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ENABLING PERFORMANCE SKILLS:
ASSESSMENT IN ENGINEERING EDUCATION

By

Jenny K. Ferrone

A dissertation submitted in partial fulfillment
of the requirement for the degree of

Doctor of Education

University of San Diego

2003

Dissertation Committee

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ABSTRACT

Current reform in engineering education is part of a national trend emphasizing student learning as well as accountability in instruction. Assessing student performance to demonstrate accountability has become a necessity in academia. In newly adopted criterion proposed by the Accreditation Board for Engineering and Technology (ABET), undergraduates are expected to demonstrate proficiency in outcomes considered essential for graduating engineers.

The case study was designed as a formative evaluation of freshman engineering students to assess the perceived effectiveness of performance skills in a design laboratory environment. The mixed methodology used both quantitative and qualitative approaches to assess students' performance skills and congruency among the respondents, based on individual, team, and faculty perceptions of team effectiveness in three ABET areas: Communications Skills, Design Skills, and Teamwork. The findings of the research were used to address future use of the assessment tool and process.

The results of the study found statistically significant differences in perceptions of Teamwork Skills ($p < .05$). When groups composed of students and professors were compared, professors were less likely to perceive student's teaming skills as effective. The study indicated the need to: 1) improve non-technical performance skills, such as teamwork, among freshman engineering students; 2) incorporate feedback into the learning process; 3) strengthen the assessment process with a follow-up plan that specifically targets performance skill deficiencies, and 4) integrate the assessment instrument and practice with ongoing curriculum development.

The findings generated by this study provides engineering departments engaged in assessment activity, opportunity to reflect, refine, and develop their programs as it continues. It also extends research on ABET competencies of engineering students in an under-investigated topic of factors correlated with team processes, behavior, and student learning.

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To God, for all blessings we experience in life.

DEDICATION

This dissertation is dedicated to:

Frank, my dearest husband, friend, and father to our beautiful children, for encouraging
me in this lofty goal,

and

Lily, Steven, Paul, John, and Mark, my dear children and their families, who are always
eager to listen, hug and whose lives provide me with constant inspiration and love.

And, of course, to all engineering students who will cross the bridge from student to
emerging professional.

"We can indeed try genuinely to attend to the world around us and to the meanings we discover as we interact with the world, and hope to realize in our own experience that we are a part of a universal community, making sense of our lives as deeply connected to each other. As we enlarge our attention to include the natural universe and the ultimate ground that it expresses and from which it comes, we are sometimes swept with a feeling of thankfulness, of grace, to be able to participate in a world that is both terrifying and exquisitely beautiful. At such moments we feel like celebrating the joy and mystery we participate in. (Bellah, et al., 1991, p. 285)

Excerpt from "The Good Society" by R. Bellah, R. Madsen, W. Sullivan, A. Swidler, & S. Tipton

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CHAPTER ONE

Introduction

Background to the Study

Reform in engineering education is part of a national trend emphasizing student learning as well as accountability in instruction. Therefore, engineering majors are experiencing new contexts and methods such as project based learning in design teams. Students are being asked to participate in cooperative activities designed to enhance their performance skills and promote interdependence. Assessing student performance to demonstrate accountability has become a necessity in academia. In the newly adopted Accreditation Board of Engineering and Technology (ABET) Criterion 3, undergraduates are expected to demonstrate proficiency in outcomes considered essential for graduating engineers. Among these outcomes, students are expected to work in small design teams committed to a common purpose and project goal.

The challenge for engineering departments that adopt ABET criteria is to utilize assessment instruments that adequately address observable evidence of learning outcomes. The growing need among engineering educators to obtain data for an outcome-driven assessment is basically a question of whether faculty are teaching "the right mix of skills and knowledge for the information age" (McGourty, 1999, p. 391). In an effort to respond to the challenges of reform, research focusing on engineering students is sorely needed to identify and address barriers to quality programs.

There have been numerous reasons for changes in the engineering curriculum. First,

is the increasing pressure from society, industry, and academia for accountability in education, for using technology responsibly, and for alleviating technical mistakes that have caused environmental problems. Second, there is a growing shift to *participative* pedagogical styles. Learning theorists have increasingly promoted learner centered modalities for maximizing student achievement (Felder & Brent, 1994; Hooper & Hannafin, 1992). The shift towards more holistic approaches in teaching engineering curricula is also an attempt to retain and attract engineering students. Third, the move towards more integrated and university-wide processes for evaluation suggests that assessment should take place from a multi-methodological position. In the all too familiar *testing culture*, outcomes are based on ranking. An *assessment culture* using an integrative approach can focus on a wider range of student outcomes - both quantitative and qualitative, that include core engineering/math courses integrated along with demonstrated proficiency in reading, writing, and oral skills. There are three components to a well-designed assessment plan according to Shaeiwitz (1996); 1) the "educational goals" for the students must be clearly stated, 2) the assessment instrument must contain a "valid set of measures", or attributes of achievement, and 3) the use of the information can assist students and faculty to improve the learning process (p. 240).

The motivation for this study is based on my personal experience as a mechanical engineer in an engineering research and development environment, which typically rely on multidisciplinary teams. The importance of design skills, communication, and teamwork in such an environment provides a unique opportunity to combine my workplace and academic experience with the growing interest in team-based collaborative structures. The trend from teacher-centered lecture methods common in engineering courses to student-centered

education seeks to maximize student participation and involvement. This transition has also prompted the expansion of research into meaningful assessment practices that include a range of learning indicators leading to greater understanding of the active learning process (Besterfield-Sacre, Shuman, Wolfe, Atman, McGourty, Miller, Olds & Rogers, 2000). Among the implications for engineering students is learning how to function collaboratively on a team, and how to acquire particular sets of competencies to fulfill common design objectives. For faculty, it means having a thorough understanding of achievement targets and incorporating sound assessment criteria to meet the challenges proposed in ABET's Engineering Criteria. Assessment therefore, can be used by a department, or program to make decisions about "learning outcomes, resource allocation, and accountability" (Shaeiwitz, 1996, p. 240).

Statement of the Problem

One rationale for the assessment of student learning in response to the new ABET criteria, is that engineering departments are seeking to introduce fundamental performance skills early in the curriculum to fulfill accreditation requirements. The attempt to focus on student learning outcomes also matches those needs that industry has deemed important as well. In the Green Report published by the American Society for Engineering Education (ASEE, 1994) titled "Engineering Education for a Changing World", educators stress the need for engineering education to be "connected to the needs of the broader community through integrated activities with other parts of the educational system, industry, and government" (p. 1). This focus is especially critical when new products are being designed and produced for the marketplace faster than ever before. By necessity, insuring a quality product becomes a team effort through the collective synergy of the group. Accordingly,

despite the lack of proven assessment methodologies validating student learning outcomes, assessment of performance skills has become an important topic in today's competitive environment (McGourty, Sebastian & Swart, 1998).

Measures are needed for engineering educators to develop effective assessment tools for course and program evaluation (McGourty, 1999). First, specific research into assessment design and practice is needed to provide a better understanding of the active learning process, and to provide a means for students to take a proactive role in their learning. Second, documenting learning outcomes could contribute evidence of commitment to continuous improvement for the department as a whole (Shaeiwitz, 1998).

Additionally, as valid assessment data is gathered, "it is possible to chart the variation in student performance among different sections of the same introductory seminar taught by different professors" (ASEE Professional Books, p. 32). A well-designed assessment tool has the potential of being used as a standard measure or template that faculty and students can share to assess student performance skills. As the assessment process become integrated into the curriculum, "shared ownership" of an assessment instrument among department faculty can be a first step towards the desired culture of improved student learning (Shaeiwitz, 1996, p. 245).

Purpose of the Study

The case study was designed as a formative assessment of freshman engineering students to assess the perceived effectiveness of performance skills in a design laboratory environment. As such, the study identified teamwork competencies and based on the findings, suggests recommendations for future use of the assessment tool and process. Specifically, the purpose of this study was twofold: one was to identify specific ABET

performance outcomes using individual, team, and faculty perceptions of team effectiveness. It was hypothesized that the extent of congruency among participant responses over the course of a semester would provide information and feedback on performance strengths and deficiencies. Thus, recommendations for future use of the assessment instrument and process would contribute to, and facilitate student learning. Second, this study attempted to discover the extent to which students perceive equal skills development for themselves across the given skills dimensions.

The focus for this research is based on three specific ABET 2000 learning competencies: (ABET 3c) the ability to function in teams, (ABET 3d) the ability to communicate effectively; and (ABET 3g) the ability to design and conduct experiments. Accordingly, the perceptions of engineering students will be examined as they work in small groups in an attempt to learn the extent to which these competencies can be demonstrated.

The mixed research methodology included both quantitative and qualitative approaches to assess specific learning outcomes. An electronic assessment instrument assessed the relationship between teamwork ratings and learning outcomes by examining the team process from three perspectives. These perspectives represent observations from individual student observations, faculty, and the perceptions among members of the team. It was anticipated that information gathered from a multi-source assessment process would "also act as a script" to guide the growth of team members (McGourty, Dominick, Besterfield-Sacre, Shuman & Wolfe, 2000, p. F1A-8). A follow-up to the survey using a mail questionnaire gathered participants' reactions to the survey instrument and process.

Research Questions

The following research questions guide the study.

- 1) Based on the findings of this study, what recommendations can be made for future use of the assessment tool and process?
- 2) What are the lowest rated sub-skills in each of the areas of Communication, Design Skills, and Teamwork?
- 3) Is there congruency in how students rate themselves, how teammates rate each other, and how instructors rate these teams on the dimensions of:
 - a) Communication, b) Design Skills, and c) Teamwork?
- 4) Did the students perceive equal skill development for themselves in the three areas of Communication, Design Skills, and Teamwork?
- 5) What are the perceptions of the process by the students?

Significance of the Study

While research of multidisciplinary teams in the workplace has received considerable attention, the study of interaction skills among engineering students is relatively new (Seat & Lord, 1999). This study should be useful to engineering departments, the business community, and academics interested in engineering pedagogy. This knowledge also provides engineering departments engaging in assessment activity, opportunity to reflect, refine and develop their programs as it continues.

The survey instrument could be used potentially as a checklist or template with wider applicability for program improvements. Expanding research among various pedagogical approaches may lead to a "set of best practices" for freshman engineering programs

(Besterfield-Sacre, Atman & Shuman, 1998, p. 139). Moreover, faculty who may not have had training in assessment practices could benefit from having a tool available that has proven to be successful in guiding students in a safe and constructive manner (McGourty & De Meuse, 2001).

The idea of transformative assessment is one that goes beyond the concept of monitoring and simply data collection. Rather, this approach to assessment uses techniques that value continuous improvement, self-examination and reflection (Angelo, 1999). Shaewitz (1996) contends that shared ownership of an assessment instrument among department faculty can be a first step towards the desired culture that can improve student learning.

Finally, assessment results within the context of peer feedback may provide a more definitive understanding of what engineering students are learning in the context of teamwork. It is crucial for engineering departments to learn and document whether ABET 2000 learning competencies are being met in the specified areas (e.g. 3c, 3d, and 3g). Therefore, this study may provide new insights into the ability of freshmen students to demonstrate teamwork. This is also an adequate reason to examine the impact peer feedback may have on improving team skills.

While progress has been made in the last several decades, the assessment movement according to some scholars, has not really contributed "solid evidence of learning improvement" (Angelo, 1999). As some researchers believe, engineering students need time and encouragement to develop their core expertise. It is an evolving process. Therefore, the results of purposeful assessment can accommodate the increasing demand for accountability and more importantly, aim towards improving student learning.

Researching performance practices and curricular elements such as small group learning among engineering students provides a unique situation to identify best practices. Sharing the results of ongoing assessment benefits the wider community and makes our best practices explicit. This benefit is especially significant to those involved in curriculum development, as it focuses our collective attention on issues we need to care about.

Limitations of the Study

The findings from this study may not be generalized to other institutions, or settings due to the small number of participants in one school (approximately 41 students in four classes). However, the groups are demographically representative of most engineering programs, which are composed mostly of males. An additional limitation of the study is the need for respondents to share honest feedback in the assessment process. It is not possible to insure complete integrity. To maximize openness and candor, every attempt will be made to conceal the identity of the respondents. Instructions for using the survey will be read from a prepared statement to all of the classes to insure uniformity of the process.

Feedback resulting from the survey can be a means to gain personal insight into areas needing development. Therefore, honesty in identifying behaviors is essential. If used as a learning tool, the assessment can help team members become aware of factors that contribute towards successful teamwork.

There are several challenges that an electronic survey imposes. First, is the time and training individuals require to learn and use the software. Second, it is difficult to predict whether the survey tool in it's computerized form will become an integral part of process improvement until the methodology is fully evaluated over several semesters. Some potential bias is anticipated due to differences in instructional practice between classes. However, the

study will not delve into causality based on differences in instructional format or pedagogy.

Definition of Terms

The following terms are defined to provide clarity to their meaning and usage.

Performance Ratings

Performance Ratings refers to the scores the respondents will assign to specific ABET engineering criteria as defined in ABET Engineering Criteria (EC) 2000. The three criteria chosen for this study are: (ABET 3c) the ability to function in teams; (ABET 3d) the ability to communicate effectively; and (ABET 3g) demonstrate an ability to design and conduct experiments.

Content Data

Content Data refers to course material and learning competencies specified in the course syllabus for the University students who will be surveyed. The learning outcomes for a computer-based engineering laboratory class include: developing and building simple computer-controlled models of systems that replicate real world experience, written and oral communication, knowledge of computer-aided systems, and modeling techniques.

Products.

The *Products* refer to the computer-controlled electromechanical systems that are constructed during a planned semester activity. The Products are designed to help students emulate engineering practice in the real world as well as introduce students to fundamental engineering concepts and skills.

Team Developer (TD)

"*Team Developer*" (TD) developed by Jack McGourty and Kenneth De Meuse (2001), is as an electronic assessment program developed nearly ten years ago. This

electronic assessment tool is designed to give the rator and ratee feedback regarding their performance skills in a "safe and nurturing learning environment" (McGourty & De Meuse, 2001, p. 1). The assessment tool is intended to provide students with an opportunity to review and reflect on their knowledge, skills and abilities during the course of the semester

The following chapter consists of a review of the literature enabling the reader to place the research questions within the context of some literature on group work and relationships. As such, attention to communications skills becomes an important link in the collaborative process. Since the development of any product design is a complex and multidimensional process, assessment and feedback is one method in which team members may gain insight into their performance skills. Thus, an important component of the assessment process is self-awareness that will lead students to personal development.

CHAPTER TWO

Introduction

Reports by the American Society for Engineering Education (ASEE) roundtable study and the National Research Council in 1995 reflected a concern confronting engineering education. These reports focused on the need to identify and promote performance attributes engineering students should possess upon graduation. In the Green Report "Engineering for a Changing World" (1994), the American Society for Engineering Education (ASEE) emphasized the need to re-examine curricula to insure that programs prepared students not only technically, but equipped them for a changing workplace. The report stated that:

"Coursework should feature multidisciplinary, collaborative, active learning; and take into account students' varied learning styles" (p. 5). Additionally, "...colleges must educate their students to work as part of teams, communicate well, and understand the economic, social, environmental and international context of their professional activities" (p. 2).

The selected bodies of literature that provide a conceptual framework for this research study include core processes of group behavior, pedagogy, assessment practice, and organizational development. Embedded in each of these four areas is literature specific to engineering education. Although the four topics are discussed under separate headings, the relationships and conceptualizations between them contribute to a complex and dynamic understanding of how individuals perceive themselves and each other as team members. From a systems perspective, the approach to the research provides a holistic view of a collection of parts working together "to create a functional whole" that lends support and

understanding of the group experience (Eisenberg & Goodall, 1993, p. 92). Therefore, whether a group is composed of "a marriage, family, team, or business, the existence of relationships among the people are what makes the group a system" (p. 92).

Section One of this review explores theoretical concepts useful for understanding small group behavior. Although considerable research exists in the literature on group dynamics, this review looks specifically at the core processes of group performance and structure of teams. The intent of this section is to identify skill measures considered characteristic of high performing teams. An overview of several models and examples of specific case studies leads to a discussion of specific teaming skills required for the professional training of engineers.

Section Two outlines current pedagogical trends where the focus in the engineering field is on learner-centered modalities and the operational practice of teamwork. Interactive approaches and cognitive teaching models support ideas pervasive in social learning theory.

Section Three examines the link between learning and assessment practice as a tool within the repertoire of effective pedagogy. While there is considerable literature on assessment programs detailing institution-wide, or longitudinal assessment practices, literature that seemed more useful focuses specifically on the implications for learning using assessment and peer feedback.

Section Four examines selected concepts in organizational development to discuss underlying assumptions about individuals as members within groups. Pivotal works in organizational development provide the over arching framework for establishing connections between teamwork, assessment and learning. Explicit in the theory of organizational behavior is the nature of task management and the unconscious processes that drive the

group's goal seeking objectives. Organizational development includes a key concept, which is the systems nature, or inter-relatedness of the group as a unit. Systems approaches encompass many different interpretations, constraints and philosophies that are not included within the scope of this research.

Additionally, the literature briefly touches on the role of communication - an important and discernable component of effective teams. Several works do connect organizational behavior with communication as having a powerful influence on group cooperation (Eisenberg & Goodall, 1993).

As recent concerns expressed by the American Society of Electronics and Engineering (ASEE) have called for curriculum reform, the topics of teamwork, systems thinking, and active learning processes have particular emphasis in this study. As teams become more prevalent in engineering programs, learning what skills students need to facilitate their development lends value to this research. Thus, core processes of group behavior, pedagogy, assessment practice, and organizational development - are blended together to support a richer understanding of conditions affecting team effectiveness.

Processes of Group Performance

Group Process - Overview

The existing literature on the evolution and focus of small group behavior has been considerable. The domain of group development and behavior pays attention to nearly all aspects of group life including group membership, goals, norms, and diversity (Napier & Gershenfeld, 1999). Furthermore, the theoretical foundations of groups are extensive, having evolved from a number of conceptual models. Among them, *psychodynamic theory* based on works of Jung and Freud in which unconscious processes drive human behavior, and *group*

dynamics traditions stemming from the Tavistock Institute in the early 1960's. More recently, in *open systems* theory, groups are seen as interrelated social systems influenced by interpersonal and environmental factors (Morgan, 1986, as cited in Gillette & McCollum, 1995).

Some common themes have emerged among these traditions. Namely, "that small group dynamics: are *distinct processes* at the interpersonal, group, and intergroup level (Gillette & McCollum, 1995, p. 7); have fundamental *norms* such as rules of behavior (Napier & Gershenfeld, 1999); "develop goals by applying the criteria of fairness" (p. 17); and place emphasis on the importance of communication within the social context (Eisenberg & Goodall, 1993; McGourty & De Meuse, 2001). Thus, in any social system, communication contributes to organization and, from a systems perspective, does not exist as a separate entity from the environment (Eisenberg & Goodall (1997). Eisenberg and Goodall contend that "a *system* is a complex sets of relationships among interdependent parts, or components" (p. 98) and *interdependence* is the "primary quality of a system" (p. 98). Therefore, in thinking meaningfully about the nature of human systems, small groups can be described as a complex set of elements functioning as entire unit in order to achieve a common goal.

Essentially, teamwork evolved from traditional organizations and built on the idea of process, structure, and social behavior (Luthans, 1977). A characteristic of recent models contains structures considered *organic*, and are further described by Luthans as being "temporary, flexible, and accommodating to change" (p. 123). Quality Circles and Re-engineering emerged due to favorable conditions of Total Quality Movement (TQM) movement in the United States in 1974 (Hammer & Champy, 1993). The use of teams was also due in part to a highly skilled labor force and the fact that major aerospace companies

were dependent on quality products. Moreover, the use of self-managing teams was viewed as a major impetus toward worker involvement, satisfaction, and commitment to a common goal (Napier & Gershenfeld, 1999). In recent years, failures in the aircraft and automobile industries as well as military and environmental disasters, have created a compelling interest in the nature of teams. Paris, Salas, and Cannon-Bowers (2000) summarized teamwork attributes into categories of cognition, behaviors, and attitudes that are described as follows:

"Cognition (or knowledge) include cue strategy associations". These are associations such as team mission, norms, team role interaction patterns, and skills. "Behaviors (or skills) consists of adaptability". This includes situational awareness, team member motivation, communications, decision-making, and conflict resolution. "...attitudes embody motivation" and includes team cohesion, trust, and "the importance of teamwork.". (p. 1054).

One trend according to Paris, Salas, and Cannon-Bowers (2000), has been a "shift in research and theoretical development to the inputs and outputs that bound, constrain, and impact team processes within organizations" (Ilgen, 1999, as cited in Paris, Salas & Cannon-Bowers, 2000, p. 1055). Moreover, the authors maintain that assessing the dynamic nature of teamwork (or process skills), is neither easy nor readily identifiable (Paris, Salas & Cannon-Bowers, 1997; 2000). Thus, team assessment tools used to analyze team performance should "identify processes linked to key outcomes" and "distinguish between individual and team level deficiencies" (p. 1056). The authors further underscore the importance of producing assessments "that can be used to deliver *specific* performance feedback" (p. 1056).

It is apparent from the literature that many evolving perspectives contribute to our understanding of teamwork. Scholars and researchers need to understand *how* teams acquire

and process knowledge at both the individual and team levels (Paris, Salas, & Cannon-Bowers, 2000). This direction is driving and shaping innovative pedagogy and offers many possibilities for more informed design of assessment questions. It may be useful in the following sections to examine perspectives that currently support these categories, particularly when developing assessment schemes that identify critical ABET skill requirements.

Definition and Characteristics of Teamwork

There are many definitions describing Teamwork. Teams are defined as a: "distinguishable set of two or more people who interact dynamically, interdependently, and adaptively toward a common and valued goal, objective/mission, who have been assigned specific roles, or functions to perform, and who have a limited life span membership" (Salas, Dickinson, Converse & Tannebaum, 1992; Paris, Salas & Cannon-Bowers, 2000, p. 1052). Guzzo (1986) offers a similar perspective describing teamwork as a combination of factors: the ability to gather information, assess problems, look for solutions, and evaluate various options for the team in determining a course of action. Using a human relations model, others have described teams as a *relational* process. It is presumed for purposes of this study that an acculturation process must take place, thereby enabling team members' the opportunity to establish a relationship.

