division elective seminar, enrolling seven students. In this class I observed how the class as a whole functioned as a group. Additionally, I spent several hours in the engineering computing laboratories on days before assignments were due to observe the participants working in groups in a less formal setting. During these observations I took extensive field notes in the form of scratch notes and head notes (Lindlof, 1995). In addition to the field notes I maintained a separate list of problems I saw in terms of group interaction. Also, following the advise of organizational communication culture scholars (Deetz, 1982; Mumby & Stohl, 1996; Pacanowsky & O'Donnell-Trujillo, 1982), I paid special attention to note the cultural practices that to me as an outsider seemed strange.

Finally, in my notes I observed the way I negotiated the boundaries between my roles as participant and observer (Anderson, 1987; Lofland & Lofland, 1995). Although I was a silent observer, I did participate occasionally in group dynamics by delivering training sessions and moderating group interaction. I attempted to pay close attention to how my role as a participant, or simply my presence as a researcher, might impact the normal group dynamics of the participants I was studying.

Procedures for Data Analysis

Data Management. Because this study amassed a large amount of data, in the form of interview transcripts and observation notes, data management is an important component to this study. Each interview transcript will be given a unique identifier. Additionally, all transcripts will be given line numbers and header information that will include the semester of the interview, the course the student was enrolled in, approximate age of the student, and the gender of the student. All notes generated from participant observation will be handled similarly. Notes for a particular class period or group observation will be given a header containing similar information to that of the interviews and grouped according to the type of activity observed. All the materials will be scrubbed of identifying information and kept secure in my office.

Coding Procedures. In order to identify the cultural communicative performances among the many other activities represented in the data I enlisted a procedure of data analysis developed by Bantz (1993). Bantz suggests that one of the key ways that researchers can understand an organizational culture is to pay attention to how it is manifested in the way members' talk, both in natural everyday situations, and in situations in which they reflect upon their work. In order to analyze the performances of organizational communication culture Bantz directs the researcher to pay attention to vocabulary, themes, temporality, architecture, metaphors, stories, and fantasy themes. Bantz's analysis is designed primarily for an ethnographic study of organizational communication culture. Because I am using interview transcripts as my primary data source I will modify Bantz's coding scheme slightly to reflect the specific areas that he says are particularly aimed towards talk, and thus the types of messages and symbolic forms that can be observed from interview transcripts. As a result, I will not examine temporality, architecture, or fantasy themes, as each of these pertain to actual interaction, and interaction is not captured in the interviews. Although I do have observation of group interaction, this is meant only as supporting data for the purposes of triangulation. Therefore, I will code for the remaining messages and symbolic forms found in the data. I explain each of these in turn from the most basic to the most complex. Table 1 provides a summary of the criteria I used to code for each of these categories.

Table 1

Analyzing Data for Communicative Performances

Codes for Culture	Selection Criteria
Vocabulary	1. New and Strange 2. Old and Strange 3. Old and Familiar
Stories	1. Ritual 2. Passion 3. Sociality 4. Politics 5. Enculturation
Metaphors	1. Conceptual 2. Orientational 3. Ontological 4. Personification 5. Metonymic
Themes	1. Frequency of Occurrence 2. Contain Multiple Ideas

First, Bantz recommends coding for vocabulary. Vocabulary is central to socialization processes and distinguishes members of a given culture from non-members. Bantz recommends identifying vocabulary particular to the organizational culture by looking for words that are (1) new and strange, words commonly used by the participants that the researcher does not know; (2) old and strange, words that the researcher knows, but not in the context in which participants use them; and (3) old and familiar, words that the researcher recognizes to be commonly used for the specific type of culture under study. Understanding similarity and variations in vocabulary is essential for understanding how members interact and coordinate their actions through messages.

Next, I will identify stories told by participants. Stories reveal moments, incidents, or epochs that are symbolically important to an organizational culture. Moreover, stories are one of the primary tools for sense-making and socialization in organizations (Boje, 1991). As Bantz observes, the researcher should identify stories where members present "'real' people acting in either another time or place or else 'imaginary' people acting in any time or place. He suggests the most illustrative stories told in an organization follow Pacanowsky and O'Donnell-Trujillo's (1983) performative scripts of ritual, passion, sociality, politics, and enculturation. By examining stories told about these performances, researchers can identity important information about organizational expectations and meanings.

Another cultural feature for which Bantz recommends coding is the metaphor. Metaphors can be useful tools for providing insight into the social construction of many aspects of an organization. Bantz observes that in order to identity metaphors effectively, the researchers should look for the metaphors that Lakoff and Johnson (1980) have identified as the most common: (1) conceptual metaphors, presenting the relationship between concepts; (2) orientational metaphors, which relate to directionality; (3) ontological metaphors, relate the nature of existence with another concept, (4) personification metaphors, attributing human qualities to inanimate objects; and (5) metonymic metaphors, taking one thing and using something related to it to represent the whole.

Finally, I will code for themes in organizational culture. Bantz gives theme analysis a specific meaning and notes that there are two criteria that define themes: "First, a topic exhibits a frequency of occurrence greater than one; a single instance of any topic is not thematic. Second, a themes represents at minimum a simplex of ideas and at maximum a multiple of complex ideas" (1993, p. 95). That is, the topic must come up frequently and be related to other ideas in the message pool. Theme analysis is important for understanding organizational cultures because it provides insight into topics and issues that are important to organizational members and illustrative of cultural practices and values.

Data Interpretation. After coding the data for examples of cultural communicative performance as demonstrated in vocabulary, stories, metaphors, and themes, I will begin to interpret the data. While engaged in the coding process I will make annotations about the data I am sorting into the categories I described above. These annotations will reference larger themes and trends I encounter in the data. Also, I will use the annotations to provide context for the particular quotation I am selecting and to relate particular selections to other selections I have already made. In making the annotations I will also pose questions that arise in the data that I will return to after I have coded all of the documents.

Next, I will cluster the data by using the selection criteria I outline above to first evaluate each item and then constantly compare (Glaser & Strauss, 1967) it to the items already in the cluster in order to ensure consistency. Items that represent similar criteria will be placed together in order to see more broadly the larger themes present in the data. After the data have been clustered I will look for emergent themes occurring both within and among the various clusters.

CHAPTER V

RESULTS

In order to begin to understand how the communicative practices of engineers either contribute to or become shaped by the mythos of engineering culture, I examined the performances of culture in engineers' own talk about their interactions with one another. In this chapter I describe the intersections of culture and interaction by presenting the findings in terms of the vocabulary, stories, metaphors, and themes used by engineers to depict their interactions with other engineers.

Vocabulary

Vocabulary is central to socialization processes and distinguishes members of a given culture from non-members. Vocabulary refers to the words participants use in their talk. Words by themselves are not always self-evident as to the context of their use. Therefore, I rely on my annotations to make sense of how certain words are used and in what contexts they appear. In this section I do not present jargon used by participants. Participants did use jargon to explain technical aspects of their work. Because participants used these words only when explaining to the researcher about particular elements of a project, they did not convey a sense of engineering culture. In engineers' talk about their education, their own work practices, and their experience working in teams I identified four main themes across all of the interviews.

Measuring Expertise by Comparing "Intelligence"

In this study, participants constantly measured their own expertise as engineers by comparing their intelligence with that of their peers through an assessment of their grades and social grouping. Participants in this study clearly linked intelligence with expertise. The word "expert" was barely used in the interviews; it was present in a mere 6%. Instead, participants in this study used vocabulary normally used to describe intelligence to comment about when someone was an expert.

One of the strategies participants in this study adopted was to equate academic grades with intelligence. Accordingly, across the entire set of interviews one of the ways in which participants judged ones intelligence, and thus their expertise, was by how well they did in engineering courses. One of the most frequent words used by participants in this study was "grades." In fact, in 91% of the interviews participants made reference either to their own grades or to the grades of their classmates under no prompt to do so from the researcher. Most uses of the word "grades" compared the user in some way to the rest of the class either by comparing grades with particular students or with the class median. In conjunction with talk of grades the word "rank" appeared numerous times across the interviews. Most participants knew their precise rank in the class and many would share their rank with the researcher even though this was not a specific question in the study. Participants could know their rank in a most courses because professors posted the grades for each exam online. Many participants seemed to reference their rank in a course in order to display their own level of expertise by gauging their performance in the course. The following interchange between the interviewer and a participant illustrates this idea.

> I: How confident are you in your ability to do well in this course?
>
> P: Very. So far, I've gotten the second highest grade in all the exams. I'm glad he puts that stuff on the web so I that I know the strategy is working. I don't need to adjust.

Or another example:

> Right now I'm ranked fifth in the class. That dropped two places after the last test because I got a 40 instead of a 42.

Through their talk about their grades and rank most participants informed the researcher of their level of expertise even though this was not a specific question. Throughout the interviews participants used many other words to compare themselves with other students specifically in terms of grades. Such words include, "GPA," "level," "score," "mark," and "evaluation." Across all of the interviews participants constantly compared themselves to others in order to measure their own level of expertise.

Without referring specifically to letter grades, participants also frequently used other words to compare their intelligence, and thus their expertise, to others. The single most common word used across all of the interviews was "smart," which was used in 92% of the interviews. Across all of the interviews, many participants drew comparisons with and between other students by placing them into categories according to their intelligence. The three most common words used by participants to describe other students were "genius," "smart," and "stupid." Across all the interviews participants placed students into these categories based on their perceived "experience," which was mentioned in 79% of interviews, and "knowledgeable," which appeared in 46%. Throughout the interviews participants made clear that having expertise about engineering work was an important part of being an engineer. In terms of the vocabulary used to describe it, participants seemed to view expertise as something everyone must have differently. Overall, participants were of the belief that as engineers they could not have the same amount of expertise as their peers, rather everyone had a different level of expertise and could be compared according to this level. As such, participants created categories of intelligence such as "genius," "smart," and "stupid" to constantly compare their own expertise to that of their peers.

Self-Promotion

Across all of the interviews participants promoted their ability to do difficult work by framing engineering work as "difficult" for peers and simply "challenging" for themselves. The word "difficult" was used in 82% of the interviews. "Difficult" and similar words such as "frustrating," "arduous," and "hard" occurred very frequently across all of the interviews. Participants used words that conveyed as sense of difficulty to describe *other* engineers' experiences with engineering work – not their own. One participant, for example, uses words such as "overwhelm" and "daunting" to describe how other engineers felt about an assignment:

> I got an eighty on that first assignment. I have programmed professionally in Java before, so that wasn't a problem for me. I wouldn't say that the first project was too difficult. I think that a lot of people were overwhelmed by the learning of Java. It can be, you

> know, a daunting task… You know, with the average of a 39 or whatever it was. Yeah, I don't know, I thought it was a good project.

Similarly, another participant uses "difficult" to describe how his peers react to assignments and "bored" to describe his reaction:

> I've been doing computer programming since I've been 12. So, I may have more experience than other students in certain areas where the professor may think it's a difficult topic and even the other students may think it's a difficult topic. But, I'm just sitting there bored out of my mind because I've done it for years and then some of the things that I haven't seems to be skimmed over rather quickly.

Whereas participants used words such as "difficult" to describe other engineers' experiences with engineering work, participants only used such words about themselves when discussing a very specific assignment that nobody was able to understand. For example:

> This was the last assignment we worked on, was a type analysis and nobody finished type analysis. It was just too big and too difficult. The biggest problem there was the poor documentation. Nobody could understand what we were supposed to do or how to make it work.

Although an initial glance at the words used out of context might suggest otherwise, participants rarely used such words to describe the difficulty they themselves had when approaching or trying to complete assignments. When discussing how they generally felt about their own work many participants used words such as "challenging, "pressure," or "detailed." Conversely, when discussing the experience that that their peers had with their work they used words like "difficult" or "hard."

It seemed that when talking with other engineers and outsiders, such as the researcher, participants wanted to convey the sense that their work was not easy, but that it was certainly not more than they could handle. However, participants clearly wished to demonstrate that engineering work was "difficult;" they did so by describing the difficulty that their peers faced when trying to accomplish assignments. Participants promoted their own ability to do work that was difficult without ever saying that they found the broad scope of engineering work to be difficult.

From Procedures to Rules

There was a clear sense throughout all of the interviews that procedures were an important part of life in this culture. Participants unanimously recognized that their in their training they learned that to achieve certain outcomes they should follow certain procedures. As was expected, the word "rule" itself appeared many times across the interviews mostly in relation to how an assignment was supposed to be conducted. The use vocabulary such as "rules" and the "right way" and indicators of the felt impact of these rules through the use of words such as "deadline" and "requirement" indicate that participants felt that engineering work was about more than just a set of procedures. The use of such strong vocabulary to describe procedures for engineering work suggests that this group of participants felt constrained by the procedures put upon them.

Participants explained that there were certain set procedures that professors and other engineers expected them to adopt in order to successfully complete assignments. Words such as "outline," "format," "structure," and "procedure" were very common. When asked how he normally completed an assignment one participant representative of the majority responded,

> I would sit down with a pad of paper and a pen and start figuring out everything that I needed to cover and actually going through the proper procedure that most people would normally use.

Across all of the interviews words such as the ones described above were used to convey the feeling that there is one "right way" to complete a task and that one can do it the "right way" by following the appropriate rules. In fact, sometimes these rules are so implicit that they cannot even be stated. As one participant notes to the interviewer:

> P: I read what the assignment was and it seemed obvious to me that there was a certain good way to do it. Just, I don't know how to make that obvious step any more explicit because it was just there.
>
> I: What was there?
>
> P: The right way to do it.

When discussing "rules" and "procedures," participants did not seem to believe that rules arose from the tasks themselves. Instead, participants felt that rules in engineering were created by engineers. Thus, participants did not have a strong buy-in to the rules. However, what is interesting is that although participants did not always see the logic or understand the rules, they were very aware that in engineering work certain tasks should be completed by following certain procedures and that they could incur penalties if they did not follow those procedures when completing assignments.

In addition to focusing on the rules for task completion, participants also used words across the interviews to describe their respect of or adherence to specified procedures. Words such as "deadline" and "requirement" are used numerous times in many interviews.

> I mean engineering school; it's a lot of work. It's certainly the most demanding thing that I've ever done. The most rigorous thing academically speaking. We have all these deadlines. Your homework in this class is due on this day, and this day. So, you have these set deadlines that you have to meet. It really, for the most part, comes down to which one needs to be done first. And so, you put out that fire and knock that out and then basically just put out a series of fires and hopefully you can do it within the deadline.

Most participants seemed to be clear that there are rules that must be obeyed and that it is there job to obey them, even if they don't like them.

Many participants noted that they enjoyed engineering work because it allowed them to be creative. However, when discussing the rule-bound nature of the work, participants clearly did not feel that they had much flexibility or leeway for creativity in their work.

Punitive Mindset

The final and most surprising theme uncovered in the vocabulary used by participants was that of a punitive mindset. In nearly every interview participants used at least one of the words listed below:

> Penalty – Trouble – Discipline – Consequences – Fail – Penalized – Fear – Punish – Forced – Reject – Caught – Constraints – Forbidden

Given the context of the interviews, that participants were asked to speak partly about their experiences in engineering courses, I expected participants to use such words. What was surprising was that they did not use them accusatorily, as ammo against the instructors. Instead, most participants used such words to frame their interactions and to give explanations or justifications for why certain things happened the way they did. As such, participants used these words in a variety of ways. Consider the following examples. When recounting why he did poorly on a major exam one student commented,

> You know, and I guess, you know, maybe that's my punishment for not going to class all the time. I will admit that.

After the interviewer asked him if he had ever been given the choice to work in a group one participant noted,

> Not in any of the formal programming classes. It was permitted… it wasn't encouraged or forbidden at the time.

Another student discussed his reason for spending an egregious amount of time studying for an exam:

> It was like absolute fear of failing this class. And, still, even though I'd done so well on all those programs, I still started studying the Sunday before the exam, just because I was like, I'm not going to do bad on this exam.

Across the interviews there is a clear sense that participants were motivated by fear of punishment and failure. Many participants who did not do things they were "supposed to do," or who did something in a way that was different from the way they were "supposed to do it" feared punishment for their actions.

There is a clear sense throughout all of the interviews that this group of engineers operated from a punitive mindset. As is mentioned above, participants were aware that engineering is comprised of certain rules one must follow. Straying from these rules is understood by most participants as grounds for some sort of punitive or disciplinary action. In a more general sense, participants used words that seemed reminiscent of a punishment/reward system, such as one might find in the military or prison system: if they did something right they were rewarded, if they did something wrong they received due consequence. Generally, participants believed that if they performed some task the wrong way, there could very well be consequences. This suggests that participants did not see their situation as one in which change and creativity were accepted by their professors or superiors, even though, as I mentioned in the previous section, participants said they enjoyed engineering work because it allowed them to be creative.

Stories

In general, participants told many stories about they way they worked alone and worked with other engineers. Most participants drew on their interaction experiences in engineering courses when recounting stories about their work, but others also told stories about their experiences in the professional world and in their personal life. Although each participant shared a variety of personal stories, the diversity of story types across all of the interviews was actually quite small. I identified five categories of stories that participants told consistently across all of the interviews.

Different From Others

The first type of story participants tell is how they are different from their peers. In these stories, characters are the focal point. The protagonist is the engineer prodigy. Engineering work comes easy for him/her and he/she finds both classes and interaction with peers to be boring. The antagonist is the commoner. Engineering work is difficult for him/her and he/she always needs the help of the prodigy to get by. The plot of these stories is that the prodigy tires of constantly helping the commoner and wonders why he/she just can't get it. More importantly, the prodigy feels that the commoner is dragging him/her down and not allowing him/her to excel at engineering work.

Consistently, participants differentiated themselves from other engineers according to their skill level and their dedication to engineering work and they noted that such differences caused problems when participants needed to work together. Participants frequently noted that there was a vast difference in skill level among most engineers. Frequently, participants commented about themselves that they had a high skill level and strong technical competence:

> I'm really good at this shit. It just comes completely naturally to me. I have lots of good inductive evidence for this. All throughout the course it's taken me significantly less time than anyone else in the course, anyone I know, to finish the homework. When I go to class, I'm bored, which is an indicator that I already understand the material more than it's just at a low enough level that it doesn't take much attention to get it right. It's just I happen to be built in a way that makes it easy.

This example is recounted by the prodigy. Although most participants acknowledged that they had a high level of skill when it came to engineering work, many did not feel that their peers shared a similar level of skill. In fact, most participants commented that their ability to perform engineering tasks greatly exceeded the ability of their peers, thus, they framed their peers as commoners. Participants commented that this discrepancy in skill level was especially problematic when working in team settings. Specifically, participants frequently mentioned feeling as if they had to help their peers get up to speed on a project. One participant commented,

> I find that often when I'm working in a group I'm the one that's pulling the other ones along, and I like being able to teach other people, but it depends on the complexity of the project. If it's too complex, well, then getting them up to speed demands too much time.

Or on a similar note, another participant mentioned how he not only had more skill, but more ambition as well:

> I always strive to get a perfect 120% on everything I do and most students would be happy with a B. The average student would be happy with a B. Whereas, I wanted to keep working on something until it was perfect, others wouldn't.

It is interesting to note that almost all participants shared these viewpoints. Therefore, most engineering participants thought that they were unique in the fact that they had more technical skill than their peers and that they wanted to succeed more than their peers did.

As a result of feeling that they excelled over their peers in these areas, many participants felt that their difference from others had consequences for whether or not they would choose to work in a group. When asked if he would choose to work in a group in the future, one participant said,

> That depends on who I have the opportunity to work with. I would want someone who would be at my same level. It's easier to split things that way and to get things done. Otherwise, one person is going to end up doing all the work and either it's going to be not you, and you don't learn anything or it's going to be you, and you're dragging all these other people behind you.

Another participant, a senior computer science major, observed his growing frustration with group work over the years:

> Yes, I choose to work in a group. Although it's getting progressively more frustrating… As I continue to get good grades and the people I'm working with are declining into possibly failing this semester and so now I'm kind of to the point where it's almost worth it. It would almost be more worth my time to just sit down and do it myself.

Many participants chose to directly deal with their frustration of the difference in work ethic between themselves and other group members.

> We had scheduled labs we had to meet in and I guess sometimes we had to write code outside of the lab but usually just me and [one other member] would go. Well, we would invite the other people to come except for they wouldn't contribute anything so we [stopped inviting them]. We figured… they wouldn't really mind if they didn't have to come. They get that extra time and we do the work and they get the grade and we figured they wouldn't care. And, we didn't really want them there because then we'd probably have to explain every thing to them. It just wouldn't have been fun.

Purposefully not inviting "slacking" or "incompetent" group members to a team meeting was a common practice for many participants. Generally, participants believed that their own skill and commitment was superior to that of their peers, and that such differences caused problems for interaction.

It is interesting to note that all of these stories are told from the prodigy's point of view. Across all the interviews in this category I did not encounter one story that had the prodigy protagonist and commoner antagonist that was recounted by a commoner. Rather, everyone who told a story was a prodigy. This nuance shows participants' clear affinity for the prodigy and their disdain for the commoner. Moreover, nearly all participants believe that they are the prodigies. Here inconstancies surface, for if nearly all of the participants were prodigies, where were the commoners? Although participants seemingly told stories about working together, these stories were really not about working together at all. Rather, they are stories about how the protagonist, the engineering prodigy, is different from his/her peers, the commoners.

Communication

Participants told many stories about communicating with other engineers. Generally, they recognized that engineers often have difficulty communicating with other people – engineers and non-engineers alike. The plots of these stories follow that the storyteller had to somehow deal with the poor communicator and had to enlist a series of tactics to make communication work. Participants present communication as strategic and goal directed – it is a skill that one either has or does not have, and they believe that most engineers do not have it. Accordingly, the plot in these stories is more important than the characters.

One participant recounted a story of his interaction with a co-worked that provides an example of engineers recognizing that interpersonal communication often makes them feel uncomfortable.