Teams are also characterized by operational definitions such as: performance (Dunphy & Bryant, 1996), goals (Cooper & Gustafson, 1981 cited in Napier & Gershenfeld, 1999), or attributes (McGourty & De Meuse, 2001), and by contextual factors such as environmental, societal and family practices (Luthans, 1997). Additionally, teams are characterized by roles and behaviors (McGourty & De Meuse, 2001), size (Hare, 1976;

Napier & Gershenfeld, 1999), group membership (Napier & Gershenfeld, 1999), relationship versus tasks oriented behavior (Luthans, 1997), and by degree of autonomy, such as *self-directed work teams* - "responsible for a 'whole' work process or segment that delivers a product or service to an internal or external customer" (Wellins, Byham, & Wilson, 1991, as cited in Eisenberg & Goodall, 1993, p. 283).

Teams are further described in their commitment to tasks as work, or project teams joined by a common commitment, or goal, dissolving later when the task has been completed. Another variation on the theme is Senge's (1990) *systems* concept of teams in which he emphasizes components of feedback, change, and openness to information to promote a *learning organization* among members.

From the many characterizations of teamwork just described, commonalities defining team behavior focus on the roles of individuals within groups, and the factors shaping team behavior. In general, several of the most important teamwork attributes include collaboration, communication, decision-making and self-management (McGourty & De Meuse, 2001). Without exception, most of the emerging concepts define teamwork as a coordinated activity demonstrating a high level of interdependence among team members, including shared authority and mutual accountability for performance (results). Defining teamwork as a coordinated activity supports a basic premise of team behavior, which is the nature and relationship between, and among group members, and becomes a major determinant in the pattern of how a group operates (Gillette & McCollom, 1995). Lastly, Davis and Masten (1996) define characteristics of highly effective teams as having:

- A high sense of commitment
- A high degree of communication.

- A healthy degree of disagreement,
- Creativity
- Agreement through consensus, and
- A sense of empowerment. (p. 277)

The next section will consider core processes of team performance that have relevance to this study.

Core Processes of Group Performance

To understand team process, roles and behavior, pivotal works by Napier & Gershenfeld (1999), focused on core processes of group development and are briefly described in the following paragraphs. These models include: the *developmental* model in which predictable stages of development occur (Tuckman & Jensen, 1977); the *task* model which incorporates a group's natural inclination towards problem solving (Hare & Naveh, 1984); and an *integrative* model in which successive developmental stages (less linear than the previous two models) support a return to earlier stages until integration of optimal performance occurs (Wheelan & Hochberger, 1996). In theory, these and many other models are marked by the difficulties and complexities surrounding the dynamics of team development, due in part to the inevitable tensions, conflicts, and priorities shaping human behavior.

Although these and other models focus on fundamental processes of group or team development, McGourty & De Meuse (2001) draw specifically upon the work of Tuckman and Jensen's (1977) twenty-year study to support their contention that highly successful teams, particularly at the student level, do not spontaneously occur, but must go through a series of "growing pains" (p. 9). The Tuckman and Jensen study provides a unique working

description of team development, which concludes that task-oriented groups go through five predictable stages of development. This process is defined as *forming*, *storming*, *norming*, *performing*, and *adjourning* (McGourty & De Meuse, 2001; Napier & Gershenfeld, 1999).

The Tuckman studies demonstrate that maturation and learning are predicated on personal awareness and evolution of the team's growth as the team struggles to form new relationships in the *Forming* stage. The second *Storming* stage is the period of reaction as team members are challenged in their roles and try to meet the group's expectations. *Norming* is defined in the third stage as the time when members share and resolve conflicts. It is also when explicit and implicit rules of behavior are integrated into the team's goals. *Performing* is the fourth stage. This is the period when team members feel comfortable with each other and are free to work towards common goals in a highly productive and focused climate. Finally, the fifth stage in team development is *Adjourning*, when the task is near completion and the team begins the process of closure, at which time relationships change along with mixed emotions of adjournment (Napier & Gershenfeld, 1999; McGourty & De Meuse, 2001).

The Tuckman model chosen to illustrate group formation and development is one view out of many surveyed in the literature. This model in particular, does illustrate the evolutionary process of group development over time, and points to predictable behaviors and difficulties individuals encounter when forming new relationships. Students working in teams bring their individual histories, skills, levels of motivation, work habits and perceptions of what is expected of them as they define their roles and allocate tasks.

McGourty and De Meuse (2001) also note that team members who know what to expect, "can better understand what is going on, why it is happening, and act accordingly" (p.

9). As the Tuckman and Jensen concept of stages focuses on the performance, or the task perspective of group members, an important component of this model is its emphasis on predictable phases of behavior that are observable to team members. McGourty and De Meuse (2001) further state that "awareness of these stages as a natural evolution of team maturity" can better prepare team members to perform in that environment (p. 11).

Furthermore, they believe that awareness of observable attributes can lead to team learning and development during the self and peer assessment process, provided students are given sufficient opportunity for honest self-reflection. Both research and expert opinion point to a correlation between processes of group development occurring as a result of reflection and self-examination. Thus, the conception of two fundamental principles; performance, reflection *and* assessment can lead to learning and team effectiveness McGourty and De Meuse (2001).

Two behavioral attributes are integral to the study. They are communication and collaboration and are considered by scholars to be at the heart of team effectiveness (McGourty & De Meuse, 2001; Rompelmam, 2000). Emphasizing the importance of communications skills provides a lead-in to the topic of collective learning. It should be recognized that most progressive educators emphasize collaborative, project based learning as an effective instructional strategy (Felder & Brent, 1994). Though McGourty and De Meuse (2001) include other behaviorally oriented attributes critical to team effectiveness, such as self-management and decision-making, they describe it is collaborative activity that they describe as the "essence of teamwork" (p. 17).

Other elements that play a vital role in organizational behavior and team effectiveness and certainly no less important include: "trust, support, and training" (Napier & Gershenfeld,

1999, p. 495); "empowerment" and "self-management" (Eisenberg & Goodall, 1993, p. 283); having a sense of "purpose" (Luthans, 1977, p. 87); and leadership, participation, and willingness to work (Gillette & McCollom, 1995). In essence, no one single factor produces effective teamwork, but rather the interaction of these attributes enables development and learning.

To underscore the perspectives just discussed, an important point is that task and relationship are factors that can either detract or add to the personal growth of team members (Napier & Gershenfeld, 1999). These studies, suggests that having commitment and openness not only encourages healthy relationships, but also establishes the environment necessary for honest self and peer evaluation. Thus, an ideal environment is one in which members feel comfortable enough to communicate their shared understandings of the group's performance.

More specifically, in the Tuckman five-stage model, "each of these substages focuses on the problems inherent in developing relationships among members" (Napier & Gershenfeld, 1999, p. 437). Thus, task definition in the initial stage is followed by an exchange of information, emotional response, and shared interpretations before reaching consensus on goals in the final stage. Since highly performing engineering teams have clearly defined goals, the five stages of team development provides a unique model for resolving difficulties at one level before advancing to the next phase.

Structure of Teams

In today's work force, both process and product become a collaborative effort. Engineering students exposed to the challenges of complex design issues and decision-making are learning, perhaps for the first time, the requirements of multi-tasking and interdependency. Therefore, the structure of teams is more likely to survive in our post-

modern world when individuals cooperatively pool their collective expertise. New product development is highly dependent on the ability of teams to bring products rapidly from design to production. As noted previously, post-modern *organic* theories aptly describe organizational behavior as a *dynamic* and *complex* process. This characterization of behavior aptly describes effective teams in the contemporary workplace. Seen also from a systems perspective, the working group could be viewed as one that "takes in resources, transforms them, and sends them out, and thus interacts with the larger system" (Luthans, 1977, p. 114).

There are numerous factors that help, or hinder a team's ability to interact effectively. As described by McGourty and De Meuse (2001), they are both "external" and "internal" (p. 13). These factors include structure, culture, resources and task. Structure for example, might represent external factors such as the grouping of members; culture reflects the values and beliefs of its members; resources would include any assets that the group possesses, and task assignment includes member's duties and responsibilities. The authors note that internal factors essential to establishing a cohesive unit and under the control of team members, stress mastery of communication, collaboration, self-management, and decision-making. While the larger environment strongly influences teams' performance, the authors stress "that team performance depends on the behavior of individual team members" (p. 15).

Gillette and McCollom (1995) contribute an additional perspective on the structure of teams. Citing the work of Alderfer (1976), team performance is characterized as a social process that depends upon the behavior of its members. Borrowing from systems thinking, they state that human systems "are composed of subunits in interdependent relationship with one another" (Gillette & McCollom, 1995, p. 37). Therefore, the eventual cohesiveness of the unit depends largely on the concept of *boundary*.

Gillette and McCollom (1995) use the metaphor of cell activity to develop Alderfer's concept of group boundaries by applying open systems theory to groups. Analogous to a cell wall, there is a continuing process of "input, conversion, and output phases" (p. 237). The boundary separates what is inside from the outside: "It provides a structure for the system, and it regulates the systems transactions with the environment" (p. 37). Thus, as it relates to human systems, boundaries are further delineated as "physical, spatial, and temporal divisions that differentiate a group from other groups" (Gillette & McCollom, 1995, p. 38). The important point, as it relates to behavior, is that a change in any one area will likely have an impact somewhere else in the system.

Expanding on this idea, there is also the concept of "subjective" or psychological group boundaries, which are defined by Hartman and Gibbard (1974) as the "psychosocial basis of group structure" (as cited in Gillette & McCollom, 1995, p. 38). This concept defines elements of group behavior considered subjective in nature. Included among these elements, would be task definition, level of motivation, stability, and trust. In addition to psychological boundaries, there is the issue of time constraints. For those individuals involved in small group work, this may be particularly challenging. Since a group may exist for a limited duration, forming a group activity may place a strain on the interpersonal relationships within the group (i.e. the "storming" or emotional phase referred to in the Tuckman model). How, and to what extent, individuals experience team membership in the Hartman and Gibbard model, is dependent on whether the group establishes "psychological boundaries". At some point in the formation process according to Gillette and McCollom (1995), the group has formed when "all of the members experience commitment" (p. 39) and identify with the group. The reality of the group's behavior and cohesion becomes an experience both

personally and subjectively.

In continuing the discussion on factors impacting a group's formation and structure, other topics may prove compelling to revisit in further research. Although not originally a focus in the study, topics such as class composition, gender and racial issues, adult development, and learning styles can also impact team formation. It is interesting to note based on studies conducted by Besterfield-Sacre, Moreno, Shuman & Atman (2001), that attitudinal differences towards engineering education have been found attributable to students' gender and ethnic background.

Lastly, as a vast amount of literature on team structure draws from many disciplines, including organizational behavior, sociology and psychology, common themes do emerge across the disciplines. The concepts of participation and belonging, including communication, decision-making and self-management, are not necessarily exclusive domains of any one group. Understanding these behaviors have led to deeper insights into specific aspects of team structure that are governed by rules of behavior, channels of communication, and factors of control and reward. All of these themes are compelling reasons to examine group activity where the behaviors are "frequent and discernable parts of a team's interaction" (McGourty & De Meuse, 2001, p. 15).

Group Communication

As seen from the literature on group behavior, it is apparent there is considerable agreement that group pressures often inhibits the full development of individual potential, (Luthans, 1997). For example, diversity often adds to group pressure in many ways, namely, in the use of language and the influences that cultural difference has upon group members. Discrimination is a powerful deterrent towards making good choices in both speech and

action. Therefore, overcoming the barriers that separate us requires effective interpersonal communication. This involves two basic skills: (1) "communicating the intention or desire to understand the ideas and feelings of the sender", and (2) "understanding and interpreting the sender's ideas and feeling" (Napier & Gershenfeld, 1999, p. 52).

Group effectiveness is also influenced by the size of the group. Small group size may be preferred for communication and interaction among members. Small group size enables members to know one another, and share common interests and goals (Hare, 1976; Napier & Gershenfeld, 1999). According to Napier and Gershenfeld, "Because communication is among people, anything that interferes with relationships among them interferes with their communication" (p. 52).

Several studies discuss the effects of group size on group learning. In a five-year study on effective teaching and learning conducted at Harvard, one of the major findings reported by the New York Times in 1991 (cited in Napier & Gershenfeld, 1999) "was that students learned more effectively when they worked in small groups in classes, and that they were more successful at retaining and integrating what they had learned when they studied in small groups" (p. 447). The study corroborated evidence elsewhere, that the structure of small groups was helpful and supportive to students. Although small groups are desirable from an instructional point of view, there are no guarantees that distortion and misunderstanding in the communication process will not occur. As the authors further contend, feedback can be an important means to reduce conflict and difference.

In another study, the effectiveness of small group work was also acknowledged. Co-sponsored by the National Collegiate Inventors and Innovators Alliance (NCIIA) and the University of Nebraska-Lincoln, the study examined engineering students' attitudes and

experiences towards teamwork (Adams, 2001). Among the objectives of the study was to determine the preparedness of students to work as team members in the workplace. The participating schools represented a diverse group of private institutions as well as some elite institutions, some of whom were "actively experimenting with pedagogical issues" (p. 598). In the study, there were 159 responses from 18 schools, although approximately 45 schools were initially contacted. The demographic breakdown demographically included "73.5% men, 26.5% women, 90.2% engineering students, 8.3% business students and 1.5% represented other" (p. 598).

The survey was based on a 5-point Likert scale, ranging from: Strongly Disagree (1) to Strongly Agree (5). Several sections of questions covered areas such as team performance; beliefs in the benefits of teamwork experience, and student satisfaction. Data collection and analysis utilized SPSS 10.0 using chi-square comparisons. Each team survey was comprised of approximately 4.2 members. Interestingly, when asked whether team were used in any of their engineering courses respondents reported "that teams were used in 2.77 of their engineering courses and 1.77 of their courses outside of engineering" (p. 598). Sample responses as reported by Adams, included "I was satisfied with my group/team experience" (scored 4.26); "I am satisfied with the quality of my team/group experience" (scored 4.21); "I think teams/groups are an effective way to teach engineering" (scored 4.77) (p. 599).

Although the scores just reported are samples of responses pertaining to satisfaction, other questions in the survey related to team training. Training was also described as useful (scored 4.04). In general, Adams reported "that students strongly believe that teaming in the classroom has prepared them for the workplace, will contribute to their career success, and

has provided them with the skill set necessary for success. Specifically, students feel strongly they can communicate, negotiate, and resolve conflicts with fellow team members; respect the opinions of others; and work with diverse teams" (p. 599).

These findings corroborate studies that suggest students who are not exposed to teams may not have the necessary expertise and skills to compete for jobs in the future. Based on the research, it is apparent that students need some help and training to work effectively as team members. They often lack an understanding of what their roles are once a team has formed. Thus, teachers may need to assist and mentor students in the teaming process; however, they may not feel prepared to do so.

In summary, supporting the success of small functional groups lies in the teacher's readiness and preparedness to provide intervention when necessary and to maintain the team process. "Groups that are provided with appropriate structure, models for work, experience in problem-solving, and guidelines for maintaining their own process, tend to perform with less tension and with greater productivity than groups that do not receive such support" (Reddi, 1993 as cited in Napier & Gershenfeld, 1999, p. 447). While these assertions provide a foundation for team effectiveness by linking performance with learning, it is also important to stress, that performance competency be coupled with self-reflection and assessment. Based on the research thus far, assessment can contribute to student learning, however, whether assessment methods have matured to become accepted as a useful learning tool is still a question of debate. This topic will be discussed in more detail in the following section.

Assessment

The current shift taking place in engineering curriculum reform holds to the belief that assessment practice can significantly influence learning outcomes and improve engineering education (Ramsden, 1992; Boud, Cohen & Sampson, 1999; Hargreaves, 1997; McGourty, Dominick, Besterfield-Sacre, Shuman & Wolfe, 2000; Davis, Gentili, Trevisan & Calkins, 2002; Olds & Miller, 1998). Many educational researchers believe that providing feedback to students on their performance skills helps to consolidate the student's knowledge, and improves the educational process in general. This belief lends support to the value of assessment practice as a developmental skill building tool (McGourty & De Meuse, 2001; McGourty et al. 2000). In an *Assessment White Paper* (1996) report, Thomas Angelo, director of the Assessment Forum, American Association for Higher Education states:

"Assessment is an ongoing process aimed at understanding and improving student learning. It involves making our expectations explicit and public; setting appropriate criteria and high standards for learning quality; systematically gathering, analyzing, and interpreting evidence to determine how well performance matches those expectations and standards; and using the resulting information to document, explain, and improve performance". (p.1)

While the shift in education, broadly speaking, indicates a shift from teaching to learning, the testing culture has traditionally emphasized standardized measures based on acquired knowledge, and not necessarily understanding, or deep learning. Often, the term assessment and evaluation has been used interchangeably. Typically, an evaluation outcome such as a score, may be used to describe some comparison, or ranking between a standard and a norm (Vos, 2000). The evaluation provides a useful *instrumental* demonstration of how

much information a student retained by exclusively focusing on the individual's accumulated knowledge (Habermas, 1971 as cited in Leach, Neutz & Zepke, 2000).

The distinction between the *evaluative* use versus the *developmental* use of assessment is currently one of debate. Some researchers hold to the view that assessment method and purpose are still not matured enough to "become well-established methods understood and accepted widely by engineering educators" (Davis, Gentili, Trevisan & Calkins, 2002, p. 211). Therefore, defining the criteria for performance has proven to be difficult.

Although a number of studies researched in the literature focus on assessment processes that include: emphasis on scoring scales (Davis, et al. 2002); reliability and validity issues (Thompson, 2001); tensions between philosophy and practice (Leach, Neutz & Zepke, 2000); objectives and consequences (Rompelman, 2000); and student satisfaction (Gatfield, 1999), only one study tapped into the behavioral aspect of peer feedback. In that study, the results were encouraging as behavioral improvement occurred simply by completing the feedback instrument. (McGourty, Dominick & Reilly, 1998; Shuman, Besterfeld-Sacre, Chimka, Wolfe & McGourty, 2001). The findings from these and other studies provide further support for peer feedback, as "there is growing evidence that feedback processes have a positive impact on student learning and attitudes" (McGourty, Dominick, Besterfield-Sacre, Shuman, & Wolf, 2000, p. F1A-8).

There are several reasons for this support, namely, that information resulting from feedback helps the student learn what skills need improvement, thus providing an impetus for change. Secondly, by providing a reference for what constitutes effective behavior, participants are provided with a "framework for understanding/self-evaluating their behavior

in a particular context" (F1A-9).

Thus, multi-source assessment systems, when used for learning has been effective in nurturing student development (McGourty, Dominick, Besterfield-Sacre, Shuman & Wolf, 2000; Angelo, 1999; Rompelman, 2000; Boud, Cohen & Sampson, 1999). In a series of studies using multisource assessment and feedback, the results consistently demonstrate that student learning improves "based on perceptions of peers and faculty" (McGourty, et al. 2000, p. F1A8). As reported in the research, one of the issues that requires further investigation is whether the information resulting from assessment should be should be used a basis for grades.

In terms of practice, assessment tools used for *developmental* purposes as opposed to *evaluative* purposes, has generated positive responses (Thompson, 2001). In a study conducted by Thompson at the University of Colorado, peer assessment showed high measures for validity with benefits outweighing any potential negative effects when used as a developmental tool. However, in confidential follow-up interviews with students, Thompson, confirmed a clear pattern of student concerns over the use of peer evaluations which might in fact be used to determine their final grades. He recommended that assessment should not be used for evaluative purposes. Other findings that emerged from the study revealed the existence of biases in the evaluation when friendship was a factor. There was also a tendency towards grade inflation when raters perceived that results would impact their overall grades.

From the literature, it is apparent that assessment is not a simple practice. If the intent, or purpose is to help participants become "more aware of how assessment can have an impact on learning" (Vos, 2000, p. 1), then the implications for assessment and peer feedback within the repertoire of effective pedagogy, can be substantial. Assessment can be used to improve

learning by providing students and teachers with information that not only "test the right things and, when repeated by different teachers, give the same results" (p. 3). Lastly, practitioners are optimistic of assessment's value as a development tool for learning when teams respond honestly about their competencies (Ramsden, 1992; McGourty, et al, 2000; Trevisan, Davis, Crain, Calkins & Gentili, 1998; Vos, 2000; Rompelman, 2000).

Assessment Methodology

As a subset to the literature on assessment, references to evaluation provided insight into the nature of assessment approaches and techniques. Although the literature clearly confirmed the need and rationale for assessment, methodologies varied (i.e., qualitative versus quantitative and formative versus summative). Little information was found on issues of reliability and validity when comparing different methodologies, such as electronic feedback, versus paper and pencil. No studies correlating computerized entries with other assessment methods could be found to validate electronic surveys as better or worse than other methods.

Three evaluation models presented in the following sections illustrate the number of ways in which evaluation is used and interpreted within organizations. These works contribute perspectives on the value and relationship of assessment to learning. The first model is Guba and Lincoln's (1989) *4th Generation Evaluation* methods, which are characterized by *generational* constructions. The second model is the *Discrepancy Evaluation Model* developed by Provus (1971). Third, is *Team Developer* (McGourty & De Meuse, 2001), an assessment and skill building program.

Guba & Lincoln's (1989) intention is to go beyond a *data collection* definition to include social, human, cultural, and contextual elements. The latter approach is referred to as

4th Generation Evaluation. Based on this approach, results from evaluations are not facts per se, but represent *meaningful constructions*, in which individuals try to *make sense* out of their personal situations. Fourth generation evaluation involves stakeholders who can be empowered, or dis-empowered through selective dissemination of evaluation findings.

Descriptions range from the purely technical; (a) 1st generation as measurement-oriented, (b) 2nd generation - descriptive-oriented and (c) 3rd generation - judgement-oriented, to a newer and dynamic form that is more holistic called negotiation. Guba and Lincoln's reference to this newer construct (the 4th generation form) rests on the assumption that realities are not out there, but are constructed and influenced by the people who do the evaluating. Thus, in their view, the ideal instrument should be designed and developed jointly with all of the stakeholders.

The arguments posited against the first three forms is over-dependency on formal quantitative measurement, with the potential to dis-empower those who are being rated. On the positive side, the 4th paradigm is based on a *constructivist* methodology, grounded in inquiry, and having a collaborative dimension. The questions posed by the evaluator are based on specific goals and objectives of the group, and through a process of discovery, are meant to be educative. Constructivism, according to Guba, provides for a "proactive" approach (p. 131). The individual becomes the shaper of his, or her destiny.