> [T]wo summers ago I worked for a company called Knowledge Tech, in which I was building PCs, servers, mail servers, things like that, for the company. I was working with one of the people who had the job before me. Well, I was replacing him. I worked with him for a few weeks. He was a very skilled programmer, self-taught, never took a single class in anything. But, he designed software, which partially predicted the stock market. If you remember, about a year ago it crashed. Well, he predicted that and it was because of it that he went to do other things for much higher job offers. Working with him was an adventure. He was your classic lone gunman programmer. He would sit down, and just having another person around, I mean near him, was a bother. But, that's how he was taught. A lot of these people like programming. They get into it because it makes sense to them. They learn it on their own and they teach themselves, so, interacting with other people is just by nature sort of a problem, I've found, especially with him. I had to put a lot of effort into communicating with him, asking him questions about his project, suggesting changes, constructive criticism was a challenge, but it could be done… When he would get uncomfortable with what I was saying, he would suddenly look like he was an autistic person. He would start rocking back and forth in his chair. He would look at me sideways. He would do things like this and I would have to interpret visual cues to sort of back off, in

> order to do those kind of things. But, even though I think he was feeling frustration and anger, he wasn't projecting frustration and anger, he was sort of confused on how to deal with it.

This story, perhaps, provides an extreme example. In everyday interactions with one another, however, participants constantly mentioned that they had trouble communicating with others both as a sender and a receiver. Another participant recounts trouble he once had trying to communicate with a partner about the nature of an assignment:

> Well, most of the time most engineers, I've run into this problem, I took Circuits 1 for my ECE degree and I worked with another guy and he would just start working and I'd be like, what are you doing, and he'd just say, I don't know how to explain it. And, that was all he could tell me and he would just keep working and literally not even invite me to work on the project with him… A lot of engineers are like that. They don't really know how to explain things or they don't know how to say, it's difficult I think to say just your ideas and what you're thinking and then have your partner bounce their ideas about their thinking and they go back and forth like that. And, to be able to keep those communications open because most engineers feel as though they have an idea and they want to just work on it rather than express those ideas in words and that's really difficult I think for some people.

Stories about poor communication abound across the interviews, but they are not the only stories participants told about their communication practices. Participants also discussed how they typically went about communicating with one another in order to work together in groups. In general, participants told stories demonstrating two tactics for group communication. The first tactic was to hold ground until someone else conceded their idea or opinion. One participant recounts how this strategy played out in a time of decision making in a group of which he was a part.

> P: We had to separate certain cells with certain methods and we all had different ideas on how to do it and we put that out on

the table and then we all decided which would be the most efficient.

I: How did you make that decision?

P: We went through the pros and cons of each decision and weighed them out.

I: Did any problems arise?

P: There were some disputes about certain things, certain methods but, for the most part, it just came down to who would back down and who wouldn't.

A second tactic was to be more covert in interactions with others. Rather than putting an opinion out for debate and holding ground until it is accepted, many participants told stories about how they would pretend not to take the lead on an assignment so as to appear to remain neutral. Later, when the time came to decide among different options, the apparently un-biased member could slip in his/her own agenda. One participant tells a story illustrative of this tactic.

> [B]asically when you form a group the first thing that happens is you have to decide who is telling who what to do. People have to know what they are doing and the only way you can do that is to have one person assigned that in the group. And so, the first thing that happens is that people are trying to become the person who is in charge. I never really try to do that. I just wait until it happens and then do what I'm told. Try to stand on the sidelines of all that and tell people this is how it really should be done. They make their suggestions and I say okay that's good but I also suggest we do this.

The majority of participants told stories about engineers' poor communication skills and desire to avoid much interpersonal communication. Additionally, participants described using both bold and reserved tactics when attempting to communicate with one another in group settings.

These stories about communication follow a plot of manipulation and control, in which communication is used strategically by participants. Most participants recognize that their peers are poor communicators and they try to differentiate themselves from their peers by revealing that they are good communicators. Participants in this study then believed that they used their good communication skills to manipulate their peers.

Engineers Are Procrastinators

One of the most consistent story categories across all the interviews was that of the engineer as the procrastinator. In nearly every interview, participants mentioned that they waited until the last minute to begin assignments and that most of their peers did the same. Most participants saw their tendency to procrastinate as a negative and counterproductive practice.

One of the interview questions asked participants how they managed their own time. The following response is representative of the majority:

> I don't. I'm bad at it, I admit it. I procrastinate, I watch TV, I surf the internet. I'll go to my computer and sit down, start reading over the assignment, and just be like, well, I have three more days until it's due, so I figure I can surf the internet or play a couple of video games or something. Then I eventually get down to the due day and, like, damn. And that's – it's a big time crunch sometimes. I just put together half-ass work and send it in or, you know, really try hard and nail it. I end up doing it all in one big block, I try to, and end up having it in the last eight hours of possible time.

Another participant expressed a similar strategy (his assignment was due on Tuesday):

> So basically what I do is I would wait until Monday night and I would go into the lab and I would see how many people were there. If there was no one there, then I knew that it was easy. If there were a lot of people there, then I knew that I'm going to stay up all night. So basically Monday night I would plan on staying up, you know, until five the next day working on this thing, if I could. Which means, you know, skipping his class and all sorts of stuff.

Participants were not generally happy about being procrastinators. However, most felt that the abundance of work in the engineering curriculum prohibited them from taking their time to work on particular assignments and to begin them early. In addition to a heavy workload, many participants further attributed their tendency to procrastinate to a mistaken level of confidence at being able to complete an assignment quickly. As one participant said,

> I procrastinate really bad, wait for the last minute, well, that is procrastinating. I think a lot of times I'm over confident in my ability to do everything at the last minute.

In general, participants saw procrastination as inevitable in engineering work.

In these stories participants themselves are the protagonists who procrastinate. They provide no explicit explanation for why they procrastinate – just that they do and they know that they shouldn't. However, nearly every participant told a story about his/her procrastination habits, and the majority did so unabashedly. Procrastination clearly means something more than "I just didn't get to it." For participants, procrastination was a way of demonstrating a nonchalant attitude towards engineering work. As the last quotation above indicates, many participants tied procrastination to confidence: If the engineer is good, he/she will be able to wait to the last minute to begin an assignment and still be able to get it done well.

More importantly, these stories contain in them an element of risk. Participants paint a picture that procrastination introduces challenge, uncertainty, and risk into engineering work. By procrastinating, participants play with the deadline knowing that not meeting it could mean failure. By procrastinating, participants become dramatis personae. They appear nonchalant about their work and approach it with an almost cavalier attitude even though they know the seriousness of not completing it on time: Failure.

Ownership

Participants in this study also told a variety of stories relating to the importance of owning ones' own ideas and work. The protagonist in these stories is the maverick, the engineer who can do it all him/herself and thrives on independent action and thought. The plots of these stories focus on a group situation in which other members try to usurp the mavericks' ability to own his/her own knowledge and work. Underlying these stories is a desire for recognition. Participants are fearful that if they work together with others they will not be recognized for their contributions. Such thinking breeds competition among engineers because each one wishes to be in control and stand out among the rest.

Many participants told stories about times when they had worked in groups and felt uncomfortable because the work was not entirely their own. Across all of the interviews this was a persistent concern. As one participant commented,

> I would get assignments and I would complete them. I wouldn't collaborate with other people. In other words, the work was all my own. The end result was entirely mine. No one else contributed to it. I did ask questions about how, I mean, I was in a team, so I did ask

> questions to other people as to how in Compaq certain things should be done with regards to formality of the final product and so on but there wasn't any group collaboration for our project.

Another participant was a bit bolder in proclaiming his desire to maintain ownership of his ideas and work.

> I guess I'm real cut throat in the work place, I would say. Honestly, I want to move up as quickly as possible, and, whatever it takes for me to do that, I want to do it to the best of my ability and everybody knows and sees that I can do that, and that it will be good. Whereas, in a group, you're responsible for all these other people and everybody gets the same. Nobody stands out because it's a group. You turn something in as a group, and so, you never get to stand outside of that and be seen for the talent that you have or the talent that you don't have. So, if you get assigned to a group where one guy is real lazy and stupid, you're kind of screwed.

Frequently, participants told stories such as this one in which a group assignment inhibited them or someone else from clearly showing what they had done and, consequently, from "standing out."

Additionally, ownership was important for most participants because it signified responsibility. The following interchange between Interviewer and Participant provides an example,

> I: Would you choose to work in a group in other job situations?
>
> P: No.
>
> I: Why not?
>
> P: I'd just rather do my own thing.
>
> I: Okay, why? Can you explain that?
>
> P: Why? Because, then I'm responsible for myself and not responsible for anyone else's work so that anything that came out with my name on it would be mine, me, myself and I.

Then I wouldn't have to worry about that. I could do all my own design. Yeah, I'd much rather work by myself.

I: What about in classes?

P: Oh, I hate group projects. I hate 'em, I hate 'em, I hate 'em, I hate 'em.

The participant recounts a short story describing the politics of group work. When working in a group, this participant notes that it is unclear who would be responsible for the finished product. Other participants told similar stories about the difficulty of taking responsibility for work done in a group. Because it is unclear which member of the group has ownership over which part of the assignment, some participants noted that it was difficult to assign responsibility to a group member. Participants outwardly commented that engineers should take responsibility for their work.

In these stories participants identified a common danger: That the engineer would not be able to stand out. The strategy used to combat this danger was for the engineer to take complete ownership over his/her own work. For participants, this often meant that engineers should work alone rather than in groups in order to protect their work and be able to claim sole ownership of it.

Metaphors

Overall, participants did not use many metaphors when describing their work and their interactions with others. A small number of participants reflected on the fact that there was not sufficient use of metaphors in engineering in order to help students understand complex problems. As one participant observed, "There's not as much use of metaphor as perhaps there should be." Most of the metaphors that participants did use were cliché, or trite and overused sayings. I did not identify any metaphors that were specific to engineering culture. However, participants did use a few metaphors across all of the interviews and these metaphor clichés used are telling about their orientation to engineering work. Across all of the interviews, I found that participants used metaphors to describe both the certainty and uncertainty of engineering life.

Metaphors of Certainty

Participants used metaphors of certainty to describe the character of engineering knowledge. The two most common metaphors that participants used to describe the way an engineer should know were "firm grasp" and "solid foundation." Many participants mentioned that in order to succeed on a particular problem one must have a "firm grasp" of the material. One participant explains in more detail:

> It's just the understanding in this class, you know, because there are little bits and pieces they give you and you just have to focus on that and understand it, and then you can use it, but until you really get a firm grasp on what they're talking about, you're kind of wobbly.

Another participant spoke similarly with the use of the "solid foundation" metaphor:

> [Engineers must] have a solid foundation from which to apply what they have learned.

Across all of the interviews participants used such metaphors to describe the expert knowledge and thorough understanding of subject matter required of engineers. Similarly, other participants said that engineers have "a very systematic way of thinking, inherently." Using such metaphors to describe the structure of thought and a coherent body of knowledge describes how engineers are expected to know. These are metaphors of solidity, of certainty, against change and flexibility. Knowledge doesn't change, and by implication, the knowledgeable engineer doesn't change. It is telling to notice the metaphors respondents used for *not* knowing, such as "mouse trying to get the cheese at the end of the maze," and "it's just a flip of the coin."