The second model is the *Discrepancy Evaluation Model*, or DEM (Provus, 1971). The basic tenet of DEM is to make comparisons between intended objectives and the achieved outcomes of the assessment. Developed in the early 1960's by a group headed by Malcolm Provus, the basic concept measures performance against a standard in order to discern discrepancies between the two measures. Since data in this model cannot be collected

until a standard has been defined, the DEM is systemically divided into activities, or functions referred to as *input*, *process*, and *output* components with a goal towards process improvement. Each of the activities can be evaluated separately. The model is intended to have a twofold benefit i.e., improved school programs, and greater accountability by educators.

Both of the aforementioned models facilitate the analysis of performance measures based on input, process and output functions. The criticism of any process based on input and output processes is that it can be interpreted as too mechanistic. The strength of the systems approach however, is the component of interdependence, and the predominant element of communication as part of the process.

Thus, if the practice of assessment incorporates the social system in which it performed, it is most effective when the practice recognizes that individuals need to manage the relationships within their overall social environment. In other words, there is more to teaming than shared practices, or quantifying product outputs. Managing, or enabling others can be highly subjective process. This interpersonal process according to Gillette and McCollom (1995), focuses on the "quality and type of relationships" that exists between individuals (p. 52). Therefore, conducting assessment also means going beyond technical skills to personal mastery (Senge, 1990).

The third model discussed in the following paragraphs refers to a *Multisource Feedback System*. This model is designed to focus on improving student performance behavior using a self and peer feedback. The system as defined in the work of McGourty, Dominick, Besterfield-Sacre, Shuman and Wolfe (2000) is:

"...a formal process that collects critical information from several sources, including

peers, self, and instructors, on both student competencies and specific behaviors and skills. As such, it has the capability to provide each student with a better understanding of his/her personal strengths as well as those areas in need of development affording the student a better understanding of personal strengths and areas in need of development". (p. F1A-7)

In the preceding description, it is intended that the student use feedback proactively as a basis for making decisions about his or her behavior. Specific action can then be taken for self-improvement. In this model, students "need a structured *post-feedback process* for significant and deep learning to occur" (McGourty, et al. 2000, p. F1A-10). Typically, the information comes from several rating sources including the teacher.

McGourty et al. have investigated multisource assessment and feedback as a potential tool for improving student learning. The authors provide a useful framework to understand the assessment process, which they articulate as "grounded in control and goal setting theories" (McGourty, Dominick, Besterfield-Sacre, Shuman, & Wolfe, 2000, p. F1A-7). In general, these two theories (as used in the context of improving student learning), suggest that people are "motivated" to improve behavior more by the goal, rather than paying attention to the discrepancy factor between the outcome and actual behavior. Furthermore, these theories share certain activities such as: "self-monitoring of behavior; followed by self-evaluation of behavior by comparison to a standard; and then self-reaction in the form of satisfaction or dissatisfaction, which in turn leads to further adjustment of behavior and, or the modification of goals" (Kanfer, In Dunnette and Hough, 1990, as cited in McGourty et al. 2000, p. F1A-7).

Multisource feedback systems take the DEM model one step further to proactively use the information for growth and development. The process is one in which "individuals either work to achieve the goal, change the goal, reject the feedback, or abandon commitment to the goal" (McGourty et al. 2000, p. F1A-8). The authors believe that feedback becomes an important criterion by which the individual rates his or her performance as being up to, or below the predetermined standard. From the perspective of control theory, feedback translates into action on a personal level. It becomes the "basis for identifying goal-feedback discrepancies" and forms the basis for improvement and change (p. F1A-7). Furthermore, in the studies conducted by McGourty, et al. it has been demonstrated that "multisource assessment instruments used in the classroom have proven to be both reliable and valid" (p. F1A-9).

All of the foregoing examples of assessment models focus attention on specific performance behaviors. Each of the examples that were described requires inputs for comparison and identification of discrepancies between the actual, and the desired behavior. The primary difference among the first two models and multisource assessment, is the emphasis of the latter on development and student learning. Assessment should reinforce key learning objectives such that "the desired learning goal of the students should approximate the intended teaching goal of the teachers and be the object--the content--of assessment" (Vos, 2000, p. 5).

As reported by Martin (1997), many other approaches to assessment while less useful, viewed assessment solely on its technical and predictive value, supporting a purely *judgmental* model. This view is concerned only with issues of validity and whether the instrument truly measures what it intends to measure. The developmental aspect is not the

objective. Interestingly, there are opposing perspectives that suggest peer feedback measures may actually undermine student learning, and "inhibit the processes it is designed to enhance" through insensitivity and unfamiliarity with the group assessment process (Boud, Cohen & Sampson (1999). At the present time, there continues to be debate between the view of assessment as a means for selection and accountability, and the view held by a number of scholars, that assessment and learning are inexorably linked (Sebatane, 1998).

Current Approaches

Assessment practices have strong implications for classroom practice. Whether assessment supports learning, or fulfils a different purpose - that of selection and accountability, the context and design of assessment instruments must clearly and explicitly identify the performance attributes one intends to measure. Ideally, "students need a structured post-feedback process if significant learning is to occur" (McGourty, et al. 2000, p. F1A-10). Despite the support for multisource assessment as a tool for learning, there is evidence of teacher resistance in providing students with opportunity to participate in self-assessment. In a survey conducted by Fontana and Fernandes 1994 (as cited in Sebatane, 1998), many teachers felt they needed in-service training before allowing their students to participate in self-assessment. This view is also shared by others. Lewis, Aldridge, and Swamidass (1998) suggest that teaming presents "special pedagogical and assessment challenges for most faculty" (p. 149). Finally, as current approaches are still a matter of debate, the distinction and benefits between multisource assessment (as a learning tool), vs. traditional forms of assessment (as characterized by standardized tests or controlled measures), is sufficient reason to research this important topic. Peer feedback and self-assessment processes can provide students with a unique opportunity for life-long learning.

However, the process must be carefully planned

Designing the Assessment Survey

When designing the assessment tool, "the content of assessment should be chosen in accordance with the learning outcomes in such a way that the desired learning process is promoted" (Vos, 2000, p. 1). Through the years, many taxonomies have guided assessment design and research. Most notably, are the works of Bloom and Krathwohl (Krathwohl, Bloom & Masia, 1956). Bloom's taxonomy places emphasis on the cognitive domain, and Krathwohl provides classification of the affective domain.

A specific list of observable and measurable attributes has been developed through the University of Pittsburgh, and is intended to guide educators in the design of assessment questions. Based on Bloom and Krathwohl's taxonomy and McBeath's (1992) action verbs, this framework focuses on the eleven ABET's EC 2000 performance outcomes. The framework provides a list of attributes that educators can tailor and adapt to their specific learning outcomes (Besterfield-Sacre, Shuman, Wolfe, Atman, McGourty, Miller, Olds, & Rogers (2000). Thus, a personalized assessment tool can be designed to operationalize specific ABET learning outcomes.

In the shift to student-centered education, educators create learning communities by guiding and giving students feedback. Consequently, the implication for assessment is in the design of a well-constructed instrument. Shaeiwitz (1996) cites the following components as a basis for a well-designed assessment plan:

- a statement of educational goals which define exactly what is expected of students;
- a valid set of measures of achievement of these goals; multiple measures are best;
- and use of the information to correct and improve the educational process. (p. 240)

Aims of Assessment Practice

The American Association for Higher Education has developed *9 Principles of Good Practices for Assessing Student Learning* (Astin, et al.) excerpts of which are cited below.

1. The assessment of student learning begins with educational values. . . it is a process of improving what we really care about.
2. Assessment is most effective when it reflects an understanding of learning as multi-dimensional, integrated, and revealed in performance over time. It entails not only what students know. . .but values, attitudes, and habits of mind.
3. Assessment works best when the programs it seeks to improve, have clear and explicitly stated purposes.
4. Assessment requires attention to outcomes, but also and equally to the experiences that lead to those outcomes.

Other principles of good practice include; the importance of connecting data to real issues, and recognizing the fact that assessment must go deeper than merely reporting facts. The deeper obligation of assessment practice to the student and to specific programs is to foster continuous improvement and instill a value for life-long learning.

In summary, the works cited in this section reflect only a limited survey of exhaustive literature on assessment models. This review highlights the highly dynamic nature of team behavior, the growing importance of assessment activity to the learning process, and calls attention to current debate regarding assessment intent. The three models illustrated differences in emphasis, yet none are considered traditional approaches. Guba & Lincoln's 4th *Generation Evaluation* model, strongly suggests evaluation is a teaching/learning process

"mutually educative for both teacher and learner" (1989, p. 254). The *Discrepancy Model* has similarities to the *Multisource Feedback* model, insofar as attempting to identify gaps between intended outcomes and actual results. The need for feedback reports and development of a personal action plan in the *Multisource Feedback* model seems especially relevant in terms of fostering peer learning and personal development. Having discussed team performance and assessment activity, the relationship of these topics to classroom culture and pedagogy is of particular interest. This topic will be briefly discussed in the following section.

Pedagogy

Although small group work is only one of many pedagogical techniques used to promote and engage students in understanding subject matter, the context of the classroom includes many other considerations. These include beliefs, values, goals, behaviors, classroom management, climate, social dynamics, and the evaluative components of assessment (Turner & Meyer, 2000). Turner and Meyer acknowledge the use of surveys and questionnaires as an important approach towards understanding the instructional context of the classroom. In their view, assessment can lend insight into behaviors and relationships between teacher, student and peers. Thus, assessment can become an integral part of the teaching and learning process (Sebatane, 1998). The link between learning and assessment is corroborated by Gipps (1996) "Assessment does not stand outside teaching and learning but stands in dynamic interaction with it" (p. 261).

Others such as Hargreaves (1997) also link assessment as a significant motivator, to teaching and learning. He reported on various initiatives to improve learning through assessment practices that had been implemented at the Queensland University of

Technology. One such initiative was the use of project-based assessments in which students analyze, design, and build small model structures. Assessment was based on specific criteria necessary to complete the project. Students thought this innovative approach to assessment and learning was particularly "enjoyable" and "thought-provoking" (p. 405).

Research studies confirm the effectiveness of innovative pedagogical practices to enhance student learning such as small group projects. "Using collaborative learning activities means structuring student interaction in small mixed-ability groups, encouraging mutual interdependence, and providing for individual accountability" (Adams & Hamm, 1996, p. vi). Felder & Brent (1994; 2001) and others, have also examined the effects of cooperative learning and confirm the overwhelming evidence that it helps to improve students communication and team skills. However, Felder and Brent emphasize that instructors need to anticipate negative reactions from students who may not have gained the skills necessary to work successfully within groups. The following section will examine some of the benefits of small group activity to student learning.

Benefits of Cooperative Learning

Cooperative learning techniques are a powerful tool for maximizing student potential. By providing students with opportunities to connect past knowledge with current experience, students tend to experience deeper learning (Felder & Brent, 1994). In numerous research studies conducted by Johnson & Johnson (1996), cooperative learning methods have been shown to have a significant and positive impact on student learning. Works by Hooper & Hannafin, (1992) also identify the benefits of cooperative learning in small groups as being socially productive. "Students who work within groups often improve self-esteem and attitudes towards their peers and schoolwork, and are often more altruistic toward group

members" (p. 279). A five year Harvard study also corroborated findings that students learned more effectively, retained and integrated their learning with prior knowledge when studying in small groups (Napier & Gershenfeld, 1999). Additionally, minority students tended to benefit as relations improved among diverse group members.

Scholars such as Felder and Brent (1994; 2001); McKeachie, (1986) have pointed out that learner centered pedagogical strategies (i.e., group-based cooperative learning) particularly in technical courses, has been shown to be more effective than traditional approaches. There is also the indication that the nature of learning and collaboration occurring among team members connects individuals synergistically to higher levels of adaptability and skills. The implications for assessment and learner centered pedagogy reflects a shift to *participative* organizational styles. "This shift can be accurately characterized as moving from an emphasis on instruction to an emphasis on learning" (Betts, 1992, p. 5).

Traditional undergraduate engineering curriculum has been problematic in the sense that increasing specialization of subject matter has contributed to the fragmentation of knowledge. According to Bordogna, Fromm and Ernst (1993), "the ability to make connections among seemingly disparate discoveries, events, and trends, and to integrate them in ways that benefit the world community will be the hallmark of modern leaders. They must be skilled at synthesis as well as analysis" (p. 4). Senge (1990) also emphasized the importance of learner centered modalities. By providing students with opportunities to connect prior learning with current experience, educators can nurture purposeful learning opportunities.

Overall, students taught with cooperative teaching methods "tend to exhibit higher

academic achievement, greater persistence through graduation, better high-level reasoning and critical thinking skills, deeper understanding of learned material, more on-task. . . . greater intrinsic motivation to learn and greater ability to view situations from others' perspectives, more supportive relationships with peers, more positive attitudes toward subject areas, and higher self-esteem" (Felder & Brent, 1994, p. 2).

In 1990, a four-year National Science Foundation longitudinal study of engineering students conducted by Felder, Felder, and Dietz (1998), traditional pedagogical methods were compared with cooperative learning methods. The research confirmed the effectiveness of cooperative learning. However, the authors contend that the obstacles preventing implementation are not insignificant. The view held among some that engineering students can successfully manage teamwork does not appear to be supported by research conducted among major universities. Teaching strategies must be designed to support learning, maturation, and the development team skills among students. Felder and others believe that educators who pay attention to cooperative learning strategies will be more than compensated for the negative reactions expressed by students who may encounter problems in the early stages of team formation.

The benefits describing cooperative teaching methods dominate the literature on this subject. The virtue of collaborative activity is also said to be highly correlated with participants agreeing on common goals, sharing concerns, and having a commitment to build trust among team members (Jasawalla & Sashittal, 1999). Shooter & McNeill (2002) cite research by Smith, Johnson & Johnson (1991) that describes the basic tenets of collaborative activity as well as the advantages for promoting this learner centered activity. These are:

- Positive interdependence: exists when students link their efforts to the efforts of others.
- Face-to-face- promotive interaction: exists when students teach and mentor their peers.
- Individual accountability: exists when the teacher not only assesses student performance but provides feedback.
- Collaborative skills: exists when students demonstrate needed leadership, management and conflict resolution skills.
- Group processing: requires the ability of students to discuss their progress and maintain a good working relationship. (p. 340)

Other learning theorists such as Piaget, Kolb suggests that "Human development is a maturation process in which education plays a role" (Eder, 1994, p. 113). Therefore, to fully assess the effects of student perceptions of performance skills, Eder states that all of the domains of learning should be included in assessment practice. These domains include the cognitive (covering the acquisition of knowledge); affective (involving the feelings); psychomotor (involving the development of activity) and the interpersonal domain.

Assumptions of Cooperative Learning

A major assumption of cooperative learning is that students will "teach and learn from each other" (Haller, Gallagher, Weldon & Felder, 2000, p. 285). The fact that many graduating engineering students will work as members of teams, it seems imperative that teaching strategies link collaborative teaching methods with assessment to gather data in some form for accountability and documentation of outcomes.

It becomes apparent that within the culture and social structure of the classroom,

teams need the support and facilitation by their teachers to maintain the learning process. Thus, self and peer evaluation can contribute to this process. Groups will tend to perform more productively than groups that do not receive such support (Reddi, 1983 as cited in Napier & Gershenfeld, 1999). This support leads to early identification of teaming skills in need of nurturing such as learning how to manage group conflict, communicate in a non-defensive manner, and to listen attentively.

Another assumption of cooperative learning revealed in the literature, is that *goal seeking* characteristics are also positively enhanced (Johnson, Johnson & Scott, 1978). For engineering students learning in a cooperative setting can promote active involvement in the learning process, with less competition, and greater opportunity for reciprocity in sharing. Yet, many issues that surfaced in the literature continue to be a challenge to researchers such as student learning styles, the role of teacher as facilitator, and racial and ability grouping. These important issues suggest that forming a cooperative learning environment is a unique and complex challenge. Considerations such as learning objectives, performance goals, structure of teams, types of students, and importantly, the nature and design of assessment tools, become important to the establishment of a learning environment. In general, cooperative groups contribute to learning by fostering collaboration, placing value on cooperation rather than competitiveness, and advocating peer teaching and learning.

Although the progressive learning strategies just presented and discussed in previous sections are relatively new in engineering education, cooperative learning has proved beneficial in the presentation of technical curricula. "In this atmosphere of mutual helpfulness, students are supposed to talk to one another as they try to resolve issues through fact-to-face discussion. By taking part in cooperative experiences, students are encouraged to

learn by assimilating their ideas and creating new knowledge through interaction with others" (Adams & Hamm, 1996, p. vi). These factors clearly emphasize an important aspect of collaborative, or cooperative learning that "knowledge is created, not transferred" (Imel, 1991, p. 1).

Finally, there is the notion of synergy, which Jassawalla and Sashittal (1999) posit as an "an integrated understanding of divergent points of view that exists in the collaborative environment". This important concept is a powerful influence in stimulating a belief in what is possible within a team effort. They believe that "Teams become transparent and reach the next developmental milestone when participants achieve high levels of awareness, clarity, and understanding of the multiple orientations, motivations, and agendas that exist within the team (p. 6). In other words, the whole becomes greater than the sum of its parts.

In summary, there is no magic bullet in the formation of teams despite cooperative learning strategies. Team members are exposed to a variety of pitfalls and barriers, including but not limited to: ability levels, interests, learning styles, gender and cultural issues, ability to engage in discussions openly, and mediate during conflict if necessary. Cooperative learning approaches have been shown by scholar-practitioners to offer promise in developing successful interactions between team members. However, effective implementation depends on the "match between recommended instructional strategies and the teacher's style" (Nastasi & Clements, 1991, p. 16). Reiterating what has been said previously, support from faculty members is necessary and showing a willingness to engage students in group discussions. Establishing rapport, is based on the premise "that learning is best achieved interactively rather than through a one-way transmission process" (Haller, Gallagher, Weldon and Felder, 2000, p. 285). Therefore, a learner-centered modality (with the teacher as guide and mentor)

is not only a participatory effort, but seems socially responsible as well. An example is provided in the following paragraphs.

Studies discussed by Shooter & McNeill (2002), support the success of collaborative and active learning techniques in establishing levels of competencies in students. In a grant from the National Science Foundation (NSF 9972758), researchers employed collaborative learning techniques to teach a course in *Mechatronics* at Bucknell University. *Mechatronics* is defined by the authors as the application of several engineering disciplines; mechanical, electrical and computer intelligence in the design of products or systems. Introduced as primarily a design course, the integration and interdisciplinary approach involves students in an active learning process through laboratory exercises.

The methodology used in the course incorporated small groups of four students who stayed together for a semester. The design projects included group processing, group homework, inter- disciplinary laboratory groups and student lectures. Students would review, discuss and resolve issues effecting their respective design projects. The aforementioned collaborative learning tenets of Smith, Johnson & Johnson guided the researcher's evaluation of group projects. Although the course was multi-disciplinary, the intent of the lectures was to introduce greater flexibility into the course and allow for student mentoring. The results of the semester study, was "overwhelmingly positive" (Shooter & McNeill, 2002, p. 340).

The assessment process that culminated the study indicated that the collaborative process was effective. Students polled on a five-point scale (1 = pathetic, 2 = poor, 3 = fair, 4 = good, 5 = excellent), indicated an average rating of 4.80 for the group design project. The student teaching exercise was rated at 3.7. In general, the collaborative approach was rated at 4.47 and noted by one student as, "anything collaborative is worthwhile" (p. 343). Thus, the

study provided evidence that collaborative opportunities for students to assess themselves and each other, contributed to personal growth and learning.

Organizational Development

The final topic in this literature review is Organizational Development. It is an important topic because it is a collection of techniques that focuses on improving the interpersonal relationships of individual within the organization (or group). Interpersonal relationships characterized in a preceding section; include norms, values, shared assumptions, roles, and expectations (Katz & Kahn, 1969; Bennis & Shepherd, 1974; Schein, 1985). Historically, organizational development emphasized *specialization* and *expertise* shifting to a legacy of post-modern concerns with the "whole person and interpersonal dynamics" (Luthans, 1977, p. 106).

The subject of organizational systems, both formal (structure and hierarchy) and informal (culture and behavior), contained a considerable amount of literature beyond the scope of this study. Given the breadth and depth collective research on organizational culture, the consequent literature represents works that relate specifically to the analysis of organizations. The works cited are representative of a systems views of organizations (Waszak et al. 2000; Katz & Kahn, 1969; and social learning theory (Senge, 1990).

"By understanding systems, we are much better able to understand the impact of norms, memberships, goals, communication patterns and leadership (authority and influence) on the behavior and expectations of the group" (Napier & Gershenfeld, 1999, p. 295). Systems thinking as it applies to education "optimizes the relationship among the elements" by developing the capacity for self-reflection, "self-correction, self-direction, self-organization, and self-renewal" (Betts, 1992, p. 5). Furthermore, systems thinking provides a

framework for deepening our understanding into the relationships of elements guiding groups' behavior. Thus, team effectiveness is dependent upon the relationship of the group's culture, patterns of interaction, and process-orientated interventions that may be provided by the teacher.

Systems theory is a useful theoretical foundation for understanding how groups can enhance their effectiveness. It does this by using the concept of feedback loops to identify and correct issues that could potentially undermine attitudes, procedures, and the ability to meet the group's predetermined milestones (Waszak et al. 1998, p. 2).

Organizational Effectiveness

Briefly, when considering organizational evolution, early scholar-practitioners such as Kurt Lewin (1951) took the view that groups were *goal-oriented* systems (p. 295). In the 1950's and 1960's, Lewin and others shifted their focus from an emphasis on the individual to the group as a whole. The group could be viewed as a system encompassing a *total social unit* made up of individuals working together within groups (p. 295). Thus, one of the assumptions of organizational culture rested on the emergence of people living and working together and forming norms and traditions.

If one views organizational effectiveness through the lens of system thinking, the relatedness between, and among group members influences the conditions under which group members work. It seems reasonable to assume that effective leadership would increase group performance, despite the fact there may not be any one best leadership style. However, presuming that goal oriented groups possess favorable capacities for self-reflection, correction and self-organization, achieving group effectiveness would depend on a leadership style capable of managing the delicate balance between task and relationship.