For participants in this study, knowledge is a quality of the engineer similar to charisma: Few have it and those who do not wish to obtain it but cannot. Those who have it, then, are the good engineers that everyone looks up to. They have a solid foundation while the others are merely running through the maze looking for the cheese.

Metaphors of Uncertainty

In stark contrast to the solidity of the metaphors framing engineering knowledge, the metaphors for engineering work are decidedly fluid and uncertain. One participant used this metaphor to explain how engineers normally approach assignments,

> We just like to jump in and do it a lot. I mean we don't really sit around and analyze the problem until we run out of time for the assignment. We usually just like to go in and take a headfirst approach into it which, again, isn't always the best way to do things.

Many participants used metaphors similar to "jump in" and "headfirst approach" to describe how they typically worked on problems. These metaphors describe a way of approaching problems without a lot of strategic planning or detailed thought. Rather, many participants said they did the following:

> "I take a top down approach,"

> "I would continue to plug away at it and try to get something working,"
> "I just learn by trial and error,"

Most participants used similar metaphors to describe their work practices, whether working alone or in a group. Consider the following example. When asked how he normally approached an individual project one participant said, "I tend to just dive right in and just go." Later in the same interview, the participant was asked how his group approached a project. He said, "We just kind of dived right in." Across many of the interviews, participants used this metaphor cliché of "dive right in" to describe the way they worked as an individual and in a group. Nowhere in the interviews did participants use significantly different metaphors to describe how they worked alone as opposed to how they worked with a group. Across the interviews there was a clear absence of metaphors that depicted the engineer as someone who planned things out in advance before beginning to work.

Despite their surface contrast, the metaphors for knowledge and work are complementary. The good engineer is one who does not need to plan. He/she can enter boldly into a problem and be confident that he/she will emerge victorious. The underlying assumption is that the engineer is well prepared and well trained. Just like the police officer who always must rely on her training to prepare her for the challenge of not knowing what she will encounter when she arrives at the scene, so the good engineer will be able to recall his/her training and quickly and efficiently deal with challenges.

Themes

Theme analysis is important for understanding organizational cultures because it provides insight into topics and issues that are important to organizational members and illustrative of cultural practices and values. In examining participants' talk across all of the interviews, I identified five general themes. Themes are distinguishable from the other devices presented herein because they represent general values and practices that stretch across the other devices examined so far. As Bantz (1993) observes, by paying attention to themes the researcher can see features of a culture that members themselves may not be able to see. Overall, I found that the talk of participants in this study yielded few themes overall; however, the themes that were found were quite consistent across all of the interviews.

Engineers should be Tenacious

The most explicit theme across all the interviews was that engineers are tenacious. No matter how difficult a challenge they faced, most participants said that they would not give up or ask for help. For participants, success meant accomplishing a task alone. Conversely, failure was framed as giving up, meaning that an engineer either decided to no longer work on a project or to ask another for help. Most of the challenges participants faced concerned the completion of assignments and "making something work." Many participants noted that having tenacity was probably the one thing that helped them to succeed the most in engineering. As one participant observed after being asked what helped him to succeed the most in a particular class:

> I would say more or less the thing that helps me the most in this class is being rather bull headed, actually. Not really giving up until the problem is solved.

As I mentioned earlier, most participants commented that engineering work was challenging. The majority of participants noted that they were up to the challenge and took it head on. In fact, when asked how he approached a particularly difficult assignment one participant said, "I just work on something until it's done, obsessively." Many participants noted that even if they knew they could not find the right answer on a problem, they would not stop trying until they absolutely ran out of time.

Most participants in this study who indicated that they approached engineering work indefatigably also discussed that the goal of the hard work they put into their engineering assignments was to end with a perfect outcome. One participant who was representative of the majority discussed how she would work hard until an assignment was complete, and then continue to work more until it was perfect:

> I'm very idealistic, so I won't stop with an assignment when it's just done and just doing a few things, but I also pound on it a little longer until I think it's perfect.

Another participant expressed a similar tenacious approach to problem solving with the goal of having a perfect outcome:

> I'm kind of a perfectionist. So, if something is broken in the program, I try not to gloss over it. I know I can get around coding that problem but I tend to go and fix it. And, in the process, I spend half an hour. I

> know I had to work around for it but it turned out to be a challenge. So, it's more for ego.

Overall, participants were reluctant to concede defeat on any projects in which they were engaged. If the problem did not seem easily solvable, it presented that much more of a challenge to participants to work hard at it and strive for a perfect outcome.

Group Work is Intractable

Another consistent theme across all of the interviews was that the nature of group work was not easy to direct or manage. Generally, when asked to reflect on why a group did or did not work together well participants responded in one of two ways: They said that the group either "just worked" or didn't or that the individual personalities of group members were so different that a group could never function well together.

As one participant observed about a group in which he had a positive experience,

> I was in a group with two other people that, I don't know, for some reason, it just seemed to work out really well.

Another participant gave a similar reason to account for why his group did not work well together and achieve their desired outcome,

> I don't know what went wrong. It seemed like he knew what was going on when we were talking about it, when it was him and me talking about it. But, I would occasionally have to explain to him things that he told me before, even with just the two of us. So, I didn't really know what was going on. I don't know why he was not making the associations between what he had just told me and what I had done with it. So, I don't know what the dysfunction was but it was definitely there.

Many participants were unable to isolate the specific reasons for either the success or failure of certain groups of which they had been apart. Instead, most participants were content to use statements like the ones above in which they confessed ignorance about the reasons for certain group dynamics.

When participants did provide a hypothesis about why a group either worked well together or worked poorly together they generally attributed the success or failure to the congruence or incongruence of individual group members' personalities. As one participant described,

> Working with other people is either a burden or a blessing, depending on who it is. I've been lucky in a lot of respects to have some good mentors, to have some good people to work with and, for the most part, pretty good experiences.

As this example illustrates, many participants believed that one of they key determinants of a good group was the aggregation of good people. Many other participants made similar comments. Overall, participants seemed to have a sense that if people were "rightly matched" a group would be effective, and if they were "poorly matched," the group would be ineffective.

> I think groups have to be rightly matched up. That's kind of an important thing. If you just have one headstrong "I'm going to do it and you do what I say," kind of guy, who does all the thinking and all the work, that's not really a group. It just kind of degenerates, of course. But if you have a diverse pool of people who do different kind of things and can contribute different things, then I think the program would be worth it.

Although numerous participants hailed the personal traits of individual group members as key determinants of group dynamics, participants still had a sense that groups were intractable. Throughout their talk of difference in individuals' personalities, nearly all participants demonstrated that they believed people could not be changed, and thus group work only succeed if people who were compatible somehow ended up working together.

Engineers Learn by Working Individually

Nearly every participant in this study agreed that, in order to adequately learn fundamental engineering concepts and skills, engineers must work alone. This is not to say that participants felt that working with others could not help them to understand ideas and pick up new skills, in fact many believed that working with others was quite beneficial in this sense; rather, participants generally acknowledged that to be an engineer meant that one had to know how to do certain things all by him/herself, and therefore must learn those things by him/herself. As one participant commented,

> It's good to be able to have the colleague that you can go to to talk about something but I think part of the engineering degree is really also being able to come up with things on your own. To be able to solve problems on your own.

Most participants felt that although groups were helpful, effective engineers had mastery of certain concepts and skills without having to rely on group members. Participants consistently expressed concern that when working in groups they would fall victim to the temptation to rely on their peers and not do the work themselves, thus not learning as much as they were supposed to. As one participant described,

> I like having to do your own work. Even if you are in formal groups, I think you learn better when you are writing the code. It's too easy to fall back on someone else.

Similarly, another participant describes how she tries to avoid going to the lab whenever possible, even if she is crunched for time as she indicates here, in order to avoid the temptation to get the answer to an assignment from one of her peers:

> Because at that point, that means I'm just getting code from people instead of actually learning myself what it is that I need to know.

On a related note, many participants indicated that they felt more personal satisfaction when they worked alone rather than with others. Numerous participants indicated that when they learned something on their own they not only had better mastery of the concept or skill, but that they consequently also were more pleased with the job they had done. As one participant observed,

> I think it's really satisfying work to complete an assignment, so I'm trying to be more self-sufficient with it. When you go from start to finish on an assignment and you haven't asked for help, it feels pretty good.

Other participants described their feelings similarly:

> I actually like working by myself more [than in groups] because it gives me more self-worth where I can say, I did this, not, I sat there while someone else did it for me.

Whether or not individual work was actually more productive than group work was not a question participants linked to satisfaction. Instead, satisfaction for most participants meant that they could claim that they had learned something completely, and learned it on their own.

Good Engineers Ignore Procedure

As indicated earlier in this chapter, participants used vocabulary that suggests their awareness of and affinity for procedure. The theme that I uncovered in the data about ignoring procedure contradicts their use of vocabulary about procedures. During my observations I noted that participants usually were tasked with solving a problem, or writing code that would ultimately serve a certain particular function. Because of the nature of these assignments there usually was only one right answer to the problem. I observed that participants often had different ideas for how to arrive at the same outcome. In the end they were not graded on *how* they reached their output, but if their output worked.

Most participants would note that the evaluation of engineering assignments was different than in other disciplines. Engineering assignments are evaluated on whether or not they provided the "right answer" – which could be assessed objectively by running the code, for example – versus work in other disciplines such as English and Art in which projects are graded more subjectively, according to the opinion of the instructor. As a corollary, most participants noted that because there was one right answer, there was a specific set of procedures that would lead them to it. Thus, participants in this study often discussed how they knew the right way to approach an assignment or the right way to solve it because they knew what the output was supposed it be:

> I don't know. I'm not particularly visual, just sort of, I'm pretty [conceptual] so it's like I knew the right way to go about it. Just like when you're assigned a proof in a math class, sometimes you look at it and you just know, this is how the proof is going to go. And, then, you have to fill in the details. You're not sure about the details but you just, the broad approach; it's just there. I'm not sure if I can make the moment of the epiphany any clearer than that.

Participants made clear throughout the interviews that they could conceptualize the answer and then draw on their training to select almost pre-formed routines in order to reach that answer. Whether participants actually used those routines is another story.

When asked how he generally approached assignments for an engineering course, participants normally responded that they were supposed to follow certain known procedures. As one participant commented after he was asked this question,

> The proper procedure idea is that you actually identify all your problems before you start fixing anything. That way you know what this is going to cause and what that's going to cause. The idea of figuring out your solution and making sure that your solution works for all the cases, making sure your solution fits the proper model and produces the proper results, and that is more on the lines of what you're suppose to do as far as how to design, rather than the way I usually do it; just start designing and, when I run into problems, design around them or patch them more. Or, design through them and just have something else that handles the problems.