Developmental theories such as Argyris and Schon's (1978) concepts of "single-loop" and "double loop" learning behavior, provided some rational for innovative coping behavior in order to adapt to challenge and change within groups. Argyris and Schon's view of the organization as a "social system", linked individual learning and to the organization's learning.

Others, such as Dunphy and Bryant (1996), added the notion of *self-management* as an important team attribute for organizational effectiveness. Dunphy advanced a classification of team attributes intended to facilitate team development in organizations. He draws the conclusion *that self-managed* teams have a positive effect on performance. Although many of the studies on teams focused on the individual attitudinal and behavioral attributes of team members, Dunphy's work examined the role of the group's performance as whole.

In summary, regardless of the setting - whether in academia or business, organizing individuals into effective teams relies on the self-management, interpersonal and communications skills of its members (McGourty & De Meuse, 2001). Moreover, the element of trust becomes the basis on whether team members are willing to help each other (Coleman 1990). Since the nature of a team's effectiveness in small group engineering projects, is predicated on cooperation and problem solving, it is in the interest of team members to trust their team members, consolidate their skills and share information. Intervention as noted previously, by a mentor or teacher may help to assist students early enough in the transition (or norming process) to reinforce effective teamwork behaviors such as self-reflection, correction, and task management.

Assumptions of Postmodern Organizations

Underlying assumptions about postmodern organizations particularly in academe, is the recognition of diversity, socialization and student autonomy (Katz & Kahn, 1966; Bennis & Shepherd, 1974; Schein, 1985). Explicit in the theory of organizational behavior is the nature of task management and the unconscious processes that drive the group's objectives (Schein, 1985). These assumptions provided further support for the need to examine teaming and communications skills.

Possible influences of organizational development flowing from these assumptions concerns the ability of groups to remain open, flexible, and adaptive, thus enabling group members to extend mutual support and progress towards effectiveness (Napier & Gershenfeld, 1999). With respect to communication, perceptions of competence, personal growth and satisfaction are derived from positive transactions and communication among the individuals within the team. Therefore, when groups begin to form relationships, an environment that is conducive to its growth recognizes; a) a group member's need for inclusion and acceptance, b) reduces uncertainty, affords personal challenge, and c) is sensitive to patterns of beliefs. These considerations underscore the components that lead to highly effective teams (Schein, 1985; Bennis & Shepherd, 1987).

Communication in the Context of the Organization

Although personal growth and satisfaction can be derived from positive transactions, in general, the nature of communication in the context of organization or group process, is a complex process. It is the concern for self and concern for others, that dictates whether one chooses to avoid, accommodate, compete, or collaborate to avoid an unproductive situation.

Conflict is also a kind of communication and as some researchers believe, "inevitable" (Kilman & Thomas, 1975 as cited in Eisenberg & Goodall, 1993, p. 269). What is of importance, is the manner in which conflict is handled. Collaboration, rather than accommodation become "a commitment to constant communication (p. 271).

The dynamics of communication among team members combines several facets: the non-verbal aspect or body language; the emotive, or feeling aspect that is expressed; as well as the verbal or content aspect (Napier & Gershenfeld, 1999, p. 21). Therefore, the impact and importance of effective communications skills on team behavior becomes evident. One of the most important elements of good communication that was emphasized in the literature was that members need to become "active" listeners by conveying their interest in others (McGourty & De Meuse, 2001, p. 16). Communication was seen to foster the ongoing process of "defining the relationships within the group, and the development of a set of arrangements between group members" (Napier & Gershenfeld, 1999, p. 22). These evolving patterns, or arrangements between, and among members facilitate adjustment and feedback (or responses).

According to Eisenberg & Goodall (1993), assumptions about communication that are taken for granted pose particular challenges. For instance, they believe that one of the assumptions of traditional management is the relationship of performance to reward and mistrust of managers who single out individuals, rather than take a "collectivized" view and reward the whole group for exceptional performance (p. 184). Communication and its relationship to the organization, as seen from a dynamic, post-modern perspective, or systems view, challenges educators to find new ways to empower individuals to take responsibility for their own learning, while at the same time, respecting the delicate

interdependence among group members (p. 191).

Given the importance of communication skills, it is not surprising that it is one of several attributes viewed as critical for a high performing team member. As small group relationships have an advantage by the very fact that size limits the quantity and quality of communication, they also have the advantage of providing the individual with opportunity for self-awareness and regulation of behavior.

Other factors found to influence communication within groups, is access to participation, "the more open the participation, the higher the morale" (Napier & Gershenfeld, 1999, p. 43). The authors also believed that efficiency is a powerful influence when group members have access to a "central leadership figure", who is able "to keep the group on the right track in working through the problem" (p. 44). Napier & Gershenfeld also refer to communication as a skill, in which, the individual sends and receives messages.

Citing from the work of Johnson & Johnson (1991), the authors stated:

"The skills involved in receiving messages include giving feedback about the reception, and the message, in ways that clarify and aid continued discussion.

Receiving skills have two basic parts: (1) communicating the intention or desire to understand the ideas and feelings of the sender, and (2) understanding and interpreting the sender's ideas and feeling. Of the two, communicating the intention to correctly understand, but not evaluate, a message is the more important". (p. 52)

Summary of the Literature Review

In this literature review, we have seen that group process skills can lead and contribute to highly effective teams. Assessment feedback and pedagogical approaches that support collaboration and communication skills among engineering students are integral to

the realization of ABET objectives.

Due to the importance of the group experience, core processes of group performance were elaborated, as well as team structure and organizational development. Although the studies cited were limited in scope, the knowledge and conceptualizations gleaned from the literature informed my understanding of how individuals perceive themselves and each other as team members, both cognitively and affectively. Various types of behaviors were distinguished that correlate with skills leading to high performing teams. These behaviors contributed to the selection criteria for survey questions.

Finally, both research and professional opinion suggest a strong need to examine current teaching methods to determine the kind of strategies needed to optimize student learning. This need also reflects concerns educators are currently experiencing in their attempt to reform engineering education. In addition, studies in group process, assessment, pedagogy, and organizational development, need further attention as they relate to the engineering practice.

By enhancing performance skills in small group activities, the research has shown there is improvement in learning and self-awareness. A systems dynamic further strengthens the concept of working towards collective rather than individual goals. Because communication and feedback is critical to improving a process, assessment can play an integral part in providing personal information as to how a system can be acted upon and improved. By using statistical procedures, this research study will focus on the attributes, processes, and interactions that comprise team behavior. The next section will turn to the design of that research.

CHAPTER THREE

Research Methodology

Introduction

The case study was designed as a formative evaluation intended to describe individual, team, and faculty perceptions of performance attributes (Sproull, 1995; Isaac & Michael, 1997; Merriam, 1998). The scope of the study concentrated on specific factors within a semester cycle. In addition, this methodology supported a "focus on important variables, processes, and interactions that deserve more extensive attention" (Issac & Michael, 1995, p. 52).

Through the use of a self-administered assessment survey, the research design measured the perceptions of ABET performance outcomes of engineering students and attempted to determine the linkage of such ratings to small group work. With regard to the assessment tool, the questionnaire related to pedagogical objectives of a course that focuses on small group work, such that team and faculty perceptions of team effectiveness and congruency among the participants, intended to provide feedback of performance strengths and deficiencies. Thus, recommendations for improvement can be used for personal and program development. It was anticipated that the response rate of the respondents would be influenced by the relevance of the questionnaire to the group's overall goals, which was to design and improve computer-controlled models of electromechanical systems (Macedo, Lord & Olson, 2000). Thus, the assessment tool provided tangible information about the student's technical skills and performance as a team member. Descriptive statistics were used to draw inferences regarding a team's ratings and actual performance. Interrater reliability

measures could also be used to determine the consistency of ratings between students and faculty, thus assessing the internal validity of the assessment tool. The research questions guiding this study, previously identified in Chapter One are noted below.

- 1) Based on the findings of this study, what recommendations can be made for future use of the assessment tool and process?
2. What are the lowest rated subskills in each of the areas of Communication, Design Skills, and Teamwork.
3. Is there congruency in how students rate themselves, how teammates rate each other, and how instructors rate these teams on the dimensions of:
 - a) Communication
 - b) Design Skills
 - c) Teamwork
4. Did the students perceive equal skill development for themselves in the three areas of Teamwork, Communication, and Design skills?
5. What are the perceptions of the process by the students?

Population and Site

The subjects for this initial study were 41 engineering students and 4 professors from 4 freshman engineering design laboratory courses. The participants were composed of students who were introduced to fundamental engineering skills in a first-year laboratory course, and their professors. Students typically work in teams of three in a laboratory environment in which they design, build, and test small computer-controlled electro-mechanical systems (Lord, Macedo, & Olson, 2000).

The objectives of the laboratory experience are twofold; the first is to expose students to a meaningful design experience early in the curriculum (Sheppard & Jenison, 1997).

Second, to introduce students to design concepts, teamwork, and other skills that align students with real world applications and meet the Accreditation Board for Engineering and Technology (ABET) Engineering 2000 Criterion 3 outcomes. Since there has been a paucity of literature on teaming skills' acquisition among engineering students, there is a need to study how students acquire and practice these skills, while completing a substantial design project.

To provide a context to assist in understanding the teams project activities, Table 4.1 describes the various Design Projects teams' are required to design and construct during the course of the semester.

Table 4.1
Engineering Design Projects

Class*	Team	Design Project
Class A	1	Fire Fighting System
	2	Mouse Trap
	3	Coin Operated Projector
	4	Slot Machine
Class B	1	Bottling Plant
	2	Elevator Cargo Transport
	3	Car Wash
	4	Candy Dispenser
Class C	1	Hot Chocolate Machine
	2	Automatic Gas Station
	3	Jelly Bean Launcher
Class D	1	Pill Counter and Bottling
	2	Golf T Loader
	3	Alarm System
	4	Metal Separator

* For purposes of confidentiality, classes are identified only as A, B, C, and D.

For example, in the construction of an Elevator Cargo Transport, the student used hands-on experience in computer programming, knowledge of circuits, basic electronics, and wiring. The electromechanical systems were computer generated using *fischertechnik LLWin* software. The actual mechanisms were constructed of Lego type pieces, wiring, sensors, and other hardware. As the electro-mechanical systems were computer driven, an important aspect in the construction was to debug the software program to demonstrate that the mechanism would actually work. The project development was also associated with a documentation phase that required written reports and oral presentations. These communication skills were essential, as students were required initially to write up a proposal, keep a notebook, and at the end of the semester present their results to a local high school. Requirements for the course during the first several weeks included learning about gears, motors, switches, and fundamental programming concepts. Teams were encouraged to self-manage their activities using a Gantt chart, an organizational tool named after its developer, and to delegate responsibility for the design and construction of their specific projects among team members.

The participating teams met for three hours of laboratory per week. Half of the laboratory time was devoted to the design project and the other half to computer-related activities associated with the project. The students were essentially self-managing and were provided with handouts that included the learning objectives, procedures, and deliverables for each of the sixteen weeks of the course.

The site chosen for the survey was an engineering laboratory on the campus of a private university located in the western part of the United States. The particular site was selected because of the availability of resources allowing focus on teamwork as it occurred in

an environment supporting a design experience early in the engineering curriculum. The engineering department at this University operates several laboratory design classes intended to provide a challenging environment whose aim is to attract and retain students in the program, however, assessment of performance skills has been limited.

Because of the large number of indicators that the curriculum presented within the design experience including teaming skills, the laboratory provided a rich setting to observe and survey small group work. It was critical to the study that the engineering professors involved in their classes also participate in the survey as a basis for assessing congruency in perceptions of teamwork among the groups. The methodologies for the engineering design students' design experience had evolved from a previous course implemented at another western university by one of the professors. Since the professional goals that freshman engineering students possess were important for this research, a purposive sampling strategy was appropriate for this study based on availability of participants, courses offered, and the site location (Sproull, 1995).

Sampling Method

The non-random method used in this study may be of some concern. However, the sample may be representative of typical freshman engineering students who possess little knowledge and experience with engineering design on a professional level. Since the four classes were offered with different professors, all students enrolled in these classes were potential participants. Demographic differences were not considered due to the small sample size. With regard to the survey, the questions related directly to the students' current experience as beginning college freshman, they were not unique as a sample in the typical sense. The fact that the university is private did narrow however, the screening of students.

Data Collection.

Data collection included the following; a) the use of *Team Developer* an electronic survey tool for students, b) similar survey questions for faculty with additional questions pertaining to specific team skills, and c) a follow-up mail survey for students.

The computer-based survey tool, *Team Developer* (TD), (McGourty & De Meuse 2001) incorporated questions based on a behavioral model of three of the eleven ABET performance skills. The assessment was intended to examine perceptions of performance as identified by measures of individual, peer and faculty ratings. The feedback report generated from the survey also provided students with an opportunity to review and reflect on their knowledge, skills, and abilities during the course of the semester. A similar survey was administered to faculty at the same time to determine if a relationship existed between student and faculty perceptions of demonstrated performance skills.

Ratings from the all of the surveys provided data on the roles, mission and purpose of the teams, which shed light on characteristics that lead to highly effective teams. In addition to quantitative ratings of student and faculty perceptions, qualitative data were collected from students to elicit reactions to *Team Developer* and the course process. The qualitative component provided triangulation of the data to establish and strengthen the validity of the results (Merriam, 1998). The inclusion of students' responses to a mail-in questionnaire (Appendix B) were intended to add depth to the statistical data. Findings generated from the analysis of all the data will provide faculty with additional information for course improvement.

As faculty members are stakeholders in this research, perspectives from the survey may help to inform and guide ongoing course development. *Team Developer* was used to

measure intended learning outcomes within the construct of cognitive, attitudinal, and behavioral elements based on Bloom and Krathwohl's Taxonomies. The Bloom and Krathwohl taxonomy provided a framework for developing survey specific questions pertaining to ABET performance attributes (Besterfield-Sacre, Shuman, Wolfe, Atman & McGourty, Miller, Olds & Rogers, 2000).

The Assessment Instrument.

Team Developer (2001) is a computer-based assessment and skill-building feedback program designed for the engineering student to elicit relevant data on performance skills. It was developed by Dr. Jack McGourty, Associate Dean of the Fu Foundation of Engineering and Applied Science at Columbia University and Director of Assessment at Gateway Coalition and Kenneth P. De Meuse of the University of Wisconsin. Columbia University is one among a number of member schools participating in a coalition to improve engineering education.

When used as a multi-source feedback system, Team Developer provides students with feedback on their own, and their team's skill and expertise, based on attributes aligned with ABET performance skills and course objectives (McGourty & De Meuse, 2001). Team Developer has been in use as an assessment tool in both academic and industrial settings along with an accompanying set of instructions contained in a Student Guide, published by John Wiley Inc. (McGourty & De Meuse 2001; Seat & McAnear, 2001; McGourty, Scoles & Thorpe, 2002). The student guidebook can be used as a supplemental text to help students to become more successful team members (McGourty & De Meuse, 2001, p. 1).

The format of the Team Developer survey consisted of a 36-item questionnaire contained on a floppy disk appropriate for students at the college level. Team Developer

measures use a rating scale based on a 5 point Likert-type scale focusing on three specific ABET performance areas. These areas are grouped under the constructs of Communication, Design Skills, and Teamwork. For example, subskill questions that focus on the category of Communication Skills examine whether the student articulates ideas in a clear and concise manner and practices good listening skills. All of the 36 survey questions attempted to assess attributes of team behaviors, as well as identify the challenges and difficulties that face students during their engineering design projects.

Used as a multi-source feedback assessment process, Team Developer is intended to provide professors and students with information about the practices, conditions or deficiencies, in teaming and performance skills that could lead to changes and/or improvement in their courses. Based on a feedback process, students can learn to function effectively in teams. Faculty used their survey to document their observations of specified competencies as well. It should be noted that Team Developer provided two databases for ABET outcomes as a framework for questions. One of these permits the user to construct his or her own questions tailored to course specific course objectives, and to address specific performance attributes.

Reliability and Validity of the Assessment Instrument

The Team Developer format "is designed to provide both the giver and receiver of feedback a safe, nurturing learning environment" (McGourty & De Meuse, 2001, p. 1). The Team Developer assessment and feedback program has been sponsored by the Gateway Engineering Education Coalition and supported in part, by the Education and Centers Division of the National Science Foundation (Awards EEC-9109794 and EEC-9727413, p. 2).

The ratings derived from the assessment are based on a summated 5-point Likert type scale (1 = not at all; 5 = to a great extent). Its purpose is to estimate an individual's overall attitude, opinion, or perception. The three categories are measured through ratings assigned to each of the thirty-six items on the survey. The respondent's rank items, which are considered to be "of equal value to each other (Sproull, 1995, p. 227), yielding an individual score as well as a team score. The self report contains a self-rating and team rating for each question, as well as an average rating for self and the team, in each of the three categories surveyed.

The scores obtained from individual and team rankings in the survey can be entered as a data set into SPSS for further analysis. The results on the student feedback report are interpreted in a range as: (4 and above) strength, adequate effectiveness (3.0-4.0), and development area (3.0 or lower) (McGourty & De Meuse, 2001, p. 49). Decimals on the student feedback report are rounded to one decimal place. The number of groups from which the data set is constructed is approximately three per class, totaling twelve groups.

Strengths and Limitation of the Rating Scale

The advantage of using a summed rating is that a single score can be derived from several items and that the sums can be rank ordered on the variables (Sproull, 1995, p. 227). Likert-type rating scales have proven to be desirable when estimating characteristics of specific factors such as individual perceptions and attitudes. The limitation or disadvantage of this system is that all raters may rate items of equal value, or possibly in the same way (p. 227). However, as noted previously, this rating scale seems most suitable for surveys involving responses based on attitude and perceptions.

The assessment tool Team Developer is designed to measure three major categories:

Communication, Design Skills, and Teamwork. These three performance measures, or categories of behavior, are deemed essential for effective group work. Categories such as Design-skill behaviors, are composed of items that assess the students' ability to transform an idea into workable solutions. Communication attributes refer to the students' ability to communicate information clearly, both in the written form and orally. Teamwork behaviors focus on abilities pertaining to personal responsibility such as delegating tasks and working cooperatively with others.

Within the Team Developer software, self and team ratings were generated for each of the thirty-six items. The mean team rating represented the rating given to the individual by all of his or her group members. Each of the three categories yielded individual and team mean averages. Thus, self and team rating comparisons could be made for any specific item, or category.

Additional data sets generated from each of the twelve teams in four classes provided thirty-nine individual participant ratings for every team member for all thirty-six items included in the survey. This data set enabled the researcher to readily compare a large number of ratings for any item or, category. In addition to self and peer ratings, ratings from the faculty survey were also be included in the analysis of team behavior. Thus, statistically, more than 1,400 data entries were entered into SPSS and were under consideration. This data set provided the basis for significance of group differences and/or possible associations between any or all of the variables (Sproull, 1995, p. 267).

Data Analysis

Quantitative:

Descriptive statistics were used to examine the results of the ratings. Hypotheses pertaining to the various dimensions of Communication, Design Skills, and Teamwork were analyzed for difference using SPSS. The null hypotheses for research question 3 (a₀, b₀, and c₀) reflects that: There will be no difference in how students rate themselves and how team mates rate each other, and how instructors rate these teams on the dimensions of: (3a₀) Communications, (3b₀) Design Skills, and 3c₀) Teamwork. In research question 4 the hypotheses reflects that: There will be no difference across the three skills dimensions.

Dependent sample t-tests and analysis of variance (ANOVA) addressing these categories examined self, peer, and faculty ratings to determine whether there was significance or individual difference among the means of the groups. Therefore, one person's score, or several groups of scores and means when analyzed, could be predictive of outcomes and/ or perceptions of team effectiveness across each individual attribute in the survey. Thus, the lowest means generated after the analysis could be used to identify deficient areas of performance and provide opportunity for further development and improvement.

Measurement of variation and/or discrepancies in the performance ratings of students in teams would generate results providing evidence (or lack thereof) of congruence between faculty and student perceptions of effective teaming skills. In addition to subject effects, any statistical differences found between attributes within the three dimensions (Communication, Design Skills, and Teamwork) could also be used in later surveys to expand or delete questions depending on their usefulness and value. It should be noted that the faculty survey was identical to the student's electronic survey questionnaire but in hard copy form. There

was also an additional set of questions in the faculty survey designed to probe the technical competency of team behavior based on the teams' overall demonstration of technical knowledge, skills, and abilities.

Qualitative:

Follow-up questions were crafted to probe specific information regarding Team Developer and process (Appendix B). The voluntary mail-in questionnaire was designed to elicit from the students their opinions of the assessment instrument and process, thus adding to the reliability of the study. These questions asked whether the assessment helped the student identify the skills necessary for effective teamwork, communication, and design. The questions are as follows:

- 1.) Did the results of Team Developer help you to identify your strengths and weakness in the area of Communication, Design Skills, and Teamwork?
- 2.) Do you feel the assessment has enhanced your learning of performance skills?

As the main purpose of a formative evaluation is to provide feedback and recommendations, analysis of these questions and any potential comments from the mail-in survey are also be included in the discussion of results in Chapter Five. This information could elicit strategies to facilitate student learning and how might this inform in the offering of the class the following year for on-going program development.

Administration of Team Developer.

Initially, it was intended that Team Developer would be administered at three intervals during the semester at a time convenient for the instructor and students. Typically, the first survey is administered three weeks into the semester, and again during the eighth and 15th week. Students receive their final survey during the last week of the course at the same

time faculty complete their copy of the survey.

However, permission from the Committee for the Protection of Human Subjects to commence the assessment was not received until late March 2002. Therefore, Team Developer was administered once to all 4 of the classes in early April 2002. Ideally, Team Developer should be administered again towards the end of the semester, however, faculty deemed it unnecessary to survey the students a second time. The decision to limit the Team Developer to one survey proved to be an important limitation of the study.

Prior to answering the survey, instructions for filling out the questionnaire were provided to students on the floppy disk. After logging on and navigating through the assessment, the participants ranked items from a list of performance based responses. The subjects evaluated themselves and their team members on the 36 behaviors contained in the survey. With just a keystroke, the survey was completed in approximately fifteen minutes. Students had been asked to check answers from a list of responses ranging from "not at all" to a "very great extent". Participants were given every opportunity to review and revise their selections at any time during the survey process. After completing the ratings, students saved their work before exiting and returned their floppy disks to the instructor. The researcher interpreted the results based on the five-point rating scale, which would be summarized individually in a Student Self Report. After tabulation of data had been completed, the individual self-reports containing self and peer scores were reviewed by the students. Self-ratings on the student report remained confidential to the rater; team members saw their ratings (as evaluated by their peers) only as averages of individual items or attributes, and as averages for each of the three categories.

The feedback report created a "snapshot" of perceptions of how each team member

performed. These reports were returned to the student along with recommendations for improvement in particular areas found to be deficient (McGourty & De Meuse, 2001, p. 49).

Ethical Considerations

Data Handling

The Committee for the Protection of Human Subjects has established procedures, which were followed during the course of this study. Practice, as well as procedure protecting the human subjects follows an ethical practice with informed consent and the right to confidentiality (Appendix C).

Respondents participating in the assessment process were confidential to this researcher. During the information and data analysis process, each respondent's identity was safeguarded and given a random number assigned by the researcher (Appendix D). The descriptive materials (such as personal comments in the essay questions) remain confidential and if used, would be done only with the subject's approval. All descriptions would be reviewed and, or amended to safeguard the individual or team's identity.

Data collected from the participants, such as surveys, floppy disks, interview tapes, and transcripts were kept in a locked drawer in the researchers home during the data analysis. When the study and analysis of the data has concluded, all of the aforementioned items will be kept in a locked drawer in the Engineering faculty office. Other personal memos such as field notes and computer data will be kept in the researcher's home. All notes and data pertaining to this study will be destroyed in five years. It should be emphasized that care and confidentiality of the data were and shall be maintained at all times by this researcher.

Risks and Benefits to the Students

The potential risk for participants in this study was minimal other than the normal risks one would encounter in daily life, and possibly a minimal loss of confidentiality. Statements on the consent form informing the participants of their voluntary participation minimized this risk. While respondents were given every opportunity to ask questions about the research study, none of the students chose to do so.

Administration of the survey was conducted only at the instructors' and students' convenience. Confidential comments by the subjects on the follow-up essay questions were mailed to this researchers home at the end of the semester. It should be noted as the survey data from Team Developer was collected in person, this researcher was available to provide instructions and respond to any student questions or concerns that might arise before or during the survey. The researcher's contact telephone number and email address was also provided to the students to voice any concerns regarding their participation in the study. Though chances were remote that problems resulting in emotional distress could result from this study, additional contact information was provided to the participants to an "on-call" University staff counselor. Students were assured that participation in the survey would not in any way affect their final grade, nor exclude the subject from any class or lab activity.

Several potential benefits of this study outweighed the potential minimal risk to the participants. As the study of interaction skills among engineering students is a relatively new area of research, the results of the study may provide engineering departments engaged in assessment activity, opportunity to reflect, refine, and develop their program as it continues. Additionally, participants may benefit by reviewing and reflecting on their own experience and learning in a positive and supportive setting.

The use of teams has become prevalent in undergraduate engineering programs. Therefore, assessment and feedback on performance measures such as teamwork, communication, and engineering design skills may benefit students by enhancing team performance. Since teams need to develop certain skills to function effectively, this study may suggest that some participants benefit more from the team experience than others do. Therefore, sharing insights and reflecting on outcomes offers the potential for all members to realize growth and development.

Beyond this, the study could extend the research on ABET competencies of engineering students and contribute to informed understanding of factors correlated with retention and improving student learning. In addition, results from the study have the potential to inform and strengthen pedagogy and curriculum when used by engineering faculty as an information tool for continued improvement.

Summary

In thinking about assessment as a way to change culture, Angelo (1999) speaks of *transformative* assessment in which we actively work towards constructing learning communities. He states that "Assessment techniques are of little use unless and until local academic cultures value self-examination, reflection, and continuous improvement" [<http://www.aahe.org/Bulletin/angelomay99.htm>].

Sharing ownership of an assessment plan and instrument among department faculty can be the first step towards the desired culture of improved student learning (Shaeiwitz, 1996). Moreover, research results obtained within the context of a peer feedback program may provide a more definitive understanding of what engineering students are learning and demonstrating in terms of performance skills. Therefore, the methodology chosen to assess

individual performance also offers a new strategy to identify performance skill acquisition and incorporate feedback for further personal development. Using a computer-based feedback survey for assessment may help to make the assessment process feasible, easier to collect, and tabulate.

Since the purpose of this study is to determine whether specific ABET 2000 learning competencies are being met in specified areas, the timely return of results also provides faculty opportunities to reinforce important learning outcomes through feedback. Potentially, achievable goals through self-knowledge may yield evidence of preferred methods of pedagogy, instructor intervention, and favorable conditions that facilitate group esprit de corps.

Additionally, the research questions offer opportunity to provide evidence of perceptions of individual and team performance along three dimensions of Teamwork, Design Skills, and Communication. Therefore, the research questions guiding this study, such as examining congruency between students rating of themselves and the ratings they receive from team members and faculty, raises important relational issues. These issues pertain to how members perceive themselves and each other in teams.

The prevalence of individual competition in American culture may often create barriers to trust and cooperation. Thus, questions examining self, team, and faculty perceptions among the various dimensions may provide useful knowledge to develop cooperative teaming skills. At a recent Frontiers in Education conference held this year of the American Society for Engineering Education and the Institute of Electrical and Electronics Engineers, Inc. (ASEE/IEEE), engineering educators stated that the need to become more globally competitive is reshaping world industry. The implication of this growing trend the

educators maintained, is seen in the reduction of layers of management throughout corporate America, while at the same time, team contributions are becoming more valued.

In conclusion, developing team skills will continue to demand reform in teaching effectiveness and pedagogy, as well as a willingness to take personal risks in order to become capable problem solvers and team members. Whether engineering students perceive equal skill development over the dimensions to be considered in this study, is an interesting question. Ratings on feedback reports could be a wakeup call to greater awareness and responsibility of learning for self-improvement and acquired proficiency. Thus, the predictive value of rating outcomes across the performance measures to be considered could be correlated to team effectiveness. Problems could be detected early, and with active intervention on the part of faculty, remediation in that skill could influence success. The material that follows in Chapter 4 will describe the results and analysis of the research methodology discussed in this chapter.

CHAPTER FOUR

Results

Introduction

This chapter is presented in three sections. The first section describes the data collection process and includes a brief description of the site, the engineering projects, and the number of respondents who contributed data regarding their perceptions of performance attributes in the areas of Communication, Teamwork, and Design Skills.

The second section is a description of the data sets and results of the Team Developer survey data used to answer the research questions (See Chapter 1). Descriptive statistics were used in the analysis of 36 performance attributes contained in the survey. The data analysis includes multiple *t*-tests and analysis of variance (ANOVA) originating from three sources (e.g., self, peer, and faculty ratings). Additional descriptive techniques were used, such as the Scheffé test for post hoc multiple comparisons. Included in this section is a discussion of the research questions as they relate directly to these findings (e.g., Research Questions 1 through 4). Team Developer questions that were found statistically significant are also addressed.

The third section includes the findings from the data collection resulting from the mail-in survey. The findings include student opinions and comments of the Team Developer survey and process. These findings relate to Research Question (5), which elicits students' perceptions of the Team Developer survey and process. The chapter concludes with a summary.

This case study is designed as a formative evaluation to describe student, team, and faculty perceptions of performance attributes. In order to measure perceptions of ABET

performance skills, two sources of data were used to address the research questions. Therefore, the analysis and results of Team Developer and the mail-in survey analysis are discussed under separate headings.

Data Collection

Description of Respondents and Site

The Team Developer respondent pool included 41 students and 4 faculty from engineering classes in a small western private university. The response rate consisted of all 4 professors and 35 students, or 85% of the students. The high response rate from students might be attributed to multiple visits by the researcher, process explanation, and the efficiency of the electronic survey.

The evaluation focused on college engineering students enrolled in the University's freshman laboratory courses. The choice of semester was dependent on participant availability as courses surveyed were offered only once during 2002. Data used in this study were collected during the spring term in 2002. As the initial request to survey students more than one time during the spring semester was deemed by the engineering faculty to be unnecessary, the actual data collection using Team Developer was limited to one event which was the second week in April 2002. The timing was also dictated by when approval was received from the Committee for the Protection of Human Subjects (CPHS).

The second set of data came from students who completed follow-up mail-in surveys, which was received before the semester concluded in May 2002. Completed questionnaires yielded less than a 50% response, although 100% of the respondents in one class returned their surveys. Notably absent were surveys from one entire class.

The sites for the Team Developer survey were two engineering laboratories located on the University campus. The emphasis on computer-aided engineering applications was an integral part of the department's Electrical Engineering (EE) and Industrial and System Engineering (ISE) programs. The innovative laboratory component of the course was intended to complement instruction on theory.

As scheduling tasks were an important part of each team's activity, one of the simplest ways to organize tasks was to use the Gantt chart to list all of the necessary steps involved in managing a design project (See Figure 4.1). Engineering students used the chart because of its simplicity and ease of use; however, instruction in its use was necessary. More complex techniques and planning tools, such as the program evaluation and review technique (PERT) and critical path method (CPM) developed and used by the military, had their origins dating back to early 1950s. However, these methods typically have been too complicated for freshman engineering students to use (Dominick, Demel, Lawbaugh, Freuler, Kinzel, & Fromm, 2001). Shown in Figure 4.1 is an example of a Gantt chart that freshman students might use in a design project.

The Gantt chart has limitations insofar as it does not convey what might happen when there are time delays in the schedule. Nevertheless, the chart could be a helpful tool in assisting students to prioritize tasks and manage their activities. The students in all four classes were instructed in the use of the Gantt chart. The chart included clearly identified activities, time estimates for task completion, and identification of deadlines. The activities were arranged along a timeline indicated by a series of bars showing the scheduled beginning and ending of each task (Dominick et al. 2001).

GANTT CHART - Freshman Design Project Schedule

*Bolted boxes denote projected start and finish dates for each task; Shaded areas denote portion of task that is completed

Typical Gantt chart for freshman design project.

Figure 4.1 Typical Gantt Chart

From *Tools and Tactics of Design*, by Peter G. Dominick, John T. Demel, William M. Lawbaugh, Richard J. Freuler, Gary L. Kinzel and Eli Fromm, p. 102. Copyright 2001 by John Wiley & Sons, Inc. Reprinted with Permission of John Wiley & Sons, Inc.

The initial stage of the design activity was to gather parts from a bin, research the electronic wiring requirements, and begin a computer analysis to validate the feasibility of potential designs. Computers were used throughout the project to prepare technical documentation, including project proposals and final reports.

In this collaborative classroom setting, each team member was expected to do a proportionate share of the work on engineering design projects and develop one's ability to

function on teams. Thus, the relationship between members was crucial to the overall development of the product. In general, shared activities (i.e., research, computer analysis, construction, and understanding the nature of the design's intent) were based on individual expertise and knowledge. Establishing team cohesion was necessary, as each team member would receive the same final grade for his or her specific design project.

Summary of the Team Developer Survey

A framework of ABET performance measures developed through the University of Pittsburgh (Besterfield-Sacre, Shuman, Wolfe, Atman, McGourty, Miller, Olds & Rogers, 2000) helped to facilitate understanding of the performance outcomes survey in Team Developer. This framework provided explicitly stated performance attributes, based on Bloom and Krathwohl's taxonomy. Thus, performance skills could be categorized into specific learning outcomes grouped as knowledge, comprehension, application, analysis, synthesis, evaluation, and valuation. Questions focused specifically in areas of Communication, Design Skills, and Teamwork (See Appendix A). Since many of the questions in the survey instrument were directly applicable to evaluating teamwork in small groups, particularly as it involved first-year students, the same questions from the Team Developer (McGourty & De Meuse, 2001) program were used whenever possible.

Descriptive statistics were used to analyze the data collected. The research data was subjected to a variety of statistical techniques to compute means (M), F -ratios (F), and levels of significance (p). The ANOVA tests found that, of the performance measures under study, Teamwork skills were more likely to show differences in perceptions than Communications Skills or Design Skills, although some questions in the latter two categories showed nominal variance. Since variance and standard deviation "are the most useful measures of variability"

(Ary, Jacobs, & Razavieh, 1990, p. 138), the deviation scores (the difference between the raw scores and the grand means) indicated a statistically significant result on the dimension of Teamwork. The most pronounced differences were found when students and professors were compared ($F = 3.400$; $p = .037$). While these results will be discussed further in the summary, the findings suggest that students' teaming skills need to improve.

Team Developer Results: Related to Research Question 1

In conducting this study, there were several important considerations. One objective was to better understand the perceptions of ABET EC 2000 performance skills among freshmen engineering students. Secondly, if properly designed, the survey instrument could reinforce the value of providing students with developmental knowledge in the identification of skill areas needing improvement.

Research Question 1

Research Question 1 asked what recommendations can be made for future use of the Team Developer assessment tool and process. The feedback reports containing the results of the survey were designed to help the student become more aware of behaviors affecting team performance (McGourty & De Meuse, 2001, p. 49). Results from Team Developer provided students with important benefits including; a) feedback reports informing students of areas of deficiency, and b) important information regarding their performance, as observed by their team members. Results also from the students' mail-in survey confirm that the assessment process was *adequately* effective. Whether actual changes in individual behavior took place resulting from this information is not known. The answer to this question is left for future research.

Recommendations for continuing the use of Team Developer highlights several important considerations; a) the electronic survey provided ease of scoring, b.) scoring criteria provided

rapid feedback on what was required for collaborative teamwork, c) students were able to participate in the assessment process, d) the significance of results in some of the performance indicators may help to explain difference in academic performance, or even attrition out of the program, and e) using the Team Developer Feedback report provided scale interpretation of the results, making it easy for students to evaluate their performance vis a vis the performance of their peers.

Team Developer Results Related to Research Questions 2, 3, and 4.

Prior to any statistical analysis, such as *t*-tests or ANOVA, it was necessary to get the descriptives established for the Team Developer data. These results consisted of the tabulated means for: a) each item by question, b) by overall category such as Communication, Design Skills, and Teamwork, and, c) mean scores by individual, by peers, professors, and teams. Thus, the arithmetic means provided the summary of data for further statistical analysis. With a sample of 39 individuals and 36 items under study, observations exceeded 1,400 data entries. All of the entries were checked twice for accuracy.

Table 4.2, displays the overall cumulative means originating from three sources: self, peer, and faculty ratings. The results, shown in Table 4.2, were the overall means tallied across the three dimensions of Communication, Design Skills, and Teamwork respectively. Table 4.2 summarizes the descriptive means. The interpretation of scores is based on a 5.0 scale noted below.

Table 4.2

Cumulative Means of Students, Teams, and Professors in Performance Categories.

Means	Communication	Design	Teamwork
Individuals	4.03	4.12	4.20
Teams	3.97	4.00	4.20
Professors	3.63	3.70	3.64

Note. Scale interpretation applies to ratings for dimensions and individual items as noted in *The Team Developer: An Assessment and Skill Building Program, Student Guidebook*, by Jack McGourty & Kenneth De Meuse, 2001 (p. 49). Judgments are based on a 5.0 scale. Above 4.0 = Strength; 3.0 - 4.0 = Adequate Effectiveness, and Below 3.0 = Development Area.

As shown in Table 4.2, in the category of Communication, the cumulative means originating from Professors and Teams were 3.63 and 3.97 respectively, indicating *Adequate Effectiveness* as judged by the Team Developer rating scale. The cumulative mean originating from Individual scores in the Communications category was 4.03 and interpreted as *Strength*.

In the category of Design Skills, Professor's mean ratings (3.70) showed *Adequate Effectiveness*. Means of Individuals and Teams indicated adequate effectiveness, 4.12 and 4.00 respectively. In the third category, Teamwork means revealed *Adequate Effectiveness* based on Professor's cumulative average of 3.64. Individual and cumulative Team means in the Teamwork category were 4.20 and 4.20 respectively, indicating *Strength*. It is interesting to note that Professors' ratings of performance skills were lowest across all three categories. Further tests were necessary to examine this discrepancy.

From the preceding tally of cumulative means, *t*-tests were performed to compare means between the groups (e.g., self and peer ratings) on 36 individual items. Tables 4.3 (Communication Skills); Table 4.4 (Design Skills); and Table 4.5 (Teamwork Skills) summarize

descriptive findings as rated by individual, peers, and professors to each of the 36 survey questions (n = 124 observations).

For example, the summary in Table 4.3 describes the means for nine questions relating to Communications Skills. This category represents how well team members communicated with each other. The mean ratings as given by the Professors are ratings of teams only. It was apparent that some difference was shown to exist between the groups. Therefore, further analysis of this data was required to determine the degree of variability between the performance measures. This initial review of Communications Skills data indicated consistently lower ratings among the Professors scores when compared to Self and Peer scores. Moreover, students rated their peers lower than the ratings they gave to themselves.

Table 4.3

Descriptive Results of Individual Items as Rated by Groups: Self, Peers, and Professors in Communication Skills

Category/Question	Number of Observations $n = 124$		
	Self $n = 35$	Peer $n = 78$	Professor $n = 11$
<i>Communication</i>	<i>Mean</i>	<i>Mean</i>	<i>Mean</i>
Q1) Articulates ideas clearly and concisely.	3.89	3.82	3.55
Q2) Clarifies what others have said to ensure understanding.	4.03	3.91	3.36
Q3) Maintains accurate system documents by practicing effective technical writing skills.	3.91	3.91	3.73
Q4) Maintains a project notebook as a means of communication between team members.	3.77	3.74	3.91
Q5) Conveys interest in what others are saying.	4.26	4.18	3.55
Q6) Restates what has been said to show understanding.	4.11	4.08	3.18
Q7) Provides others with constructive feedback.	4.03	3.92	3.73
Q8) Listens attentively to others without interrupting.	4.00	4.04	3.91
Q9) Uses facts to get points across to others.	4.23	4.14	3.73

Note: Questions adapted from: *The Team Developer: An Assessment and Skill Building Program*, by Jack McGourty and Kenneth De Meuse (2001). Published by John Wiley & Sons, Inc. Reprinted by permission of John Wiley & Sons, Inc.

Table 4.4 displays means for the questions relating to Design Skills. The Design Skills questions were associated with skill sets that involve planning and organization of activities. Important skills, such as analytical thinking, required engineering students to look at their design projects from different points of view and apply practical solutions to the problems at hand. Skill sets in this category varied as evidenced by the results. Again, the mean results shown in the table reflect team member self-ratings, ratings of peers, and the professors ratings of the teams.

Table 4.4

Descriptive Results of Individual Items as Rated by Groups: Self, Peers, and Professors in Design Skills

Category/Question	Number of Observations $n = 124$		
	Self $n = 35$	Peer $n = 78$	Professor $n = 11$
	<i>Mean</i>	<i>Mean</i>	<i>Mean</i>
Q10) Plans and controls alternatives of the design and recognizes the need for information gathering.	4.31	4.24	4.00
Q11) Demonstrates an ability to plan projects.	4.29	3.99	3.64
Q12) Applies logic in solving problems and formulates solutions through the evaluation of alternatives.	4.23	4.04	3.82
Q13) Defines the design problem and identifies objectives that will optimize the design solution.	4.23	4.00	3.82
Q14) Establishes tasks for work sessions goals and prioritizes steps important to the design process	4.00	4.94	3.82
Q15) Analyzes problems from different points of view to find the best solution.	4.04	3.88	3.55
Q16) Understands the use of flow charts to represent computer operations	4.03	3.94	3.82
Q17) Documents collection procedures for validation and replication of the design.	3.86	3.82	3.18
Q18) Aware of the need for integrity of the data	4.23	4.17	3.09
Q19) Uses existing theory and methods to solve open-ended design problems.	3.94	3.86	3.55
Q20) Implements fabrication and completion of his or her design task.	4.00	3.96	4.00
Q21) Selects appropriate parts, equipment, test required for the model.	4.29	4.14	4.09

Note: Questions adapted from: *The Team Developer: An Assessment and Skill Building Program*, by Jack McGourty and Kenneth De Meuse (2001).). Published by John Wiley & Sons, Inc. Reprinted by permission of John Wiley & Sons, Inc.

In Table 4.5, descriptive analysis compared the means for questions relating to Teamwork Skills. Skills in this category include attributes such as cooperation, willingness to share information among fellow members, and the extent to which members help and encourage one another.

Table 4.5

Descriptive Results of Individual Items as Rated by Groups: Self, Peers, and Professors in Teamwork Skills

Category/Question	Number of Observations <i>n</i> = 124		
	Self <i>n</i> = 35	Peers <i>n</i> = 78	Professors <i>n</i> = 11
<i>Teamwork</i>	<i>Mean</i>	<i>Mean</i>	<i>Mean</i>
Q22) Reinforces the contributions of others.	4.06	4.03	3.64
Q23) Encourages participation from all involved	4.26	4.21	3.73
Q24) Cooperates with others.	4.40	4.38	3.73
Q25) Shares credit for successes with others.	4.54	4.55	4.18
Q26) Accepts criticism openly and non-defensively.	4.17	4.31	3.45
Q27) Encourages team communication by asking open-ended questions to encourage discussion.	4.03	4.06	3.64
Q28) Works towards solutions and compromises that are acceptable to all.	4.40	4.28	3.82
Q29) Delegates tasks among team members and is willing and able to provide and seek assistance.	4.37	4.23	3.55
Q30) Understands and uses techniques for organizing activities such as the Gantt chart, or other diagrams.	3.66	3.71	3.64
Q31) Assumes personal responsibility as a team member.	4.51	4.37	3.73
Q32) Encourages ideas and opinions even when they differ from his or her own.	4.17	4.24	3.64
Q33) Conveys understanding of other's perspectives through active listening.	4.29	4.29	3.45
Q34) Acknowledges issues that the team needs to confront and resolve.	4.14	4.19	3.36
Q35) Applies principles of conflict management to interaction with others when necessary.	3.71	3.79	3.55
Q36) Identifies behaviors that support team performance.	4.23	4.28	3.45

Note: Questions adapted from: *The Team Developer: An Assessment and Skill Building Program*, by Jack McGourty and Kenneth De Meuse (2001). Published by John Wiley & Sons, Inc. Reprinted by permission of John Wiley & Sons, Inc.