As this participant demonstrates, engineers must follow "proper procedures" to achieve "proper results." Yet as is clear from this excerpt, although participants know that there is a right way to tackle assignments, they rarely follow it. As I presented above, participants said that they work backward from the outcome. Here, they are acknowledging that there is a clear design process that they have been taught. Both of these are "right ways" to do it, but they differ fundamentally. Overall, participants followed the outcome-oriented "right way" and generally disregard the design oriented "right way." Another student responded similarly,

> I don't do it right. I know I don't do it right. When I get a programming problem, rather than writing out the idea and going through the whole dextrin of it and having a list and showing that it solves the problem, I come up with an idea and I start coding. And, my outline is my main function and then I just write functions that I decide, all right this needs to be this, I need a function to do this and a function to do this, let me go see if I can write those. And, then, I step back another level and I start writing again. And, sometimes it ends up real,

> real again, sometimes it ends up really, really, messy, nasty, but it usually works eventually.

Although participants often clearly chose to ignore following the proper procedure to complete an assignment, I found no place in the data where participants provided any reason for choosing to do it another way except that they were just running out of time. Most participants, as did the one above, indicated that they ignored the procedure for how they were supposed to approach their work and that they felt a bit bad about it, but they continued to do it regardless.

Engineers Aren't Social

Perhaps the most pervasive theme across all of the interviews was that engineers, as a whole, are not a social group of people. Over and over again, without prompting from the researcher, participants declared that engineers are not social. As one participant described it,

> If you're not that good at programming, you will pursue other things, which will take you into worlds where social interaction is more important. But, if you're good, you won't.

Throughout all of the interviews, participants detached sociability from engineering. As the excerpt above demonstrates, participants acknowledged that the good engineer was not social.

Many participants discussed that engineers either had the choice to be social or to become good engineers. When asked how he normally managed his time, one participant responded, "I gave up my social life." Across all of the interviews this was a common response. Most participants indicated that they had consciously sacrificed their social life in order to achieve success as an engineer. Another participant commented,

> I have no social life now because I have to stay in the components lab – like, until eleven and that night I got out early. Usually I stay until two or three.

Further, participants seemed to value this sacrifice of their social life and look down on others who did not make similar choices:

> I have actually gotten [all the assignments] in, so. But I mean, that's a sacrifice as far as, you know, well, I'm going to stay up all night and I'm going to skip all my classes the next day. I mean, some people probably have more important things to do.

Across all of the interviews participants consistently agreed that to be an engineer meant that one recognized the sacrifices he/she had to make and would make a conscious effort to sacrifice their social life for their work.

In the data I obtained from participant observation, however, I found that their was a contradiction between the way participants talked about the lack of sociability among engineers and the actual social practices they engaged in on a daily basis. For example, one day after class was over I observed a group of six students gathered in the hallway. One of the students was showing the others his new notebook computer. After they had finished gawking and passing the notebook around, other students began to talk about their own computers. The conversation quickly escalated into a discussion about where to buy the best parts for your computer and how to get the best deals on them. The students were laughing and joking with one another. Then suddenly one student said to another, "Shit, we're late for class." The other student responded, "Ah, whatever, this is more fun."

This observation from my field notes serves as one example of many of how participants were not as antisocial as they claimed to be in the interviews. Instead, participants regularly socialized with one another before and after classes and normally intertwined social communication with task-based communication when working together on assignments. Clearly, participants did not practice what they preached in terms of divorcing social relations from engineering work.

CHAPTER VI

ANALYSIS AND DISCUSSION

This study sought to uncover the extent to which the mythos of engineering culture intersects with the ways engineers interact with one another. In order to explore this question, I adopted a cultural communicative performance perspective so that I could examine the communicative performances of engineers as they either contribute to or become shaped by the mythos of engineering culture. In order to identify cultural communicative performances in engineering culture I used a modified version of Bantz's Organizational Communication Culture coding scheme with which I identified the vocabulary, stories, metaphors, and themes of engineering culture. In this chapter I look broadly across the results presented in Chapter 5 to identify the cultural communicative performances used by participants in this study to constitute engineering culture. I then analyze each of these performances in terms of their ability to create and sustain effective interaction among group members. I conclude by discussing implications for theory, practice, and further research.

Communicative Performances of Engineering Culture in Group Interaction

In the previous chapter I presented the results of my analysis of participants' talk about their work practices and interactions with others. Pacanowsky and O'Donnell-Trujillo (1983) argue that all cultures are performed communicatively by members who engage in several types of distinct performances. Bantz (1993) suggest that by analyzing vocabulary, stories, metaphors, and themes present in organizational cultures, the researcher will be able to identify those communicative performances constitutive of the culture. Following Bantz's recommendation, I analyzed all of the data presented in the previous chapter to identify common themes overarching the various devices. I then looked to participants' own discussion of their work practices and the practices they used when interacting with others to identify the ways in which each of the themes were performed communicatively. As Bantz (1993) suggests, I let the broad themes particular to the culture of the participants point me towards the performances that constituted them communicatively.

In this section I consider the ways in which the various components of the mythos of engineering culture, discussed in Chapter 3, intersect with the cultural communicative performances enacted by participants in this study. Then, drawing primarily on the work of LaFasto and Larson (2001) who studied 6,000 team members in order to isolate the practices of effective teams, I explore how these performances might impact how engineers interact with one another.

Ritual Performances

Pacanowsky and O'Donnell-Trujillo argue that a communication perspective on organizational culture sees the constitution of culture through practices in which members ritualistically engage. Rituals consist of either the *kinds* of activities performed regularly by cultural members, or the *ways* in which members perform certain activities. Participants in this study constituted engineering culture by performing a number of rituals. The first ritual performance enacted by participants in this study centers on the way that engineers approach assignments: Waiting until the last minute to being them. For participants in this study, the ritual of waiting to begin was a sign of their expertise and mastery of technical skill. Participants were confident that they could begin a complex assignment a few hours before it was due and rely on their technical skill and expertise about engineering concepts to complete it. This ritual served to substantiate the component of expertise that substantiates the mythos of engineering culture. Participants prided themselves on their ability to wait until the last minute to begin an assignment even though they were aware that it was easier and caused them less stress to begin the assignment earlier. Although performing this particular ritual serves to instantiate the engineer as both an expert and a technical guru, waiting until the last minute to begin an assignment is unproductive when interacting with others. LaFasto and Larson observe that effective teams plan their activities in advance and set priorities and goals that are proactive in order to meet anticipated problems. When engineers wait until the last minute to begin an assignment they do not effectively meet this criterion. Because the complexity of operations increases when the number of people working on the assignment increases (Gouran, Hirokawa, Julian, & Leatham, 1993), group work requires increased planning of interaction among members. Performing the ritual of waiting until the last minute to begin an assignment prohibits effective planning and specification of procedures for individual members.

The second performance in which participants ritually engaged was to begin a project without understanding its details. Participants in this study often started large assignments without first exploring the concepts behind them. Most participants commented that they learned by "diving in" and tinkering with something: No amount of theory would help if they could not engage in practice. For participants in this study, beginning a project without understanding all the details was a sign that the participant was tough and could solve a difficult problem by relying on his cunning and craftiness. This ritual performance is influenced by the macho component in engineering culture. The macho is someone who dives in and relies on his/her overflowing self confidence to get them through. LaFasto and Larson suggest that it is imperative that team members are confident. They note, "Clarity drives confidence; confidence drives commitment" (p. 159). Because engineers are confident in their work they inspire others to also be confident. They also are committed and help others become committed to their work. However, confidence proves problematic if it is not backed by clarity. LaFasto and Larson observe that group members must be clear in articulating their goals and the processes in which they engage. Similarly, Bormann (1996) argues that clarity among group members is a key to shared understanding and action. It is difficult for engineers to be clear about the processes in which they engage if they do not have a full understanding of all the details involved in a certain project. Thus, this performance ritual can both positively and negatively impact engineers' interactions with others.

Another ritual performance demonstrated by participants in this study is that engineers work individually. Many participants began assignments by consulting with their peers, but one of the important rituals constitutive of engineering culture is that engineers actually do the work themselves. Whether they were building a circuit switch or programming a compiler, engineers in this study actually did the hands-on part of their work alone. This ritual performance demonstrates three component of the myth, the engineer as maverick, technophile, and non-communicator. For participants in this study, working alone was important for several reasons. First, it meant that they could have control over their work. Here we see the influence of the maverick component. Participants wanted to be able to change something when they wanted and work in a style that was comfortable for them. They felt that working with others inhibited their autonomy and control. Second, working alone meant that participants could spend time enjoying the technology without interruption from others. Here, the influence of the technophile component bears its weight. Participants have a genuine affection for the technology with which they work and feel that interaction with others distracts their attention and focus from the technology. Third, working alone meant participants did not have to work at communicating with others. Here we see the influence of the non-communicator component. Many participants believe that it takes too long to explain their ideas to someone else. They also believe that people either do or do not get along with one another, and they don't view their desire to work with someone else great enough to run the risk of getting stuck with a partner that they won't be able to work with. This ritual performance goes directly against many of the main tenets of team work. Poole (1994) observes that individuals who place a strong value on individualism and who prefer to work alone often find themselves frustrated with groups because of their interactive and communal nature. LaFasto and Larson argue that preference for individual work does more than frustrate group members; it also distinguishes between effective and ineffective teams. The authors suggest that effective teams balance both working knowledge factors, qualities that individuals have individually such as experience and problem-solving ability, and teamwork factors, practices that members enact when working together such as openness, supportiveness, and action orientation, and personal style. By choosing to work individually, engineers only utilize working knowledge factors and thus do not contribute effectively to the maintenance based functions of a team (Pavitt & Curtis, 1994). This ritual performance works against engineers' ability to interact effectively in groups.

Sociality Performances

Sociality refers to formalized codes of acceptable interaction with others. Sociality performances are telling about a culture because they direct attention to that culture's unique set of norms for how members should interact with one another. In this study, I identified two key performances. The first sociality performance is that participants boldly display their opinions about a variety of issues including the competence of other engineers, the best way to complete an assignment, how tasks should be divided, and how much time should be spent on something. By boldly displaying their own opinions about these and other matters, engineers disqualified the opinions of their peers. Most of the time disqualification occurred under the semblance of expertise. Participants claimed to have expertise about a certain topic and therefore boldly displayed their opinions on that topic. Here we see the influence of the expert component of the myth. For participants claiming expertise was important because it substantiated them as a good engineer. Many times however, participants claimed expertise in areas in which they clearly were not experts. Because participants boldly displayed their opinions under the guise of expertise, their peers either often felt unable to express their own opinions or boldly expressed their own opinions as well and found themselves in a combative relationship with another expert. This sociality performance directly defies the first of two qualities LaFasto and Larson claim are the basic ingredients for team success: Openness. Openness refers to a team environment in which team members are willing to deal with problems, surface issues, say what's on their minds, and exchange ideas openly. More simply, it refers to a group climate in which individuals are able to achieve empathic communion (Bormann, 1985). By enacting the expert component of the myth, and boldly displaying opinions without reverence for the opinions of others, this sociality performance functions to close off openness in group environments.

The second sociality performance existing in engineering culture is that engineers deny each other technical and emotional support. Many participants in this study indicated that there were times when they sought both technical and emotional support. Typically, participants sought such support when they were tasked with an assignment that was well above their skill and knowledge levels. Seeking support demonstrates one instance in which the engineering myth does not hold strong, for it directly contradicts the essence of the macho. The macho would never ask for help or seek support from anyone. Although participants did not look for support from their peers or their professors often, there were notable cases in which they specifically indicated that they wished to receive more support. The fact that many participants perceived that peers or professors would deny them and others support, however, further illustrates the saliency of the component of the engineer as the expert. Participants did not want to offer their peers support because they believed that as competent engineers they should be able to deal with their problems on their own – they should have sufficient expertise to work through difficult issues. This sociality performance defies the second of the two qualities LaFasto and Larson claim are the basic ingredients for team success: Supportiveness. At the core of this quality is the idea that group members have the desire and willingness to help others succeed. In engineering culture generally, the components of the macho and the maverick prohibit engineers from helping others to succeed. More specifically, by enacting the sociality performance of denying others support, engineers do not work to "encourage someone whose confidence is wavering" or place "a charitable interpretation on people's difficulties when they are struggling" as LaFasto and Larson suggest that supportive team members should do (pp. 14-15). Instead, this sociality performance encourages engineers to look down on those who need support and thus works directly against this practice of effective team members.

Political Performances

Pacanowsky and O'Donnell-Trujillo argue that one of the clearest ways in which members engage in political performances is by showing personal strength. The authors argue that communicating personal strength is one of the ways by which individuals attempt to influence and dominate one another through communicative acts. Participants in this study engaged in three types of political performances in which they communicated personal strength. The first political performance was the exclusion of those who were not technically competent. When working on projects with other engineers participants often either formally or informally excluded their peers who they felt did not have strong technical skills. Participants either asked their less technically competent peers to leave the group or stopped inviting them to work on group projects and instead shouldered the work themselves because they feared social loafing (Pavitt & Curtis, 1994). The influence of the macho component works here to encourage participants to take action against those who they feel are inferior to them. Also, we see the influence of the technophile component in that participants earnestly believed that the good engineer should have strong technical competence and participants articulated numerous times that strong technical competence came from a devotion to technology itself. By excluding less technically competent peers, participants send the message that engineers must be able to adroitly and adeptly work with technology. Because it moves directly to exclusion, this political performance directly opposes feedback. By excluding members based solely on their level of technical competence, participants focus entirely on task based functions and not on maintenance based functions of a team. Feedback, as a maintenance based function, is completely lost. LaFasto and Larson suggest that one of the important competencies of a team leader is that he/she demonstrates sufficient technical know-how. This political performance ensures that group members are technically competent. However, the authors also suggest that feedback is an important practice among effective team members. By engaging in the political performance of exclusion, participants never have the opportunity to provide feedback to their peers. This political function of exclusion works both with and against the practices of effective teams.

The second political performance enacted by participants was to show that things were easier for them than for others. Pacanowsky and O'Donnell-Trujillo (1983) say that one key feature of political performances is the demonstration of personal strength. Participants clearly showed their personal strength in a variety of areas including technical competence and acquisition of engineering concepts by explaining the ease at which they mastered these skills and the difficulty their peers experienced when trying to apprehend those same skills. Although the expertise component plays somewhat into this, this performance suggests a new feature of the myth not discussed in the existing literature: The engineer as the prodigy. The data in this study suggest that participants often discussed how the good engineer just "got" difficult concepts. This particular political performance of showing how things were easier for them than for others also serves to perpetuate the engineer as the prodigy. As a consequence, participants who didn't "get it" as easily as others felt discouraged and often dejected when they encountered this performance of engineering culture in their interactions with others.

The third political performance enacted by participants in this study was that they constantly compared themselves to other engineers. In discussing their grades and their rank and talking with their peers about whether or not they knew a certain programming language, participants constantly compared themselves to others. Comparison was done primarily to assess expertise. Here we clearly see the influence of the expertise component on this performance. For participants in this study the only means by which they could discern whether or not they were an expert was to compare themselves to others. If they knew more about a given topic or were more proficient in a given skill they perceived themselves as having expertise in that area. LaFasto and Larson do not present any qualities of effective team members that indicate whether this performance contributes to or detracts from effective interaction. However, Festinger's (1954) social comparison theory may provide some insights. Festinger argues that individuals constantly compare themselves to others in order to evaluate their opinions and abilities, and figure out their strengths and weaknesses. Social comparison can be positive in that it promotes individuals to reach for lofty heights, yet it can also be negative in that it can cause dissonance in individuals who are not capable of attaining what others have. In a group setting, comparing oneself to others then can also have positive and negative effects as there is the possibility that group members will improve their own performance or become discouraged and perform less effectively.

Enculturation Performances

Pacanowsky and O'Donnell-Trujillo suggest that enculturation refers to those processes by which members acquire the knowledge necessary to behave as competent members. Because I did not study socialization practices specifically, I looked to the data generated by participants in this study to suggest those unique performances in which participants would have engaged to become competent members of engineering culture. The data suggest that participants would have learned to enact two performances. The first enculturation performance that participants would have learned to enact was the construction of an in-depth knowledge base. Acquiring such a knowledge base is essential for enculturation into engineering culture. Accordingly, participants indicated that one of the things they learn about being an engineer is that they must have a solid and pervasive knowledge about engineering practices and techniques. In this performance we see the influence of the expertise component. Having an in-depth knowledge base was the first and one of the most important steps to becoming an expert. Participants prided themselves in being technically competent and grasping difficult engineering concepts, and for the most part they were accurate in their assessment of their skills. LaFasto and Larson suggest that one of the most important qualities of a team member is experience. Experience consists of the ability to understand and perform activities related to group tasks. Therefore, this enculturation performance contributes to the success of an effective team.

The second enculturation performance participants would have learned to enact would be to ignore procedure. As newcomers to the profession of engineering participants discovered that there were a variety of procedures that engineers are expected to follow in terms of task completion. Newcomers quickly learned, however, that *real* engineers often ignore those procedures. For participants, ignoring set procedures meant that the individual had more flexibility over his/her own work and insinuated that the engineer had a better grasp of engineering concepts: He/she could utilize them at any given time and in any given way. The component of the maverick plays a key role in the constitution of this enculturation performance. LaFasto and Larson suggest that effective teams establish processes for difficult tasks such as decision making and problem solving. Additionally, functional theory (Frey, 1996; Gouran & Hirokawa, 1996; Gouran et al., 1993) posits that crucial to successful decision making and problem solving in groups is the extent to which members' interaction ensures that particular requirements of their tasks are being fulfilled. In essence, groups must perform certain functions, or follow what LaFasto and Larson call processes, in order to achieve successful outcomes. Because engineers engage in this enculturation performance of ignoring procedure, it is entirely possible that they will purposefully deviate from the functions or processes of effective group decision making or problem solving and contribute to an ineffective group outcome.

The Missing Performance: Passion

Pacanowsky and O'Donnell-Trujillo (1983) explain that in passion performances organizational members transform mundane practices into organizational "passions." That is, they talk about commonplace work in a way that links everyday practices to larger themes about which members can be passionate. The mythos of engineering culture suggests that engineers would regularly engage in passion performances in that engineers link their mundane interactions with technology to the creation of broader social good. Participants in this study often talked about their mundane interactions with technology but did not convert those interactions into passion. As I examined the vocabulary, stories, metaphors, and themes in engineering culture, I did not uncover any overarching themes that suggested that participants talked about their work in a way that transformed the commonplace into passion. Many participants did discuss the tedium of their work – spending many hours in the lab coding and debugging. They did not however, transform the discussion of these practices into discussions about aspects of their work about which they felt strongly. After reviewing the extant literature on engineering culture, I fully expected participants to link their daily interaction with technology to the broader social good brought to fulfillment by the implementation of their creations. Participants in this study did not discuss their work in this way. In fact, several participants commented that the work engineers do has no direct impact on, or relevance for, society.

It is possible that participants engaged in passion performances not about engineering culture, but about student culture. Perhaps because participants were beginning engineers who had, for the most part, not yet built anything that served a useful and concrete function that somehow aided society, they were unable to engage in the types of passion performances the literature suggests. Instead, it is possible that the passion performances that participants did enact were performances that transmuted their everyday practices into passion performances about grades or getting good jobs.

It is also possible that participants did not enact passion performances. An absence of passion performances may impact group interaction. LaFasto and Larson suggest that effective teams share a common goal that is easily identifiable and known by all. If participants do not share a common passion for their work, and either have disparate passions or do not transform everyday work practices into passion performances, it is possible that they will not work well together towards a common goal. Communicating organizational passions may be on way by which group members can focus on common goals and thus increase their satisfaction with group outcomes (Keyton, Harmon, & Frey, 1996).

Implications for Theory, Practice, and Further Research

This study has shown that the mythos of engineering culture does shape the communicative performances constitutive of engineering culture and although many of these performances may constrain effective group interactions, there are others that clearly promote it. These findings have implications for theory, practice and further research on cultural communicative performances, engineering culture, and group work.

Implications for Theory

The findings of this study have implications for theory development in the areas of cultural communicative performance, engineering culture, and group work.

Cultural Communicative Performance Perspective. The performance perspective has primarily been used to describe organizational cultures. The present study has shown that the performance perspective can be put to more uses than just description. In this study, I have used this perspective to explain how engineering culture functions to constrain and enable group interaction. In this respect, the performance perspective can be used to explicate the functions a particular culture serves in interaction. This study also shows how performances take life by exploring the ways in which the myth of the engineer influences the creation and maintenance of certain performances. In their formulation of the performance perspective, Pacanowsky and O'Donnell-Trujillo do not explain how or why a performance comes into being. This study has attempted to provide one such example.

Engineering Culture. Much of the research on engineering culture holds that the mythos is coherent, persistent, and pervasive. The findings of this study support these claims. There are currently no studies that examine engineering culture from a communication perspective. Most research relies on the observation of engineering practices to form a basis for the mythos of engineering culture. This study adds communication theory to the study of engineering culture. By applying the cultural communicative performance perspective to the study of engineering culture I have shown how engineering culture is performed communicatively and how the mythos of engineering culture influences those performances. Additionally, the findings of this study suggest that although the mythos of engineering culture has a strong influence on communicative performances, certain components have more influence than others. For example, the components of the maverick, the expert, and the macho influenced many more of the communicative performances of engineering culture than the myths of the technophile and the non-communicator. Moreover, the communicative performances suggest that the myth might also contain a component of the engineer as the prodigy, which previous research has not explored.

Group Work. The findings of this study also contribute to theory on group work. Recently, the bona fide groups perspective (Putnam & Stohl, 1990, 1996; Stohl & Putnam, 2003), which suggests, among other things, that context is embedded in the interactions of group members, has gained increasing currency (see for example, Frey, 2003). This study has shown *how* context (engineering culture) can affect the specific practices of effective groups. By applying the cultural communicative performance perspective to the study of contexts that permeate group boundaries, this study helps to make sense of why certain group practices may succeed while others may fail.