The results displayed in Tables 4.3, 4.4, and 4.5, provide some insight into the ratings given by the respondents to the survey. However, further analysis was required in order to learn whether a statistically significant difference was present among the means. SPSS provided a

variety of statistical techniques to compare differences among the groups and to determine which were the lowest rated subsets among the performance measures. Tests using analysis of variance (ANOVA) provided for the computation of F -ratios and tested for significance among the means of the three groups. Those means that were revealed as statistically significant are shown in Tables 4.6, 4.7, and 4.8 and identified by their category; Communications, Design Skills, and Teamwork respectively. An alpha level of .05 was used for all statistical tests.

Table 4.6 shows the F values, a frequency distribution resulting from ANOVA, and items that revealed significance in Communications Skills. An asterisk identifies the questions that were reported to be statistically significant at the .05 alpha level.

Table 4.6

Analysis of Variance (ANOVA) to Assess the Significance of Difference Among the Means In Communication

Category	F	Sig.	N=124
<i>Communication</i>			
Question:			
Q5. Conveys interest in what others are saying.	2.860	.061	
Q6. Restates what has been said to show understanding.	4.780	.010 *	

* $p < .05$.

Although the results for Question 5; *Conveys interest in what others are saying* ($p = .061$), appear to be relatively small, it does not show meaningful significance. Question 6 however; *Restates what has been said to show understanding*, indicates that respondents' perceptions were generally consistent and revealed significance ($p = .010$). This finding was the only outcome in the Communications category where difference was observed, demonstrating that the ability to promote understanding was perceived differently among the respondents. Of

the remaining eight questions in this category, on average they did not show significance at the .05 alpha level. Table 4.7 provides the ANOVA results for attributes in the category of Design Skills.

Table 4.7

Analysis of Variance (ANOVA) to Assess the Significance of Difference Among the Means in Design Skills

Category: <i>Design Skills</i>	<i>F</i>	<i>Sig.</i>	N=124
Question:			
Q11. Demonstrates an ability to plan projects.	3.092	.049 *	
Q18. Aware of the need for integrity of the data.	7.483	.001 **	

* $p < .05$. ** $p < .01$.

As shown in Table 4.7, two questions revealed significant differences among the means. Question 11 results; *Demonstrates an ability to plan projects*, was found to be significant ($p < .05$), and Question 18; *Aware of the need for integrity of the data*, indicates significance ($p < .01$). With respect to Design Skills, significant differences were found for two of the twelve dimensions. As each of these dimensions was found statistically significant at the 95% and 99% confidence level respectively, there does appear to be differences in how students, peers, and professors perceive skill competency with regard to establishing goals, planning projects, and preserving the data. Individuals tended to rate themselves higher than the ratings given to them by their peers or professors. While a significant (F) ratio indicates that the means are not equal among the attributes tested, further tests are needed to determine how the means differ among and between the groups.

Results from the analysis of variance (ANOVA) among the means in Teamwork are displayed in Table 4.8.

Table 4.8

Analysis of Variance (ANOVA) to Assess the Significance of Differences Among the Means in Teamwork Skills

<i>Category: Teamwork</i>	<i>F</i>	<i>Sig.</i>	<i>N=124</i>
Question:			
Q24. Cooperates with others.	3.206	.044 *	
Q25. Accepts criticism openly and non-defensively.	4.516	.013 *	
Q29. Delegates tasks among team members and is willing and able to provide and seek assistance.	4.575	.012 *	
Q31. Assume personal responsibility as a team member.	4.223	.017 *	
Q33. Conveys understanding of other's perspectives through active listening.	5.313	.006 **	
Q34. Acknowledges issues that the team needs to confront and resolve.	4.355	.015 *	
Q36. Identifies behaviors that support team performance.	4.348	.015 *	

* $p < .05$. ** $p < .01$

A review of the data using ANOVA techniques did unearth statistical differences among the means in each of the three categories surveyed. These differences again related to the respondents' varying perceptions of skill competency. When results in Table 4.8 are compared to results from the preceding tables (4.6 and 4.7), it is worth noting the trend towards an increased number of differences found in observations of Teamwork skills. While these results will be discussed again in the summary, the findings suggest that students' teaming skills may need to improve. Detailed discussion and recommendations regarding the findings will be discussed in Chapter 5. The preceding tables highlight the significant differences found on each of the performance measures. These findings relate directly to Research Question 2.

Research Question 2

Research Question 2 attempted to determine the lowest rated sub-skills in each of the areas of Communication, Design Skills, and Teamwork. Although more than one low rating was

found in each the categories (See Tables 4.6, 4.7 and 4.8), only the lowest rated attributes are reported here. In Communication, (Q6) *Restates what has been said to show understanding* ($F = 2.860, p = .010$); Design skills, (Q11) *Aware of the need for integrity of the data* ($F = 7.483, p = .001$), and Teamwork, (Q33) *Conveys understanding of other's perspectives through active listening* ($F = 5.313, p = .006$). As reported elsewhere, a greater number of statistically significant differences at the .01 and .05 confidence level were found in the ABET (3D) category of Teamwork.

When examining the mean averages among the survey responses, two questions received uniformly lower scores as rated by Self, Team, and Professor's responses (Table 4.5), Question 30: *Understands and uses techniques for organizing activities such as the Gantt chart, or other diagrams*, and Question 35: *Applies principles of conflict management to interaction with others when necessary*.

It was also important to learn how the differences in means varied among the groups, therefore it was necessary to conduct multiple comparisons between and among groups. These data sets are displayed in successive Tables 4.9, 4.10, and 4.11, in each of the categories of Communication, Design Skills, and Teamwork.

Table 4.9

Analysis of Variance for the Category of Communication Skills

Source	SS	df	MS	F	Sig.
Communication Skills		Between Groups			
	1.383	2	.692	1.650	.196
		Within Groups			
	50.711	121	.419		

* $p < .05$

The variance between the means using an ANOVA is the ratio of observed differences between and among groups and is designated as F . According to Ary, Jacobs & Razavieh, 1990) “As variance between groups increases, the F -ratio increases. As variance within increases, the F -ratio decreases” (p. 200). The F values shown in Table 4.8 (Communications Skills), represents the variance between groups ($F = 1.650, p > .05$). No difference was detected among the groups in Communications Skills. See also Tables 4.10 and 4.11 for results in the categories of Design Skills and Teamwork.

Table 4.10

Analysis of Variance for the Category of Design Skills

Source	SS	df	MS	F	$Sig.$
Design Skills	1.522	Between Groups 2	.761	1.977	.143
	46.578	Within Groups 121	.385		

* $p < .05$

In the category of Design Skills, although the F ratio has increased ($F = 1.977, p > .05$) over Communication Skills, no significant difference was evident between and among groups in this category. Similarly, an analysis of variance for the category of Teamwork is shown in Table 4.11.

Table 4.11

Analysis of Variance for the Category of Teamwork

Source	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>Sig.</i>
Teamwork Between Groups	3.138	2	1.569	3.400	.037 *
Within Groups	55.837	121	.461		

* $p < .05$

In the computation shown in Table 4.11, variance is evident for the category of Teamwork. In this performance measure, the ratio is large enough to be statistically significant ($F = 3.40, p < .05$). There was a difference between the ratings of the groups. Further tests were necessary to determine where the means differed.

The findings displayed in Tables 4.9, 4.10, and 4.11 were generated from the one-way ANOVA comparing all of the groups (i.e., students, teams, and professors) across the performance categories. The first F -ratio in Table 4.9 is not significant, and demonstrates that perceptions of Communications effectiveness did not differ among groups. The second F -ratio is also similar. The third F -ratio, which is significant at the .05 level, is based upon the comparison of perceptions of teaming skills between groups and among individuals within the groups. The data infers that perceptions of team effectiveness differed among the groups and is beyond chance expectation ($F = 3.400, p < .05$).

The data generated from the ANOVA was subjected to further analysis using a Scheffé test for Post hoc multiple comparisons. When a significant F -ratio is found, indicating means that are not equal, Post hoc comparisons can be used as a procedure to determine where the means

are different (Sproull, 2002). According to Sproull (2002), with this procedure "all possible comparisons among the means may be made" "The Scheffé is a conservative method and thus safe to use" (p. 286).

In the previous Table (4.11), the computed results from multiple comparisons were shown. Values resulting from the Scheffé test for the first comparison were compared to the computed F values that were found in the previous analysis using only an ANOVA. Breakdowns of means among three groups (Students, Peers, and Professors) are displayed in the next table (4.12).

The Scheffé results shown in Table 4.12 summarize the findings of mean scores among the raters (i.e., Students, Peers, and Professors). The post hoc results summarize the findings of mean scores among the groups (i.e., Students, Peers, and Professors). Professors rated the teams lower ($M = 3.6364$) than student's ratings of themselves ($M = 4.1962$). Students also gave consistently lower ratings to peers ($M = 4.1957$). Teamwork yielded significant results when mean scores among the three groups were compared. Students and Professors perceived teaming skills as less effective than the students' perceptions of their own skills.

Table 4.12

Scheffé ^{a,b} Test Among Groups in Teamwork

Recode to Self And Others	N	Subset for alpha = .05	
		1	2
Professor	11 ^b	3.6364	
Peer	78		4.1957
Student	35		4.1962
Sig.		1.000	

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 22.676.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

The data indicates, at least from a teamwork perspective, that groups vary in their opinions of factors that constitute team effectiveness. The groups shown in Table 4.12 are displayed as aggregates in which all four classes have been combined. The results do not reflect difference by class.

With respect to possible differences among the four classes, additional ANOVA's were performed in which no significant results were found, although one class showed consistently lower mean scores across all three performance measures (i.e., Communication, Design skills, Teamwork). The findings based on class comparisons are shown for each category in the following Tables 4.13, 4.14, and 4.15 (Communication Skills, Design Skills, and Teamwork respectively).

Table 4.13

Scheffé^{a,b} Between Classes A, B, C, and D in Communication

Group	N ^c	Subset for alpha = .05
Mean Communication		
A	37	3.7117
B	20	3.9794
C	40	4.0722
D	27	4.1083
Sig.		.140

Means for groups in homogenous subsets are displayed.

Classes are designated as A, B, C, and D to maintain confidentiality.

- a. Uses Harmonic Mean Sample Size = 28.764.
- b. The group sizes are unequal. The Harmonic Mean of the group size is used. Type I error levels are not guaranteed.
- c. Number of observations.

Table 4.14

Scheffé^{a,b} Results of Means Between Classes A, B, C, and D in Design Skills

Group	N ^c	Subset for alpha = .05
		Mean Design Skills
A	37	3.8018
B	20	4.0708
C	40	4.0958
D	27	4.1049
Sig.		.331

Means for groups in homogenous subsets are displayed.

Classes are designated as A, B, C, and D to maintain confidentiality.

- Uses Harmonic Mean Sample Size = 28.764.
- The group sizes are unequal. The Harmonic Mean of the group size is used. Type I error levels are not guaranteed.
- Number of observations.

Table 4.15

ANOVA Results of Means Between Classes A, B, C, and D in Teamwork

Group	N ^c	Subset for alpha = .05
		Mean Teamwork
A	37	4.0072
B	20	4.1033
C	40	4.1750
D	27	4.3259
Sig.		.387

Means for groups in homogenous subsets are displayed.

Classes are designated as A, B, C, and D to maintain confidentiality.

- Uses Harmonic Mean Sample Size = 28.764.
- The group sizes are unequal. The Harmonic Mean of the group size is used. Type I error levels are not guaranteed.
- Number of observations.

Although the results shown in Tables 4.13, 4.14, and 4.15 indicate variation among the classes, differences between the mean ratings were non-significant ($p < .05$). These findings compared student and peer responses only. However, when comparisons were made between students, peers, and professors, differences were found statistically significant in Teamwork ($p < .05$); (See Tables 4.11, and Table 4.12). Research Questions 3 and 4 were used to probe whether there was congruency among the ratings.

Research Question 3.

Research Question 3 asked if there is there congruency in how students rate themselves, how teammates rate each other, and how instructors rate these teams in the 36 skill-sets surveyed within the categories of Teamwork, Communication and Design Skills. An assumption of this study was that no difference would be found in the ratings between students and professors across the performance skills. This proved to be false.

Interestingly, mean averages as reported by Professors' ratings of performance skills, were the lowest across all three categories. An explanation for this discrepancy may be that team members do not have sufficient experience as freshman in peer interactions to effectively assess teamwork skills, whereas professors may indeed know what is involved in student-to-student interactions and project planning.

Research Question 4.

Research Question 4 asked whether the students perceived equal skill development for themselves in the three ABET areas of Teamwork, Communication, and Design Skills. Skill competencies were varied and mixed in some respects. Self-scores were more favorable than scores given to peers, suggesting that individuals hold higher opinions of themselves than they have of their fellow team members. Inferences from this finding may be interpreted in several

ways; e.g., self-rater bias, or expectations that team members should demonstrate greater participation in the team's activities. Working cooperatively and successfully with others could improve through practice.

The results of this study point to avenues that could be investigated further. First, interaction differences as perceived differently in teaming skills need further analysis. Since a team's ability to demonstrate effective behavior depends on many factors, Team Developer provided students with an opportunity to review and reflect on a range of performance skills considered important to team success. Therefore, the data that represented Communication, Design Skills, and Teamwork outcomes provided a better understanding of skills and behavior coming from one cohort of students. Assessing attitudes with different freshmen would add to this baseline of information.

Results Related to Team Developer Survey Questions

The second part of this summary of results presents findings pertaining to specific Team Developer survey questions. The survey questions provided students and professors with an understanding of characteristics associated with effective teamwork. Questions that probed individual behaviors and were found to exhibit differences (to be statistically significant) are briefly reviewed in the following paragraphs. The questions are based on the descriptive results of individual items as rated by self, peers, and professors regarding team competencies (See Tables 4.3, 4.4, and 4.5). These questions discuss attributes that were in need of improvement and highlight developmental areas, as well.

In the category of Communication Skills, Question 6: *Restates what has been said to show understanding* ($F = 4.780, p = .010$), places emphasis on comprehension. Transferring project information to fellow team members depends upon the individual's competency to deliver

information clearly and accurately. When communication is oral, students must be able to listen and convey interest in what others are saying. Demonstrating understanding and responding to one's team members can also be conveyed through eye contact and body language. Results in Question 6 indicate that student's ability to recall, repeat, or paraphrase key concepts from memory needed improvement. This finding suggests that communication skills may improve if these abilities are applied and practiced.

In the category of Design Skills, differences were found in Questions 11 and 18. Question 11: *Demonstrates an ability to plan projects* ($F = 3.092, p = .049$), and Question 18: *Aware of the need for integrity of the data* ($F = 7.483, p = .001$), suggest that students have some difficulty in organizing their time effectively. Valuing the need for diligent documentation by selecting and documenting specific action plans is important to design success. There were significantly larger numbers of respondents scoring themselves and others lower in these two outcome measures.

In addition, demonstrating an ability to plan projects was dependent on the use of Gantt chart for organizing activities. Weekly reviews with the professors were helpful in discussing corrective action to ensure timely completion of their projects. An aspect of good planning requires shared understandings among team members. In addition, as awareness of the need to preserve integrity of the data was found to have significance, students may not be fully aware of ethical codes, or issues that guide decision-making in the professional practice of engineering.

Questions addressed in the category of Teamwork, measuring the ability to create a team environment, resulted in significant (F) ratios having the largest number of observed differences. Because the computed (F) value was found to be greater than the critical value based on the degrees of freedom, it was found to be significant at the .05 level and beyond chance expectation. The assumption that there would be no difference among the groups in Teamwork is

proved false. The following paragraphs discuss the findings based on the scores of all the respondents.

Question 24: *Cooperates with others* ($F = 3.206, p = .044$), collaboration is predicated on the ability to apply principles of constructive conflict management skills in interactions with others. Findings in this category reveal differences in perceptions of team support and collaboration. This outcome takes into consideration the need and willingness to share responsibilities with other team members and demonstrates commitment to the team's overall goals.

When respondents were asked in Question 26: *Accepts criticism openly and non-defensively* ($F = 4.516, p = .013$), results indicated that basic principles of group development and interpersonal dynamics were underrated in terms of appropriately balancing positive and negative comments. An application of this performance behavior is avoiding judgmental language.

Question 29: *Delegates tasks among team members and is willing and able to provide and seek assistance* ($F = 4.575, p = .012$), the issue again reports difficulty in assigning team member roles and establishing a process for accomplishing tasks. Based on Bloom and Krathwohl's definition, the ability to function on teams is highly dependent on one's comprehension and understanding of what one must *do* to become a full participant in a team project.

Question 31: *Assumes personal responsibility as a team member* ($F = 4.223, p = .017$). This outcome suggests there is low involvement, or synthesis in the knowledge, comprehension, and application of teamwork to be fully involved in the team efforts. This attribute has meaning

for group cohesion, as helping team members create plans for participation involves personal commitment, and extending encouragement to get everyone involved in the process.

Question 33: *Conveys understanding of other's perspectives through active listening* ($F = 5.313, p = .006$). The importance of collaboration in teamwork has been discussed in detail in Chapter 2. Key points in developing any group process are the ability to listen, and being attentive to differences in personal style. The application of active listening also demonstrates the ability to ask questions in order to clarify misunderstandings, as well as take an active interest in what others are saying without interrupting a conversation.

Question 34: *Acknowledges issues that the team needs to confront and resolve* ($F = 4.335, p = .015$), involves the knowledge of what it means to engage in constructive conflict management. The ability to identify underlying issues, construct solutions, and evaluate outcomes so that everyone wins, demonstrates important values such as respect and cooperation. Since this analysis suggests that significant differences exist in the perception of collaboration, it could mean that constructive conflict management could be used to improve the collaborative process.

Similarly, the last question in the Teamwork category, Question 36 states: *Identifies behaviors that support team performance* ($F = 4.348, p = .015$) indicates differences in the perceptions of observed behavior. Attributes that support team performance include respect for differences (whether the difference lies in culture or experience), remaining non-judgmental, and not the least of which, is the enjoyment one receives when interacting with others to reach a goal.

The questions discussed in the previous paragraphs measured observations of performance competencies across each of the categories of Communication, Design Skills, and Teamwork. Through the analysis, a significant difference was found among the respondents in

Teamwork. There is indeed a difference between and among the groups in perceptions of teamwork. In general, students rated their teamwork skills higher than their professor's rating of their skill competency. Teamwork reported the greatest number of skill-set differences among the three ABET dimensions surveyed, with 47% of the questions rated lower in *t*-tests when sub-skill means were compared with the grand means for those behaviors. As the findings suggest, Communication ($p = .196$) and Design Skills ($p = .143$) display no significant difference. Teamwork ($p = .037$) revealed the largest variance. An observation that can be made from the data is that teamwork responses among students appeared to have little correspondence to teaming interactions as perceived by the professors. Another interpretation of the finding is that the results are simply due to chance.

Summary of the Follow-up Survey

Description of the Data

The information contained in the final section is comprised of results from the mail-in survey (Appendix B). This researcher provided a questionnaire along with a stamped self-addressed envelope to each of the professors for distribution to students before the course ended in early May 2002. The respondents had been recorded as having completed the in-class Team Developer survey so that the follow-up questionnaire was intended to solicit the students' overall impressions of the assessment process. Of particular interest to the study was whether students found the student feedback report a motivator for improvement.

Data Results

The results of the mail-in survey consisted of two questions and are presented in Table 4.15. The scores are based on a 5 point Likert scale (ranging from a score of 1 to 5), and represent mean values resulting from the following statements: 1) Not at All 2) To a Limited

Extent, 3) To a Moderate Extent, 4) To a Great Extent, and 5) To a Very Great Extent. As noted previously, completed questionnaires yielded less than a 50% response, although 100% of the respondents in one class returned their surveys. Table 4.16 provides the mean scores in the analysis of the mail-in surveys.

Table 4.16

Students Perceptions of the Survey Process

<i>Question 1</i>	
<i>Did the results of TD help you to identify your strengths and weakness in these areas?</i>	
n	M
15	3.80

<i>Question 2</i>	
<i>Do you feel the assessment has enhanced your learning of performance skills?</i>	
n	M
15 ^a	3.67 ^b

Note: The scale interpretation is based on a 5 point scale: Not at All = 1 to 5 = To a Very Great Extent.

a. Number (n) of students in 3 classes who completed and returned the questionnaires.

b. Mean (M) based on Likert scale.

Data Analysis

Interpretation of the scale indicates that the Team Developer survey process was moderately helpful. The initial goal was to obtain completed surveys from all 35 students who had met the initial criteria, which was to fully complete the Team Developer survey. The proportion of students responding was disappointing, however, as the urgency for returning the survey had been clearly stated to the professors and to the students. Although surveys were

returned from three of the classes, the reason for the non-response from one of the classes was never learned.

The comments included on the survey expressed varied opinions. According to one student whose comments on the assessment process read, "To be honest, this [assessment] should be performed with adults in night school. People our age don't take this seriously. Sorry." This student further stated that the assessment did not enhance the learning of performance skills. Another student expressed the opinion that "a greater scale, or range might more effective in finding problem areas." One statement expressed the belief that the process helped one student "realize all the factors that are expected in group/individual work." Another student concurred by indicating that "TD was good because it helped us notice our strengths and weaknesses and what others thought of us".

Although the survey process tended to be viewed favorably by 29% of the students, 13% found the assessment and process helpful only to a "limited extent" or "not at all". One student stated, "When filling out the questions in the beginning, many did not apply or, were hard to remember." The respondent further stated "I was not paying attention to specific qualities about people", while, another student indicated that "I did not pay attention." As shown in Table 4.16, the majority of students agreed that the results of the process tended to adequately identify their strengths and weakness in specific areas.

The foregoing responses were analyzed by grouping similar themes such as "helpful", "useful" and "enlightening", and noting the patterns that emerged. It was interesting to note that the majority of respondents in the mail-in survey (86%) felt the opportunity for self-discovery was beneficial. Only two of the students raised unfavorable comments of the survey process.

These students referred directly to their lack of personal attention to specific qualities in their teammates as the reason for not finding the process useful.

In general, based on the overall results of the mail-in survey, students held positive impressions that self-awareness of performance skills is beneficial. Self-valuation and desire to improve in areas that were deficient provided a view, or map, to the nature of teamwork as well as behaviors expected of team members during the project process.

The teams in the three classes, in which surveys were returned, held generally positive impressions of the assessment process. Their confidence in the design process was further corroborated by successful completion and demonstration of their design projects to local high schools in the area. The final research question (5) relates specifically to the students' overall perceptions of the Team Developer survey and process.

Research Question 5.

Question 5 asked: what are the perceptions of the process by the students. In general, results of the follow-up survey indicated the process provided useful information by helping students explore their own performance skills as team members. Based on the findings, there are several implications, the first of which is classroom implementation. Some of the students did not feel prepared to answer the questions, as they had not been observing their peers' behaviors. By linking multisource assessment to classroom learning, the process becomes less of an isolated event, but a source for communicating essential course objectives (including personal development).

Second, these perceptions of the process indicate that some pre-survey instruction should be provided. Studies have shown that "information about rating biases provided to the raters ahead of time improves instrument reliability and validity" (Woehr, & Huffcutt, 1994, as cited in

McGourty, et al., 2000, p. F1A-10). McGourty et al., further contend that "Students who are aware of normal biases that can affect their ratings, are more likely to avoid such rating decision errors" (p. F1A-10).

Summary

Descriptive statistics were used to address the 36 questions in the Team Developer survey in order to assess engineering students' experience in three ABET performance areas. The 39 respondents, including professors, received team reports of the summarized results. Positive results from the study indicated that the Team Developer survey and process was seen as beneficial in drawing attention to, and heightening awareness of, effective team behaviors. As such, students' perceptions of the relevance of team skills were modestly augmented through the assessment process.

Evaluating performance skills at the course level can present realistic data of elements that demonstrate mastery or deficiency in particular abilities. As a skill building program, improving performance would be considered successful only if clear action steps for change were undertaken by students in order to meet new objectives. Overall, the findings represent an array of results with a specific sampling group that attest to the value of the survey process. Further, the findings lend support to the value of collaborative group activity.

Given that Teamwork skills were perceived differently among the groups, greater attention should be given to explaining the benefits and outcomes of the assessment process, thereby reducing the propensity to overstate their teaming skills. When teams were compared to professors' overall ratings of team performance, professors held a lower opinion of teaming skills. Additionally, differences found in the ratings among the four classes suggest variance could be due to pedagogical style, or team member assignment. Further research is necessary to

ascertain the reasons for this result. It should be noted that all teams were selectively predetermined by their professors. Fundamentally, the variances revealed in the ratings suggest that effective team collaboration among engineering students has not been fully explored.

As the main objective of the survey was to measure perceptions of specific ABET competencies in Communication, Teamwork, and Design Skills, the findings revealed areas where improvement was needed. Improving student performance in Communication, for instance, is arguably one of the important skills likely to improve team cohesion in the forming and norming of group activity. Social reinforcement in the norming early stages according to the literature is largely subliminal (Napier & Gershenfeld, 1999, p. 114). Having clear expectations and being attentive to behavioral cues reinforces group cohesion. The lower mean scores in Communication skills given by students to their team members could be attributed to behavioral interpretation, lack of verbal exchanges among team members, or the fact that many freshman students have not had communications courses in their general education curriculum.

Teamwork criteria in particular, such as forming a team and taking on collective responsibility, encompass essentials such as personal attitude, climate, and careful planning of their ultimate objective. Among the survey questions, delegating tasks among team members and assuming personal responsibility as a team member was only moderately successful, as perceived by their professors.

While the feedback report provided detection of important strengths and deficiencies, the question of whether there was opportunity to address skill deficiencies cannot be verified since no post survey was conducted. The findings do lend support, however, to the value and benefits of assessment. Addressing issues to improve teaming skills needs further study.

Recommendations resulting from the research will be presented in Chapter 5.

CHAPTER FIVE

Summary of Findings, Implications, Recommendations and Conclusions

Introduction

The case study was designed as a formative evaluation of freshman engineering students to assess the perceived effectiveness of performance skills in a design laboratory environment. The study used performance measures based on criterion proposed by the Accreditation Board of Engineering Technology 2000 (ABET) to assess the level of teamwork. The study also looked at the usefulness of Team Developer, the assessment instrument as a measure ABET skills, and as a feedback tool to facilitate student learning.

The mixed methodology used both quantitative and qualitative approaches to assess students' performance skills and congruency among the respondents, based on individual, team, and faculty perceptions of team effectiveness in three ABET areas: Communications Skills, Design Skills, and Teamwork. The findings of the research were used to address future use of the assessment tool and process. The following is a discussion of the findings and implications for future research.

Summary and Discussion of Findings

Communication Skills

As reported in Chapter 4, the research used statistical techniques to analyze the surveys. Of the nine performance measures in the category of Communications

Skills (ratings based on total number of observations by the respondents; individuals, groups, and professors, $n = 124$), only one item demonstrated significance when means among these *subset skills* were compared. This item was Question 6: *Restates what has been said to show understanding* ($F = 4.780, p = .010$).

Further post hoc tests were conducted to compare means of performance measures *between groups* (i.e., students, peers, and professors), and *within groups* (i.e., students only with peers). The conclusion drawn from the multiple comparisons yielded no statistically significant differences between and within groups based on the Scheffé test ($F = 1.650, p > .05$). However, an interesting aspect of the findings was learning that Communication performance measures were consistently rated lower overall by individuals ($M = 4.03$), teams ($M = 3.97$), and professors ($M = 3.63$), when compared to the cumulative means in Design Skills ($M = 4.12$; $M = 4.00$; $M = 3.70$) and in Teamwork ($M = 4.20$; $M = 4.20$; $M = 3.64$) for the same groups.

It is difficult to ascertain the reasons why Communication Skills were rated lower, although one possible reason could be that professors and students may have had limited access to engage in dialogue. It is not known the extent to which professors and students engaged in interpersonal communication, however, some research suggests that one barrier to communication is the natural tendency individuals have to avoid being judged adversely. Another inference is that some freshman engineering students may not have had communications courses in their general education programs, which may also explain the lower ratings. While it is important to understand the ratings found in Communications Skills, follow-up of these results needs to be integrated into future assessment practices. The results so

far, bear out the conjecture that technical programs may not be providing students with essential non-technical skills (Downing, 2001).

In general, it is of particular interest to learn that observations of communication effectiveness were lower than one would expect. According to the participants' responses as shown by students' self-ratings and the rating given to peers, there is a need to improve communications skills. As discussed in the literature, skills in communication will have an impact on team behavior and ultimately define the relationships within the group (Napier & Gershenfeld, 1999). This is an important finding. Napier and Gershenfeld describe communication as a *skill*, with an emphasis on two parts. The first is "communicating the intention, or desire to *understand* the ideas and feelings of the sender," and second, "understanding and *interpreting* the sender's ideas and feelings" (Johnson & Johnson, 1991, as cited in Napier & Gershenfeld, 1999, p. 52). The perceptions of the respondents with regard to communication skills appear to validate, in a sense, that these group skills need enhancement.

Design Skills

Important skills relating to Design, which are associated with planning, organizing activities, and analytical thinking, require students to look at their project designs from different points of view. The findings described in Chapter 4 revealed significant differences in 2 of the 12 performance measures in Design Skills at both the .05 and .01 alpha level. The two items which demonstrated significance were Q11: *Demonstrates an ability to plan projects* ($F = 3.092, p = .049$) and Q18: *Aware of the need for integrity of the data* ($F = 7.483, p = .001$).

Further post hoc tests conducted to compare means of performance measures between groups (i.e., students, peers, and professors), and within groups (i.e., students only with peers) resulted in a similar conclusion to those found in Communication Skills. No statistically significant differences between and within groups were found in Design Skills ($F = 1.997, p > .05$).

First, with respect to students' abilities in the area of project planning (Q11), planning "is not just about judging whether something is right or wrong. A more important role for project evaluation can be defined in terms of learning and planning for future efforts. Implicit in this learning process is ongoing evaluation and review" (Dominick, Demel, Lawbaugh, Freuler, Kinzel & Fromm, 2001, p. 204). These organizing activities take time; they require the group to review, compromise, and clearly articulate task expectations and responsibilities. There appears to be a need to improve in the area of Design Skills. In particular, understanding and using the Gantt chart for effective project planning and record keeping were identified as performance measures that needed improvement (See Table 4.7). From my personal experience in the aerospace industry, it is vitally important to a design project that team members be able to review plans and tasks. Taking a look at time estimates and prioritizing time for the unexpected is important. Everyone needs to be involved in the decision making process if any of the subtasks need to change.

Second, preserving the integrity of the design data when gathering information "is an integral part in the design process" (Dominick, et al., 2001, p. 20). For instance, design teams need to refer to reference sources such as market trends, physical specification sheets, patents, and reference data. As the students had to

research options for their design and collect parts, it was not clear whether team members kept notes or informed their peers about design changes or decisions. Ideally, as the design develops, specific problems or changes require further iteration and note keeping. Again, it is uncertain whether team members felt it necessary to document every detail of the process. Yet, in order to replicate a sequence of steps, avoid mistakes, and use lessons learned, team members need to rely on accurate notes.

The findings may point to a need for instruction to link the design process to the importance of maintaining a thorough documentation system. From this researcher's eighteen plus years of experience in industry, documentation *is* the language of engineering. Engineering ideas in the form of sketches and notes "is the graphic language used by industry to communicate ideas and plans from the creative design stage, through production, to service and use" (Brown & Kicklighter, 1995, p. 19).

Responses among students and their peers did reveal gaps in their perceptions of performance strengths in Design Skills. However, it could not be determined if this pattern would increase or decrease over time as only one survey was conducted. This factor was a serious limitation that will be discussed in another section of this chapter. This pattern was also true for performance measures in Communication and Teamwork. This topic needs to be explored, perhaps to introduce an assessment strategy that not only focuses on "mediating influences" but on specific performance outcomes (Tittle, Hecht and Moore, 1993, p. 17).

Teamwork Skills

The most interesting finding among the categories was found in measures of Teamwork ($F = 3.04, p < .05$) when all groups were compared (i.e., students, teams, and professors) using similar tests and procedures as previously described. As reported in Chapter 4 (See Tables 4.8, 4.11, and 4.12), significant differences exist between the perceptions of competencies in teaming skills among students and professors. Professors perceived students' teaming skills as less effective than the students' perceptions of their own skills. The actual results showed statistical significance in seven sub-skill attributes critical to successful teamwork ($p < .05$ and $p < .01$). The null hypothesis (3co) in Question 3 that specified that no difference exists in how team mates rate each other and how instructors rate these teams on the dimensions of Teamwork was rejected.

The questions addressed in the category of Teamwork, measuring the ability to create a team environment, resulted in significant (F) ratios having the largest number of observed differences. The assumption that there would be no difference among the groups in Teamwork is proved to false. A brief summary of the questions that revealed significant differences follows. These findings were based on the total number of observations given by all of the participants ($n = 124$).

Question 24: *Cooperates with others* ($F = 3.206, p = .044$). The findings in this category reveal differences in perceptions of team support and collaboration. This outcome takes into consideration the need and willingness to share responsibilities with other team members and demonstrates commitment to the team's overall goals.

Question 26: *Accepts criticism openly and non-defensively* ($F = 4.516, p = .013$). These results indicated that basic principles of group development and interpersonal dynamics were underrated in terms of appropriately balancing positive and negative comments. An application of this performance behavior is avoiding judgmental language.

Question 29: *Delegates tasks among team members and is willing and able to provide and seek assistance* ($F = 4.575, p = .012$). The issue again reports difficulty in assigning team member roles and establishing a process for accomplishing tasks. The ability to function on teams is highly dependent on one's comprehension and understanding of what one must *do* to become a full participant in a team project.

Question 31: *Assumes personal responsibility as a team member* ($F = 4.223, p = .017$). This attribute has meaning for group cohesion, as helping team members create plans for participation involves personal commitment, and extending encouragement to get everyone involved in the process. This outcome suggests there is low involvement, or synthesis in the knowledge, comprehension, and application of teamwork to be fully involved in the team efforts.

Question 33: *Conveys understanding of other's perspectives through active listening* ($F = 5.313, p = .006$). The importance of collaboration in teamwork has been discussed in detail in the review of the literature. Key points in developing any group process are the ability to listen, and being attentive to differences in personal style.

Question 34: *Acknowledges issues that the team needs to confront and resolve* ($F = 4.335, p = .015$). This question involves the knowledge of what it means to

engage in constructive conflict management. The ability to identify underlying issues, construct solutions, and evaluate outcomes so that everyone wins, demonstrates important values such as respect and cooperation. Since this analysis suggests that significant differences exist in the perception of collaboration, it could mean that constructive conflict management could be used to improve the collaborative process.

Similarly, the last question in the Teamwork category, which is:

Question 36: *Identifies behaviors that support team performance* ($F = 4.348, p = .015$) indicates differences in the perceptions of observed behavior. Attributes that support team performance include respect for differences (whether the difference lies in culture or experience), remaining non-judgmental, and not the least of which, is the enjoyment one receives when interacting with others to reach a goal. Teamwork reported the greatest number of skill-set differences among the three ABET dimensions surveyed. Additionally, post hoc tests resulted in the following findings. Among the raters (i.e., Students, Peers, Professors), Professors rated the teams lower ($M = 3.6364$) than ratings students gave themselves ($M = 4.1962$). Students also gave consistently lower ratings to peers ($M = 4.1957$).

It appears that a pattern of higher valuation of teaming skills exists among freshman students when comparing this group with their Professors. Possible inferences could be due to students desire to succeed, fear of failure, competition anxiety, or any number of possible explanations having to do with the ability to fully understand and apply honest performance evaluations. It should be recognized that deficiencies can exist in the assessment process due to the subjective nature of the process and the fact that comparisons among individuals and groups can be an

arbitrary judgment especially when grades matter. Some might argue that freshman engineering students may not have developed the skills necessary to recognize the subtle distinctions between judgements of tasks versus judgement of relationships.

Implicit in this discussion is a concern that students may not adequately know how, or what to assess when evaluating the teaming process. As McGourty and De Meuse (2001) contend - there is an art to giving and receiving feedback, "the process is seldom easy" (p. 26). The key "is to convey the information in such a manner that it is viewed by the member as a *way of giving help*" (p. 27).

Again, from this researcher's personal experience it would seem advantageous to offer mini-sessions to students prior to assessment to reiterate the programs objectives and the student's responsibilities to achieving success in effective performance skills. Thus, a realistic view of evaluation could be established that more closely resembles a real world scenario between management and employee.

To re-think the assessment process, particularly in designing survey questions, the need exists to clarify significant elements students need for effective teamwork. Hawks (1996), in research studies conducted at Brigham Young University, identified essential facilitators of the learning process. Beyond memorizing technical material and working for a grade, students were encouraged *to learn about themselves* "and how they work" (p. 316). Hawks explained that expectations required of students needs to be clearly stated. These expectations included: "Students must be honest with themselves and others," engage in open discussion, make an effort to understand the course objectives, and "must be willing to evaluate their growth" (p. 317). These interpersonal factors may need to be emphasized in pre-survey instructions and

presented to students more emphatically.

Hawks also made the point that his engineering students increased their deep and thoughtful learning when told they had control over their own grades and when they (the students) accepted personal responsibility for their learning. Therefore, an emphasis on the student's role in developing a personal plan for addressing performance deficiencies would address the concerns regarding grades. The emphasis would be on the integrative process of curriculum in the development of human potential. Performance in project teams was not just about the acquisition of technical knowledge, but also learning about oneself. It is apparent that freshman students need help to realistically evaluate their abilities and constructively use the feedback they receive from their peers. Educators might develop a "how to" list of giving and receiving feedback. McGourty and De Meuse (2001) stress the importance viewing feedback as an "opportunity to grow and improve" (p. 28).

To underscore Hawk's point that students need to be "honest with themselves", students in this study (in all performance categories) consistently rated themselves higher than the ratings they gave to peers. Perhaps freshman students need to be reassured that although assessment involves a judgement of behavior, this is not about the person or their grades. As McGourty and De Meuse (2001) contend "... with forethought and planning, feedback can help to build trust among teammates and can lead to rewarding experiences for everyone involved" (p. 26).

In addition, the inability of freshman students to realistically critique themselves is not unique to this University. An important part of engineering education is to teach freshman students to realistically evaluate themselves *before*

they experience real world situations of performance reviews. The need is *to equip freshman students with an honest sense of personal evaluation.*

Moreover, a question also arises whether faculty might directly benefit from professional training designed to enhance their abilities to guide and counsel students. On the one hand, educators are requiring a standard however, including professional training may need to be addressed by engineering departments. By implication, professional development may be necessary for managing group dynamics and human relations. An implication as well as a finding, is that although student centered skills may be the primary focus of the reform movement, staff development may be an important piece of the study.

In summary, while no significant effect was found in the categories of Communication and Design Skills, the category of Teamwork yielded significant results when mean scores among the three groups were compared. There is indeed a difference between and among the groups in perceptions of teamwork. In general, students rated their teamwork skills higher than their professor's rating of their skill competency.

An assumption of this study was that no difference would be found in the ratings between students and professors across the categories. At least in the case of Teamwork, this proved to be false as statistical differences were revealed. Interestingly, these results tend to be inconsistent with surveys conducted elsewhere that demonstrate that "student peer ratings are consistent with overall perceptions of faculty" (McGourty, Dominick & Reilly, 1998, p. 16). Although it is not clear that differences were due to self-rater bias, or simply freshman inexperience with the

process, the need exists to explore this possibility in further research.

Implications for Research

Before proceeding with recommendations for future research, it may be useful to examine the implications of the study and specific areas of concerns that emerged from the findings. The limitations of the study will also be used to inform further research directions. From the outset of the research, it was anticipated that Team Developer would contribute to the engineering assessment literature as the evaluation draws from the experiences of engineering students. Thus, the study adds to a body of literature that only recently has begun to be explored.

Although the findings from the study revealed performance measures that needed improvement, results for the most part indicated *Adequate Effectiveness* based on the cumulative means and Team Developer's 5-point scoring scale. Empirical findings in other research studies support findings that student peer review and feedback can assist students in developing critical evaluation skills and reinforce ABET 2000 outcomes (McGourty, Dominick & Reilly, 1998). In this study, it is uncertain (based on only one survey) whether evaluation skills among the respondents in this study were positively enhanced. Further research is necessary to explore this question.

As discussed by McGourty and others, engineering educators need to increase their attention to evaluation processes that play a role in student outcomes as well as their personal development (McGourty, Dominick, & Reilly, 1998, p. 17). This study contributes to the literature on performance effectiveness through its analysis of performance competencies in such areas as Communication, Design Skills, and

Teamwork. Through the use of Team Developer, the evaluation demonstrates how freshman engineering students and professors can support course objectives and learning outcomes as prescribed by ABET 2000.

The value of the study is further underscored by results found among the performance measures. Based on the participants' responses, it raises concerns that non-technical performance skills among freshman engineering students needs improving. This concern is echoed by many engineering educators, such as Downing (2001) who states, "Although an engineer's primary characteristic is technical competence, the lack of non-technical skills will constrain professional growth" (p. 114).

It becomes apparent that the stakeholders in this effort go beyond the students to include faculty, program administrators, and potential employers. Engineering educators point to the value of providing innovative assessment approaches to facilitate student learning and competency. Therefore, this research adds to a body of literature that seeks to provide a model for such an educational effort. Supporting peer feedback and using assessment instruments, such as Team Developer, demonstrate a methodology that makes it potentially effective for student learning.

Team Developer provided insight into some of the difficulties freshman engineering students' experience in the practice of teaming skills. It also shed light on performance measures that were important to student success, such as communications skills, and the need for student development plans (e.g. a personal action plan focusing on developmental areas) intended to support these areas. As such, the study provided an example of an evaluation process that addressed

observable evidence of learning outcomes among freshman engineering students. By providing an assessment model appropriate for college coursework, the study shows the challenges educators face as they attempt to address important learning outcomes and performance skills linked to ABET 2000. Without consistent and creative approaches to assessment, any attempt for improvement in tradition-based settings will be counterproductive.

Implications of the Study

The case study was designed as a formative evaluation to support an engineering program that utilized cooperative-based approaches to student learning. It was anticipated that the study would contribute to a further understanding of ABET performance competencies among freshman engineering students. Further, the study contributed to practitioner literature that assists faculty in aligning curriculum objectives with workplace practices and needs.

1. The use of student peer review provides educators with essential information related to educational objectives.
2. Incorporating feedback into the learning process enables the student to become actively involved in the learning process.
3. Professors and students need to engage in meaningful dialogue and work on interventions to address deficiencies in performance skills resulting from the students' self-reports.
4. Administering the survey instrument over two or three intervals would allow for multiple comparisons of student performance and provide a baseline for establishing goals, monitoring teams' progress, and meeting objectives.

5. Self and peer feedback offer opportunity to flesh out whether further intervention is necessary to improve student's performance skills

Limitations of the Study

One of the more significant limitations of the study was the restriction to only one survey. A faculty decision had deemed it unnecessary to conduct a second evaluation. As Team Developer was administered during the second week of April (mid-way through the semester), the students may not have been functioning as a team, which could explain the lower scores. Had the students been given another survey towards the end of the semester (once familiarity with their team members had been established) results may have shown they had acquired the skills necessary to function as a team.

Limitations of the study also include issues related to: sample size, representativeness, demographic issues, qualification of data, student input, follow-up, and rater bias. Since this was a purposive sample from a small engineering department in a private university, the number of respondents was limited to 41 and the sample was not homogeneous. It could be argued that in descriptive research, 30 subjects or more are desirable. However, as a case study, the number of respondents may be less important than how the sample is represented in terms of gender.

Apart from the size, the homogeneity of the population was skewed towards male participants. According to education researchers, size alone is no guarantee against bias, as "Representativeness is the most important consideration in selecting a sample" (Ary, Jacobs & Razavieh, 1990, p. 179). The fact is that engineering programs typically have a greater numbers of male students. The researcher can only

speculate that an even gender mix might result in different findings based on the theory that male and female communication patterns differ.

Demographic data were not gathered. In addition to factors such as cognitive and affective learning skills, other influences such as professors' teaching styles, varying student social experiences, and gender or cultural differences may have played a role in some of the teaming interactions. Gender or cultural differences in general, are among the significant barriers that contribute to communications difficulties. It is unclear how these effects may have influenced or explained the performance measures.

Missing data was also a limiting factor in the study. Evaluating the results required *all* of the data. An unanticipated consequence was the fact that one entire class did not return the mail-in surveys, although the request for the mail-in surveys had been requested on several occasions. Nevertheless, the gaps revealed in the respondents' perceptions of performance skills are an interesting finding. This study could not determine whether this pattern would increase or decrease over time as monitoring a team's progress would require several surveys.