Implications for Practice

The findings of this study also have implications for practicing engineers. As Margolis and Fisher observe (2001; 2003), many engineers, especially women, are unhappy with the profession because they believe that they cannot live up to the "geek myth." This study shows that the mythos of engineering culture is performed in very specific practices in which engineers engage. Although the myth is influential, it is not obdurate. By paying attention to these specific practices in which the myth is performed, engineers can work purposefully to change the myth. That is to say, the myth does not exist solely at an ethereal level; rather the myth exists and is perpetuated at the level of communication practice. Therefore, to change the myth engineers can change the communication practices in which they engage. These findings offer hope to those who believe that the myth does not accurately represent engineering culture and who wish to modify it.

A more obvious implication for practice is that these findings have the potential to help engineers work more effectively with others. Many recent studies of engineering work have suggested, in passing, that the culture of engineering may impede engineers from working effectively in groups (Ford et al., 2000; Lovgren & Racer, 2000; Workman, 1995). These researchers have not studied engineering culture in a systematic way with the goal of identifying specific cultural practices that intersect with group work. Rather, most studies on engineering culture have pointed to overarching features of engineering culture, such as individualism and love for technology, and have used common sense to claim why such features are not conducive to team environments. However, as Weick (1983) observes, theory and research from an organizational communication perspective should focus on what people routinely overlook when they apply common sense. “Common sense” says that if engineers just talked more with one another, and learned to value personal relationships as much as they value technology, they would work together more effectively. Unfortunately, helping engineers to work better in teams is not that easy. As an example, this study has shown that enculturation performances influenced by the technophile component of the engineering culture myth are actually performances that contribute to the effectiveness of a team – a finding that contradicts common sense. This study has identified specific communicative performances of engineering culture that work with and against the qualities of effective teams. By focusing attention on these specific and concrete performances, engineers can modify these practices in order to improve their ability to work with others.

Implications for Further Research

The findings presented herein have shown that many of the qualities of engineering culture can influences the way engineering students work in groups and how they understand the nature of group work. Through the presentation of specific cultural communicative performances, the findings also provide an explanation for why engineers might sometimes experience "grouphate" (Keyton et al., 1996; Sorenson, 1981), or negative feelings about participating in groups. For engineers, there are many specific structural impediments to effective teamwork. The findings of this study have highlighted several such impediments by analyzing the way in which the myth of the engineer influences certain cultural performances. With these cultural constraints in mind, engineering students must be trained to develop group interaction and communication skills that combat these tendencies, transferable skills with which they can function not simply in localized group settings, but in any group of engineers with which they work.

Future work in this direction should be aimed at developing training modules and procedures with which to teach effective group skills that respond to the specific constraints placed on teamwork by the performances of engineering culture and that promote the performances that contribute positively to effective group work. Also, work should be done to uncover more of the enabling and constraining performances on group work specific to engineering culture. Additionally, work should be done that compares these findings to the communicative performances of engineers in the professional work world. A bona fide groups perspective (Putnam & Stohl, 1990, 1996; Stohl & Putnam, 2003) would suggest that in professional organizations different loci of member identification will renegotiate the boundaries of group work from those experienced by engineering students. Comparative studies performed between engineering students and practicing engineers will help to triangulate the performances of engineering culture that have the most profound effect on teamwork as well as lead to recommendations with which researchers and practitioners can apply the insights generated about engineering teams to practical and meaningful interventions.

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APPENDIX A

INTERVIEW PROTOCOL

Interview Protocol

Fall 2002

3155/ 4120

> “I am part of a research team that is interested in learning more about how students learn computer science. We're interested because we’re involved in a project that will be redesigning some of the courses in the computer science curriculum.
>
> In this interview we'd like to learn about your experiences in this class, and also something about the way you like to learn. This should take about 45 minutes.
>
> None of this information will be shared with your professor until after the semester is over. Even then, your information will be confidential. We will not disclose your name. The tapes and the materials from this interview will be kept by Dr. Michele Jackson, a professor in the Department of Communication. We will never use information from this interview in a manner that will threaten confidentiality. It is important to us that you feel comfortable to share your perspectives. If you have any concerns or questions, I'm happy to discuss them before we begin.”

[note the person’s sex and approximate age. Note how they are dressed and what their communicative behaviors seem to be, which course they are being interviewed for—3155 or compiler construction]

Our first questions are generally about your education and work experience

What is your major? Has it always been that? How far along are you in your program?
How many computer science classes have you taken, including this semester? What were they? Who taught them?

Have you worked professionally as a programmer or an engineer? For how long? What kind of work did you do?

[If not yet answered] What responsibilities did you have? What kinds of decisions did you have to make? How did you make them? [prompt for example]

Did you work with others in that job? If yes, then 'can you please describe this?'

Would you choose to work in a similar way in other jobs?

Next, we're interested in your experience with working in groups with other students

In which courses have you worked in a group with other students?

Have you ever been given a choice to work in a group?

If yes, then 'did you choose to work in the group? Why or why not?

What was that experience like?

(how many people were in the group,
what was the task,
how did they go about doing the task,
did any problems arise and how were they handled?
Prompt for specific <u>examples</u>)

If you had a choice, would you work in a group again? In a class? In your job? (If there's a difference, then, why?)

Can you think of an example (other than the one above) where you worked in a group and it worked well? What happened there? Would you say that you were collaborating? Why or why not?

Can you think of one where it didn't work well? What happened there? Would you say that you were collaborating? Why or why not?

Do you think there should be more group work in computer science or engineering courses?

If yes, then like what? What is the benefit? What do people learn from being in groups?

If no, why not? Are there specific disadvantages (to learning? To the task?)

Next, we have some questions about how you study for programming languages courses

Generally, how do you approach assignments for your programming courses?

Think of assignment that you handled in a pretty routine way – what was it, can you tell me the story of how you completed it? [reflect what you hear made it routine]

Now think of an assignment that was not routine for you, that you had to something unusual for, perhaps you were not sure about it– what was it, can you tell me the story of how you completed it? [reflect what you hear made it unusual]

So, are there standard steps, then, that you try to follow when you're working on a programming assignment?

If yes, work to get them stated.

If no, then work to get them to state how they decide how to go about doing an assignment.

How much time do you spend on this class? What is this time spent doing? Studying? Reading? Programming?

What sorts of things take more time than others?

Is the way you study in programming languages about the same as for other courses? Or not?

How are they the same/different?

What have you found to be the biggest problems when trying to finish assignments?

…in this course

…in general

How do you think you are doing in this class?

What is the one thing that you think will help you the most?

What is the one thing that you think will hurt you the most?

How would you compare the difficulty of this course to other programming languages or even computer science courses? Can you explain?

If you think about the way you learn best, what is the one thing that you consider most important? [Purposefully way open ended…could be from them, could be from instructor, could be from material, etc.]

Last, we're interested in your opinions on the way 3155/ Compile Construction course is taught

How often do you attend lectures? Where do you sit? What are your general reactions to the lectures?

…clear? Interesting? Sufficient?

…to how they are presented?

[for 3155]
Several times throughout the semester your instructor asked the class to turn to their neighbors, introduce themselves, and work on a short problem together. What was your initial reaction to hearing this assignment? Why?

How often did you work with someone else when the instructor asked you to?

If ever did – Why did you? How would you describe your experience?

Did you introduce yourself to the person you worked with?

No: why not

Yes: did it make any difference?

If ever did not – Why not? What did you do instead?

At the end of the assignment your instructor sometimes asked a group to explain their answer or to go up and write the answer on the board.

What did you think of this? Did you ever do this? Would you?

Did you learn anything from the groups who presented?

Have you had to do things like it in other CS classes? How about other classes outside CS here at CU?

[for compiler construction]
What did you think of the instructor's use of discussion in class?

How typical is it in computer science courses?

Did you find them helpful or valuable?

Do you think they improved your ability to understand the material?

Do you think they improved your ability to work with others?

Do you think the instructor should continue to use these? How could they be improved?

What is your reaction to the exercise I facilitated?

Did you find it helpful or valuable? Did it make a difference?

Have you done something like that before? How would you compare it?

[back to all]

What does the instructor do during class that you think works really well? Do you have an example? Why did you pick this?

What does the instructor do during class that bothers you or you think doesn't work well? Do you have an example? Why did you pick this?

How was the teaching style in this course similar or different to other courses that you have taken? What do you mean?

Which recitation are you in? How often do you attend recitations? What are your general reactions to the recitations?

…generally, what do you do in recitation?

What does the TA do during class that you think works really well? Do you have an example? Why did you pick this?

What does the TA do during class that bothers you or you think doesn't work well? Do you have an example? Why did you pick this?

That's it for my questions. Is there anything else you'd like to add?

Is there anyone you know who also would be interested in talking with me? Anyone else who would be helpful??

APPENDIX B

HUMAN RESEARCH COMMITTEE (HRC) PROPOSAL

Request for Approval for Research Involving Human Subjects
A Tool-Supported Programming Languages Curriculum

Submitted January 25, 2001
Michele H. Jackson William M. Waite Amer S. Diwan

Expedited approval is requested for a three year research project investigating methods for developing skills of teamwork and collaboration among students in computer science courses. Data will be collected from January 18, 2001 through October 30, 2003 under the supervision of Professors William Waite (Electrical and Computer Engineering), Amer Diwan (Computer Science) and Michele Jackson (Communication). Correspondence regarding this proposal should be addressed to Michele Jackson (270 UCB, 94 Hellems, 492-8139, jackson@colorado.edu).

A. Purpose and significance of the project

Purpose. (1) To develop and assess computer-based collaborative programming tools for use in the computer science classroom. (2) To investigate the nature of collaboration and teamwork within engineering groups. The tools will be deployed within these courses offered by the Computer Science department of the University of Colorado, Boulder: Data Structures, Programming Languages, and Introduction to Compiler Construction. The courses will be offered by professors William Waite and Amer Diwan, who are also investigators on this project.

Significance. Successful engineers must be able to recognize and fill gaps in their education, work effectively in groups, and use past experience to predict future performance. In order to prepare a student to be successful engineers the university must teach them the set of scientific knowledge underpinning their particular discipline. In addition it must also teach them to recognize holes in their knowledge and fill those holes, to work with others in both knowledge acquisition and artifact creation, and to plan their activities based on an accessible history of previous projects. Translating these general educational objectives into specific classroom environments is a serious challenge. First, limitations of available design tools tends to constrain instructors to the use of relatively well-defined, simple problems that bear little resemblance to the problems that are faced by practicing engineers. Second, engineering curricula typically do not include courses specifically intended to develop skills needed for group work. Given that group projects are typically only one of the many components of existing courses, these projects are inadequate in teaching students the necessary collaborative skills. The approach of this project is to involve students in realistic projects beginning with the introductory courses but to use an infrastructure to selectively hide the complexity from the students. As students progress to more advanced courses, more of the complexity is revealed, until finally, students are involved in realistic projects involving significant collaborative work.

This research will contribute by (1) developing and assessing a suite of tools that will allow computer science undergraduates to engage in more complex, significant, and realistic projects earlier in their program of studies, (2) improving the understanding of the processes engineering students use to solve problems and accomplish tasks, with the aim of (3) providing some recommendations regarding the means to improve collaboration and teamwork within technical groups. Results also may provide knowledge transferable to computer science curricula at other academic institutions.

B. Methodology

(1) A general description of the structure of the project

Research will progress through 3 stages for each course being modified by this project. The first is a *planning phase*. During this phase, we will attempt to collect data by observing the course as it is currently taught and to interview students enrolled in these courses. Attempts depend on securing the permission of the instructors of the courses, and may not be possible. The second phase is the *enactment phase*, in which either Diwan or Waite will teach the course, tools will be deployed, and data will be collected as described below. The third phase is the *assessment phase*. No additional data will be collected during this period. However, information generated from previously offered instances of Data Structures and Introduction to Compiler Construction (from 19xx to 19xx) will be used in the assessment (specifically, previous student performance on assignments and exams, as well as previously collected student comments on their study habits.)

When: Will be completed in stages. Please see schedule appended to this proposal.

Where: Interviews and observations will take place at the Boulder campus of the University of Colorado, arranged individually to meet student availability. The tools being developed are accessed over the Internet through a web browser, therefore data collection is 'virtual,' not tied to any specific place or time.

How long: Data collection tied to a particular course will last only for the duration of that course.

How many subjects will be recruited for each phase of the project: As described below, all students enrolled in a particular course are required to use the online instructional tools. In terms of interviews and observation (as described below), we will attempt to recruit all students enrolled in the relevant course. However, participation will be voluntary.

(1) A description of the subject population including recruitment methods, age, type and number of subjects

The subject population consists of the students enrolled in these courses: Data Structures (Spring 2002-Spring 2003), Programming Languages (Spring 2001-

Spring 2003), and Introduction to Compiler Construction (Fall 2001-Spring 2003). The enrollment cap for Data Structures is 180, 96 for Programming Languages, and 22 for Introduction to Compiler Construction. Subject age will vary with student enrollment, no subjects have known characteristics that would identify them as an at-risk population.

Two types of data will be collected for this study. The first is data generated by tool use. Students will be required to use the tools as part of completing the course. Students cannot opt out of use the tool. Because many of the research questions center on issues of group interaction or aggregate behavior of the group, the input of specific single students cannot be partitioned out of the data. For example, one research question is how much time was spent using each tool. Because this is data collected during the normal operation of the course, does not put the student subject at risk, and is directly relevant to course procedures and course development, we request exemption from the use of consent forms for the collection of this data. A disclosure statement (below) will be distributed at the beginning of the course, as well as included on the interface of the tools themselves.

The second type of data collected will be generated through interviews and observations. Students will be recruited as research subjects from the courses specified above. The researchers will make clear that participation is voluntary and the names of those choosing not to participate (such as refusal to grant an interview or refusal to allow observation of a group meeting) will remain confidential from the instructor (who will be a member of the research team) until after the semester ends, in order to eliminate the risk that participation might effect the evaluation of that student. Solicitation for interviews and observation will be made by Professor Michele Jackson or her research assistant, neither of whom teaches within the computer science department, by means of an announcement during regularly scheduled class time. Interviews or observation will be conducted by Jackson or her research assistant. Efforts will be made to interview at least 50% of the students in each of the courses and to observe all project groups in the Compiler Construction course.

For interviews, consent forms will be presented to the subject immediately before conducting each interview. For observations, consent forms will be presented at the beginning of the semester, before the first observation. As a result, information regarding when, where, and how long, are not included on the consent form, for the "when" and "where" will be negotiated before the data is gathered and will, therefore, be self-evident to the subject (in other words, the consent form does not ask the subject to consent to an indeterminate event, but rather to a specific event whose details are largely known by the subject). The consent form reflects this, as it includes space to identify the specific date of the activity for which consent is being given.

(1) Copies of any surveys, questionnaires or interview schedules to be used

<u>Interview Schedule</u>

“I am part of a research team that is interested in learning more about how students learn computer science. We're interested because we’re involved in a project that will be redesigning some of the courses in the computer science curriculum.

In this interview we'd like to learn about your experiences in this class, and also something about the way you like to learn. This should take about 45 minutes.

None of this information will be shared with your professor until after the semester is over. Even then, your information will be confidential. We will not disclose your name. The tapes and the materials from this interview will be kept by Dr. Michele Jackson, a professor in the Department of Communication. We will never use information from this interview in a manner that will threaten confidentiality. It is important to us that you feel comfortable to share your perspectives. If you have any concerns or questions, I'm happy to discuss them before we begin.”

Our first set of questions has to do with the class specifically.

First, we’d like to know if you are completing work for this course as an individual, or in a team.

[Indiv] We’re interested in why you chose to work as an individual rather than in a team?
[Team] We’re interested in why you chose to work in a team rather than as an individual?

Generally, how do you approach assignments for this course? Such as, what steps do you [or you and your partners] follow when you’re working on an assignment? Please describe from beginning to end. (try to get them to be quite specific)

…How do you break down your time
…[team] How they divide the tasks
…[team] How do you and your partner decide who is responsible for what?

Do you do things [doing assignments] the same for other courses? Or different?

What have you found to be the biggest problems when trying to finish assignments?
…in this course
…in general

…prompt for: problems with the environment
…problems with time
…problems with technology
…[team]problems with each other. [Listen for if team members trust each other]

How confident are you in your ability to do well in this course?
What is the one thing that you think will help you the most?
What is the one thing that you think will hurt you the most?

Do you manage time well?
Do you consider yourself a leader?
[team] are you the leader in your group for this course? What makes you say so?

How satisfied are you with your work in the compiler construction course?

Our last set of questions is more general

If you had a choice in any class, would you want to work in a group, or individually? Why?
Do you think you would also choose the same thing in a work [business] setting? Why?

How satisfied are you with your abilities in your computer science courses in general?

If you think about the way you learn best, what is the one thing that you consider most important? [purposively way open ended…could be from them, could be from instructor, could be from material, etc.]

(1) A description of the procedures involving human subjects

Human subjects may encounter one or more of the following two procedures:

1. Interviews (approx 30-40 minutes, audiotaped) conducted one-on-one with a researcher.
2. Videotaping of normally-occurring student group meetings, held to accomplish assigned course projects. Such taping will be unobtrusive.

Informed consent will be obtained for each of these procedures.

No procedures will be deceptive or embarrassing to the participants. Subjects may find talking about the course discomforting; however, no efforts will be made to produce such discomfort and participants will be informed that their participation may help to improve the course through the researcher's reports. Participants will incur no expense and may benefit from an improved sense of their own learning styles and greater involvement in their education.

C. A description of the risks and benefits to the subjects

Risk: Possible anxiety from revealing opinions not supportive of the course of the instructor during interviews.

> Strategy to avoid risk: Researchers will follow protocols typical of action research. Voluntary participation; measures to ensure confidentiality of interview data if requested, statement of benefit of research to be included in the consent form.

Benefits: Increased participation and voice in the delivery of education. Possible improvements in self-reflection and awareness of learning styles.

D. A description of the means for ensuring privacy for subjects

Privacy within the project. Interview data will be kept confidential; subject names will not be released to the instructor until after final grades are submitted. Observational data will be reported on a general level; in the case of any relating of specific incidents, any information that could be used to identify specific individuals will be changed, combined into an aggregate, or excluded in order to preserve confidentiality. Pseudonyms will be used in place of subjects' real names.

Privacy outside of the organization. In all presentations or publications resulting from this study, confidentiality will be preserved. Pseudonyms will be used for individuals within the organization. Because reporting and disseminating results (and the tools themselves) depends on identification with specific courses within the computer science curriculum and also on identification with the University of Colorado, pseudonyms will not be used for the course or for the institution. However, this should pose no risk to the confidentiality of the data.

Audiotapes and videotapes will be transcribed. Subjects will be informed through the consent form that videotapes will be held by the RI indefinitely, secured by locked cabinet. Tapes will never be used for purposes other than research, insofar as these uses are in conformance with any rules set by the University of Colorado, or by sponsor of this study, the National Science Foundation.

E. Final disposition of the research materials

Research materials will consist of audiotapes of interviews, videotapes of meetings, written notes, transcripts of interviews and meetings, and documents and statistics generated by use of the tools themselves.

All interview and observational research materials will be held indefinitely by the RI Michele Jackson, secured by locked file cabinet. All data generated by use of the tools will be held indefinitely by RI William Waite or RI Amer Diwan, secured online.

APPENDIX C

CONSENT FORM

Informed Consent Form for a Study of Tool Supported Programming

You are being invited to participate in a research project conducted by William Waite (Department of Electrical and Computer Science, CB 425, 492-7204), Amer Diwan (Department of Computer Science, CB 430, 492-5172), and Michele Jackson (Department of Communication, CB 270, 492-8139), faculty at the University of Colorado. For further information on this project, please contact Professor Waite, Campus Box 425, Boulder CO, 80309, (303) 492-7204.

This is a research study about the experiences and attitudes students have when they are asked to use collaboration-based tools for learning computer science.

As part of the study, you are being asked to do one or more of the following: to be interviewed for approximately one hour and to have that interview audiotaped, or to allow the researchers to videotape a meeting of a group you may be assigned to for this class.

We will arrange to conduct the interviews in a place that is convenient for you. Observations will take place at CU. We will ask questions relating to the nature of your study routines, your perception of the course and your progress, and your opinion of working with others. Sample questions include: Generally, how do you approach assignments for this course? If you had a choice in any class, would you want to work in a group, or individually? Do you manage time well?

The potential risks associated with this study are discomfort you might feel being interviewed about a class you are taking. None of the information from the interview will be shared with your instructor until after the end of the semester and final grades have been submitted. All information from interviews or from observations will be kept confidential. This means that your identity will be protected in all analyses and reports. We expect the project to benefit you in that you will have an opportunity to become more reflective about your own study habits. Your participation will also help faculty as they consider ways to improve the computer science curriculum.

If you have decided to participate in this project, please understand that your participation is voluntary and you have the right to withdraw your consent or discontinue participation at any time. You have the right to refuse to answer any question(s) for any reason.

In addition, your individual privacy will be maintained in all published and written data resulting from this study. Specific identifying information will be withheld and pseudonyms will be used. We will use this data for academic research purposes (transcribing, coding, analyzing, and reporting information), and to plan future developments to this course. All copies of audiotapes or videotapes will be held by Prof. Jackson indefinitely, secured by locked cabinet: they will not be destroyed.

If you have questions regarding your rights as a subject, any concerns regarding this project or any dissatisfaction with any aspect of this study, you may report them -- confidentially, if you wish -- to the Executive Secretary, Human Research Committee, Graduate School, Campus Box 26, Regent 308, University of Colorado-Boulder, Boulder, CO 80309-0026 or by telephone to (303) 492-7401. Copies of the University of Colorado Assurance of compliance to the federal government regarding human subject research are available upon request from the Graduate School address listed above.

You are being asked to sign two copies of this consent form. You may keep one, and one we will keep for our records.

I understand the above information and voluntarily consent to participate in the research project entitled Tool Supported Programming.

I consent to be interviewed this day _________________, 200_, and to have that interview audiotaped:

Yes__________________

No __________________

I consent to the videotaping of the group meeting held this day ____________, 200_.

Yes__________________

No __________________

Signature of Subject ___________________________ Date ______________.

Signature of Researchers _______________________ Date _______________