One of the advantages of using Team Developer is that peer feedback is intended to have students "react to the peer feedback they receive and to implement improvement efforts" (McGourty, Dominick & Reilly, 1998, p. 14). Although students had the opportunity to express their opinions regarding the Team Developer instrument and process in a follow-up survey, it is not known if students actually used their Self-Reports to plan activities for skill building.

Finally, using the results of Team Developer as suggested by McGourty and

De Meuse (2001), would require the professors and students to review the results, engage in discussion, and develop some sort of working agreement with students to improve performance deficiencies. Making judgments is a complex process in any assessment. It is imperative to explore and refine the methodology. For instance, in a pre-survey discussion, paying greater attention to such issues as the surveys importance may decrease any tendency towards self-rater bias. The rater needs to know how to interpret what is being observed. Based on comments in the follow-up survey, some students had indicated that they "were not paying attention to the behavior of others." These comments suggest that students may not have had ample time for self-reflection and inquiry about the inferences resulting from choices made when answering the survey questions (Lewis, Aldridge, & Swamidass, 1998; Bournier, Hughes, & Bournier, 2001). Nonetheless, the benefits of self and peer assessment focus on development needs, and faculty may find frequent use of assessment and feedback to be a good measure of behavioral change.

It could be argued that engineering students at the freshmen level have limited group experience and may be less reflective judges of teaming skills as compared to more senior engineering students. However, no verification as to the veracity of this assumption can be made, as longitudinal studies using Team Developer have not been conducted at this university. The need exists to add the findings of this study to assessment of higher level coursework in order to understand how students acquire and apply learning.

Implications for Further Research and Recommendations

This study has relevance for both students and faculty in engineering

programs. The study was designed to investigate three ABET performance skills among freshman engineering students and confirmed the value of administering classroom surveys using instruments such as Team Developer. The following sections will discuss the implications for future research, offer a combination of insights and recommendations from this researcher, as well as those gleaned from the participants and the research in each of the performance categories. Some of the recommendations also were derived from limitations that were imposed on the study.

It is clear that further research is necessary to gain insight into the long-term effects peer feedback may have on skills development. Since this research is based on one case study characterized by specific groups, the study has inherent limitations. As the study was conducted at a private University and in a relatively small engineering department trying to be innovative, the need exists to gain a larger perspective of the assessment model over time and with other student populations. Thus, the following insights are offered. Based on the tangible results of the surveys, the Team Developer survey effectively probes specific learning outcomes and performance skills, but the process needs strengthening. More specifically and ideally, Team Developer needs to be administered several times over the course of the semester. The utilization of information from this research offers several reflections such as the following:

1. Long term use of Team Developer could provide institutional data for program improvement and provide baseline data for further studies.
2. The value for assessment on classroom practice is one where the process needs to be fully integrated with the curriculum such as using the results found in the assessment for team development.

3. As the study looked at only groups at the freshman level, further studies using an electronic feedback assessment process are needed to track and monitor engineering students over the course of their undergraduate education.
4. Although pre-survey instructions and protocol were identical in all four classes, and all four classes had been exposed to the same course objectives (design process, and small group settings), means computed from the survey questions were consistently lower in one of the classes (See Tables 4.13, 4.14, and 4.15). The need exists to link additional information to assessment strategies such as students' backgrounds, personal experiences, and/or group motivation, thus affording greater opportunity to explain discrepancies resulting from the analysis.

On Communication Skills

5. Structure and conduct several surveys over time to probe the extent to which students liked working in small groups. Questions probed early in the course may shed light on early forming stages of teams.
6. Research assessment design (e.g. constructing survey questions) that incorporates a variety of formats exploring communication factors that influence team effectiveness, such as leadership, competition, and trust. These factors would provide other valuable insights.
7. Strengthen opportunities for dialogue between student and professors (e.g., developing working agreements). Dialogue involves "a set of arrangements having certain rules, norms and regularity to it" and should be an ongoing process (Napier & Gershenfeld, 1999, p. 22). Further research into assessment design could explore ways to maximize teacher-student collaboration, an important aspect shaping team

behavior.

8. Assess and review team results early in the forming stages of teams. This is the stage in which discomforts surface and feelings of trust impact goal setting activities.

Thus, observations made during this phase could reveal potential communication difficulties and addressed through coaching and support.

9. Raise awareness of effective communication. Communication and dialogue, as advocated by Senge (1990), is an enabling strategy intended to promote a learning community. Napier and Gershenfeld (1999) describe communication as comprised of two elements: "the content aspect and the relationship aspect" (p. 22). Since some of the communication and interaction exists outside of the group's awareness, a successful assessment may be to design questions that raise awareness of the elements of effective communication.

10. Corrective action for deficiencies found in Communications performance measures could include: a) short lab sessions to explore individual project experiences with other teams in class; b) oral presentations to strengthen speaking and listening skills (e.g., restating what others have said to ensure understanding builds on two fundamental roles in communication- the *active listener* and *influencer* role); and c) sharing lessons learned (e.g., problems encountered during the research period, such as organizing and working with others). Thus, communication lays the foundation for the creation of a friendlier environment.

11. Stress the two fundamental roles in communication, which help to create a team environment. The first is the *active listener* role, which places emphasis on listening skills to improve understanding and reduce conflict. Second, is the *influencer role* in

which his or her viewpoint is expressed in a manner that wins support from others (McGourty & De Meuse, 2001, p. 16).

On Design Skills

12. Explore ways to promote and develop collaborative activities for technical demands. For instance, actively using organizing tools such as the Gantt chart is highly supported as it promotes skills associated with planning, organizing activities, and analytical thinking. Provide opportunity for students to use the tool interactively, as one of the benefits of the Gantt chart is seeing options from different points of view.

13. Develop and ensure that an awareness to preserve the integrity of the data "is an integral part in the design process" (Dominick, et al., 2001, p. 20). Findings revealing significance in this area ($p < .01$) place value on its importance in design activities.

14. Consider providing training or video topics with respect to project planning. Dominick et al. (2001) pointed out that project planning "is not just about judging whether something is right or wrong. A more important role for project evaluation can be defined in terms of learning and planning for future efforts. Implicit in the learning process is ongoing evaluation and review" (p. 204). As noted previously, organizing activities takes time; they require the group to review, compromise, and articulate clear explanations of task responsibilities. Training tapes would provide excellent and useful resource material in developing this skill.

15. Strengthen teaming skills by providing students with handouts on effective team performance. Conduct weekly question/answer sessions to test how team members effectively organize and manage their time, coordinate their schedules, and plan their

projects as team members. The use of Team Developer should be continued to reinforce these team behaviors.

On Teamwork Skills

16. Establish a two-part process to support continuous improvement. The first part would consist of a pre-course briefing, survey, and interview in the early weeks of the course to establish a baseline of data regarding the extent of students' teaming skills. Secondly, the briefing on group work would include elements of effective teamwork (e.g. handouts on the value of cooperation; how to accept criticism non-defensively; and how to identify behaviors that support team performance).

17. Consider a post-course survey of questions based on acquired project-based performance skills, attitudes, and course objectives. This survey could also test the efficacy of the feedback reports. As discussed previously, it may be important for students to have more time before the actual survey in order to discuss the implications of the feedback process and its use as a tool for personal development.

18. Professional development for faculty to insure successful implementation of student's teaming skills. Consider faculty preparation by providing teamwork training and build the capacity among professors to facilitate performance skills. Engineering professors may need additional support and training in group dynamics, communications skills, and teamwork to effectively provide feedback counseling to their students.

Future use of the Assessment Tool and Process

The basic question posed in the study was the future use of the assessment tool and process. As previously noted, it is recommended to continue using Team

Developer, but strengthen the process through the administration of several surveys and using the results of assessment for team development. Several important themes are worth noting. Although the survey proved enlightening to students, some expressed ambivalence towards the assessment process. Professors should stress the value of the instrument as a tool to further personal development.

Future research into assessment design might also consider adding components to the survey protocol, such as information that could inform personal development. That is, how will inferences drawn from the results be used to assuage anxiety, or disappointment drawn from a particular context in the student's self-reports? Students may need to assimilate the idea that teams do not automatically form, but evolve (McGourty & De Meuse, 2001).

The following recommendations based on findings resulting from the study support the continued use of Team Developer as a multisource feedback model.

1. Summaries of effective performance measures may assist students in clarifying their performance deficiencies and strengths. This may be problematic for faculty, since it requires a shift in thinking that redefines the use of assessment as a learning tool versus an evaluative tool. Students should be encouraged to use their feedback report to define precise action steps taken to "determine whether they have met, exceeded, or fallen below [their] objectives" (McGourty & De Meuse, 2001, p. 60).
2. Follow-up with corrective feedback based on students' self-reports (e.g., through discussion). In thinking about Eisenberg and Goodall's (1997) definition of feedback as a "collection of processes that interacts over time" (p. 101), the implication for practice as noted previously, is that there may be no substitution for ongoing

assessment. To truly reap the benefits of corrective feedback, subsequent follow-up to assessment is highly recommended.

3. Build into the survey process *feedback loops*. Past research and practice indicates that feedback loops are more likely to reveal detailed explanations for negative patterns that arise among group interactions. As such, feedback loops designed into evaluation add to organizational learning and produce "actionable knowledge" (Argyris, 1993, p. 250.) In other words, successive feedback loops and self-correcting procedures, such as working agreements, should be applied and tested over time. Again, several assessments over the duration of a semester would provide a broader view of individual and group progress. This would add depth when exploring the subtleties of team dynamics.

4. Develop a plan. McGourty and De Meuse (2001) strongly contend that performance can lead to improvement provided action steps are specifically defined into a student's personal development plan (See Item 5 below). Perhaps the most controversial implication for assessment practice is the tendency among some educators to place the students' goals and personal development second to course activities. According to the research, developing the plan and engaging in subsequent follow-up by the Professor takes time. Part of the problem educators face is that assessment places a considerable burden on the professor. Not only must they fulfill course requirements, but also self and peer assessments require mentoring and mediation practices which may make faculty uncomfortable. Monitoring the team's progress is essential.

5. Use lessons learned from the survey to probe other performance skills. For

example, the survey could be expanded to include other ABET 2000 performance requirements.

6. Expand the use of the assessment instrument to include other endeavors, not only what students know, but also their values, attitudes, and learning styles - all of which can lead to or impede learning. Thus, assessment practice can focus on outcomes, both curricular and personal.

7. Results from Team Developer need further examination. Based on the findings, new exploratory survey questions could flush out whether low scores given to team members in specified areas were the result of *passengers* who did not fully participate in the teams' activities, or some other reason.

Improving the Process

8. Use team teaching. Utilize more advanced students as mentors who have been through the introductory design course. Benefits would provide students with teaching *and* learning experiences that may lead to a set of best practices in collaborative activity.

9. Include other assessment instruments. The use of other surveys (e.g., Myer-Briggs Type Indicator) could expand the number of variables. Surveys that identify non-technical skills, such as learning styles, could inform professors of students' preferred methods of learning. In addition to technical competency, integrating psychological constructs would enable professors and students to examine not only: a) "self-regulatory skills," such as cognitive processes, but b) "affective" beliefs that include values, interest, confidence, and anxiety (Tittle, Hecht, & Moore, 1993, p. 14-15).

10. Expand the assessment information. For instance, data could also include: a)

levels of satisfaction while working within groups, b) feedback on the contributions of others, c) personal learning styles and d) maturity levels.

11. Extend the future database of information to include longitudinal studies. These studies would provide a benchmark to monitor progress.

12. Explore how gender and cultural differences affect performance skills. Further research into these topics may yield rich information regarding their impact on teaming interactions. Additionally, how do gender differences influence skill performance in the use of hand tools, leadership styles, and most importantly, ethical considerations? The latter consideration is based on the need to be socially responsive, not only to others, but to the environment as well.

13. Promote weekly reviews and self-evaluations by students. The use of a journal or diary could highlight any discrepancies between personal and team goals during the project process.

14. Use opportunities for creative pedagogical techniques, such as the use of video taping to focus attention on personal development and skill building.

15. Provide training modules to improve performance skills in the classroom as well as for home use. The training modules could contain information on teaming skills, writing technical reports, oral communication, and using organizational tools such as the Gantt chart.

Conclusions

In general, findings from the study called attention to the notion that: a) assessment is a learning process, which is a focus on group process, b) individual mastery must be viewed in conjunction with group goals, c) students and their

professors need involvement and commitment to the teaming process, d) working with others demands a two-way communication extending beyond the course content to reflective and constructive dialogue about performance behaviors, e) sufficient reflection and discussion is needed prior to any survey to insure a full and honest appraisal of performance behaviors, and f) review and follow-up assessments with self-correcting feedback loops in order to monitor the teams' progress and development of a personal action plan.

The documentation of performance competencies is of critical importance for several reasons. Information gathering is necessary to acquire baseline data for future accreditation processes, as well as to substantiate ABET's requirements. The real value of any assessment process is more than data collection. Does the process address questions as to what is truly valued by human beings (e.g., differences and cultures)? Group interactions are only a small part of this complex mosaic and are difficult dynamics to measure. Technical skills have always drawn greater attention, in traditionally taught engineering courses, yet to be effective, working with others is also a skill that can be improved with practice.

Drawing from personal experience as an engineer in industry, I have discovered teams sometimes work well and sometimes they do not. Teaming skills are not discretionary competencies but a mandatory part of a highly skilled workforce. As educators, we cannot ignore the barriers to effective teaming that often surface in group work such as demographic and experiential differences. Cultural and language barriers to communication pose particular challenges when attitudes may undermine the building of relationships. Moreover, resistance to change is far more

common when human interaction becomes exclusive rather than inclusive. As educators, clearly defining performance objectives for our students is an important part of pedagogy; however, it is not just an academic exercise. Students must be helped to understand, appreciate the value of teaming at the skill level.

Overall, the study provided insight into how engineering students and their professors perceive observable performance behaviors. Interestingly, the discrepancies found among the results of students, teams, and professors ratings revealed differences in judging team skills. There could be several explanations. The professors may have higher aspirations than their students, and as suggested in the literature:

"... when a group confronts a series of alternatives ranging from easy to difficult and selects one, this is referred to as the group's *aspiration* level. Performance above this level will be considered successful; performance below this level failure. The level of aspiration will influence members' self-evaluation, group activities, attractiveness of membership, and subsequent group cohesiveness" (Waung, MacNeil, and Vance, 1995; Atkinson and Feather, 1966, as cited in Napier & Gershenfeld, 1999, p. 185).

Another inference may be that of selective perception (Napier & Gershenfeld, 1999). The relationship between student learning and pedagogical practice is clearly a multi-faceted and complex relationship. How individuals perceive themselves and others, according to the authors, is such that even with respect to the most objective tasks, "it is nearly impossible to keep our subjective views from altering our perception of what really exists" (p. 3). Another insight posited by the authors is the

effect of change individuals experience when they join a group:

"It seems that in a group, people's individuality – the sum of qualities that characterize and distinguish them from all others – somehow becomes warped, unsettled, and distorted. Factors operate, in both the group and the members that distract and/or subtract from their individuality" (p. 5).

The prevailing emotion, according to the authors, is anxiety and uncertainty. It is not surprising that perceptions will differ among participants in any study. From the vast amount of literature on assessment activity, techniques vary widely. Yet, the need to understand students' perceptions of their classroom experience is crucial in order to foster a realistic view of what students can expect in the workplace. This task places enormous burdens on faculty to design, administer, and evaluate assessment and feedback. Nevertheless, using assessment informs the professors as to what students have learned, and when used as a means to improve learning, can predict their future success. These are all reasons for promoting its usefulness.

As reported in this study, cooperative learning in small groups has been found to have distinct advantages for assessment practices, particularly in areas such as teamwork and hands-on projects. However, this alone is only part of the assessment process. Faculty members may need to promote the *practice and reflection* of teaming skills, in order to transform students from groups of individuals into effective teams. Educators should keep an eye on the results as corroborative evidence found at other universities suggests that students *need help* in becoming effective team members.

In conclusion, enabling performance skills among engineering students has been shown to be an essential segment of engineering curriculum reform. The goal to prepare students to become effective team members is to give voice to an acculturation process that supports relationship and sharing. Weiss (1993) as cited in Davis and Masten (1996) described effective teams as having the following characteristics:

- "A sense of commitment,
- A high degree of communication,
- A healthy degree of disagreement,
- Creativity,
- Agreement through consensus, and
- A sense of empowerment" (p. 277).

Enabling performance skills among engineering students through assessment and feedback requires the collective efforts of educators and students in dialogue. According to Senge (1990), Argyris and Schon (1978), and others, the importance of communication is not only vital to the learning process, but connects people in so many ways.

"It is our conviction that quality dialogue – in which individuals are respectful of the validity of others' lived experiences and mindful of the constructed natures of our own studies – is the cornerstone of our future. Without such dialogue and the community it inspires, all talk of diversity, cooperation, and ecology will be for naught" (Eisenberg & Goodall, Jr., 1993, p. 339).

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APPENDIX A

Survey Questions Adapted from:
The Team Developer: An Assessment and Skill Building Program
By Jack McGourty and Kenneth P. De Meuse, 2001.

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Survey Questions Adapted from:
The Team Developer: An Assessment and Skill Building Program
 By Jack McGourty and Kenneth P. De Meuse (2001).

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Category	<u>Question</u>
Communication	Q1) Articulates ideas clearly and concisely. Q2) Clarifies what others have said to ensure understanding. Q3) Maintains accurate system documents by practicing effective technical writing skills. Q4) Maintains a project notebook as a means of communication between team members. Q5) Conveys interest in what others are saying. Q6) Restates what has been said to show understanding. Q7) Provides others with constructive feedback. Q8) Listens attentively to others without interrupting. Q9) Uses facts to get points across to others.
Design Skills	Q10) Plans and controls alternatives of the design and recognizes the need for information gathering. Q11) Demonstrates an ability to plan projects. Q12) Applies logic in solving problems and formulates solutions through the evaluation of alternatives. Q13) Defines the design problem and identifies objectives that will optimize the design solution. Q14) Establishes tasks for work sessions goals and prioritizes steps important to the design process. Q15) Analyzes problems from different points of view to find the Best solution. Q16) Understands the use of flow charts to represent computer operations. Q17) Documents collection procedures for validation and replication of the design. Q18) Aware of the need for integrity of the data Q19) Uses existing theory and methods to solve open-ended design problems. Q20) Implements fabrication and completion of his or her design

Team Work	<p>task.</p> <p>Q21) Selects appropriate parts, equipment, test apparatus required for the model.</p> <p>Q22) Reinforces the contributions of others.</p> <p>Q23) Encourages participation from all involved and works as a team.</p> <p>Q24) Cooperates with others.</p> <p>Q25) Shares credit for successes with others.</p> <p>Q26) Accepts criticism openly and non-defensively.</p> <p>Q27) Encourages team communication by asking open-ended questions to encourage discussion.</p> <p>Q28) Works towards solutions and compromises that are acceptable to all.</p> <p>Q29) Delegates tasks among team members and is willing and able to provide and seek assistance.</p> <p>Q30) Understands and uses techniques for organizing activities such as the Gantt chart, or other diagrams.</p> <p>Q31) Assumes personal responsibility as a team member</p> <p>Q32) Encourages ideas and opinions even when they differ from his or her own.</p> <p>Q33) Conveys understanding of other's perspectives through active listening.</p> <p>Q34) Acknowledges issues that the team needs to confront and resolve.</p> <p>Q35) Applies principles of conflict management to interaction with others when necessary.</p> <p>Q36) Identifies behaviors that support team performance.</p>
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APPENDIX B

Follow-up Survey Questions

Follow-up Survey Questions

Your reply would be valued and appreciated! Attached is a pre-addressed and stamped envelope to facilitate the mailing of your response. Just mark the reply that matches your impression of the survey. Thanks so much!

The purpose of the Team Developer (TD) survey is to help you identify the skills necessary for effectiveness in design, communication and teamwork.

Check the answer which best describes your view of the assessment.

1.) Did the results of TD help you to identify your strengths and weakness in these areas?

1	2	3	4	5
Not at All	To a Limited Extent	To a Moderate Extent	To a Great Extent	To a Very Great Extent

2.) Do you feel the assessment has enhanced your learning of performance skills?

1	2	3	4	5
Not at All	To a Limited Extent	To a Moderate Extent	To a Great Extent	To a Very Great Extent

Comments:

APPENDIX C

Student Informed Consent Form

Informed Consent Form

1. Since the purpose of the study is to understand small group interactions given peer feedback, the research study will examine whether the predictive value of assessment when linked to the learning process influences learning outcomes.
2. The purpose of this exercise will involve participants in a student survey using the Team Developer Assessment and Skill Building Program.
2. A short essay questionnaire will also be included as a follow-up to the survey.
3. There are no risks anticipated as a result of participation in the survey beyond a possible mild fatigue.
4. Participation in the study may, or may not be a benefit. The benefit may be that the feedback provided to the participant will contribute to personal growth and development.
5. Participation is completely voluntary and withdrawal from the study may be exercised at any time without any effect to grade or exclusion from classroom activity. Data collected prior to withdrawal will not be used and destroyed.
6. Opportunity will be given to ask questions of two contact persons, the researcher and faculty member listed below whose phone numbers and e-mail address will be provided if additional help or information is needed.. In addition, a University staff counselor can be reached at 260-4655.
7. There will be an opportunity to review and revise any of the responses after logging on to Team Developer. The survey should not take more than 20 minutes to complete.
8. The identity of the participants will be kept confidential. Unless specifically requested all field notes, drafts as well as final report used in the study will be given a randomly assigned number.
9. Storage of the floppy's used in the survey and hard copy essays will be kept in a locked cabinet in the engineering department office. Destruction of all data will occur after five years.
10. Two consent forms will be provided to the participants, one to sign and return, the other to be kept by the participant for future reference.
11. There is no agreement, written or verbal, beyond that expressed in this consent form.

I, the undersigned, understand the above explanations and, on that basis, I give my consent to my voluntary participation in this research study.

Signature of Subject

Date

Location

Signature of Principle Researcher

Date

APPENDIX D

Disk Labeling Diagram (To Insure Participant Confidentially)

Disk Labeling Diagram for TD Survey

NOTE:

- *Each student uses their pre-selected random number and personal password to access the survey.
- **Lab and team number labeled on disk.

- Teams made up of 3 or 4 members.
- Each student receives a floppy containing the survey
- Each Lab section labeled on disk.