ONE MORE THING: FACULTY RESPONSE TO INCREASED EMPHASIS ON PROJECT TEAMS IN UNDERGRADUATE ENGINEERING EDUCATION

by

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ABSTRACT

Tenured and tenure-track faculty members at institutions of higher education, especially those at Research I institutions, are being asked to do more than ever before. With rapidly changing technology, significant decreases in public funding, the shift toward privately funded research, and the ever increasing expectations of students for an education that adequately prepares them for professional careers, engineering faculty are particularly challenged by the escalating demands on their time. In 1996, the primary accreditation organization for engineering programs (ABET) adopted new criteria that required, among other things, engineering programs to teach students to function on multidisciplinary teams and to communicate effectively. In response, most engineering programs utilize project teams as a strategy for teaching these skills. The purpose of this qualitative study of tenured and tenure track engineering faculty at a Research I institution in the southwestern United States was to explore the variety of ways in which the engineering faculty responded to the demands placed upon them as a result of the increased emphasis on project teams in undergraduate engineering education. Social role theory and organizational climate theory guided the study. Some faculty viewed project teams as an opportunity for students to learn important professional skills and to benefit from collaborative learning but many questioned the importance and feasibility of teaching teamwork skills and had concerns about taking time away from other essential fundamental material such as mathematics, basic sciences and engineering sciences. Although the administration of the College of Engineering articulated strong support for the use of project teams in undergraduate

education, the prevailing climate did little to promote significant efforts related to effective utilization of project teams. Too often, faculty were unwilling to commit sufficient time or effort to make project teamwork a truly valuable learning opportunity because those efforts were not perceived to be valuable and were rarely rewarded. Few formal professional development opportunities were available and few incentives were in place to encourage other informal efforts to develop the necessary skills. Those who committed significant effort to project teams were challenged by concerns about team composition, student accountability and assigning individual grades for group teamwork.

CHAPTER I: INTRODUCTION

"Alphabetically," the senior engineering faculty member responded defiantly when asked about his strategy for forming project teams. Weekly faculty meetings for the Introduction to Engineering course were often monopolized by conversations about the challenges of dealing with student teams. But this seasoned professor had little interest in a discussion related to teamwork or any other "soft" skill. Given the wealth of evidence indicating that faculty members play a vital role in facilitating teamwork in an academic setting, his attitude was rather curious and provided the impetus for this study.

Tenured and tenure-track faculty members at institutions of higher education, especially those at Research I institutions, are being asked to do more than ever before. With rapidly changing technology, significant decreases in public funding for higher education, the shift toward privately funded research, and the ever increasing expectations of students for an education that adequately prepares them for professional careers, engineering faculty are particularly challenged by the escalating demands on their time. The undergraduate engineering curriculum has traditionally been packed with a very heavy load of highly technical engineering- specific courses in addition to extensive math and basic sciences courses. Administrators of Colleges of Engineering sometimes find it difficult to staff all of the required courses for their undergraduate student population. In recent years, most companies and corporations have expressed a desire to hire graduates that have important professional skills such as the ability to function on multidisciplinary teams and the ability to communicate effectively. The foremost accreditation organization for engineering programs, ABET, Inc., has responded

by adding accreditation criteria requiring undergraduate engineering programs to demonstrate that their students have these skills. Specifically, Criterion 3 Program Outcomes states “Engineering programs must demonstrate that their students attain the following outcomes: (d) an ability to function on multidisciplinary teams … (g) an ability to communicate effectively” (ABET, 2009). Thus, the emphasis on teamwork in undergraduate engineering curricula has heightened considerably.

Given that most engineering faculty members at Research I institutions have significant research programs in addition to their teaching loads, these added responsibilities represent a burden that some engineering professors find taxing. Research indicates that some faculty members question the importance and feasibility of teaching teamwork skills and have legitimate concerns about taking time away from teaching other essential fundamental material such as mathematics, basic sciences and engineering sciences. Other professors find value in these skills but are not particularly comfortable with the responsibility of teaching teamwork skills having little firsthand experience working on or managing teams. Some faculty members, on the other hand, embrace the requirement and derive satisfaction from teaching teamwork skills to students who are preparing for professional careers as engineers. In most cases, important factors, such as organizational climate and individual background characteristics, influence the response of faculty to the increased emphasis on project teams in undergraduate engineering (Colbeck, Campbell & Bjorklund, 2000, Rotfeld, 1998).

Research Problem

While the career of a professor seems enviable to some who view it as six or seven years of intensity followed by years of blissful autonomy, many fail to recognize the significant demands that are placed on professors throughout their careers. Most tenured and tenure-track are expected to wear many hats including scholar, instructor, mentor, researcher, advisor, service provider, entrepreneur and consultant. The demands on faculty, specifically engineering faculty, continue to expand as they are expected to help students develop professional skills such as effective teamwork and communication skills. In recent years, the need to develop students' professional skills has become more evident. In fact, in a study of prospective employers who were asked to assess the importance of 23 characteristics of entry-level employees, team-building skill was the top-ranked skill (Motiff, 2003). In response to these demands, accreditation organizations and program administrators have placed formal requirements on engineering faculty to teach students to work effectively on teams.

While the importance of teamwork and effective communication cannot be denied, many faculty members find it challenging to teach these skills for a number reasons. Some instructors may rise to the challenge and find creative and innovative ways to utilize project teams in their courses. However, some faculty, particularly tenured faculty, who have spent most of their careers in college or university settings, have little or no personal experience working on or managing teams (Colbeck, Campbell & Bjorklund, 2000) and may not be as receptive to the task as others. With the significant demands on their time, many professors cannot or will not devote time to learning new

methods needed in order to effectively teach these skills (Rotfeld, 1998). In addition, the motivation for faculty to invest time to develop these skills may be limited as reward structures continue to focus on research over teaching (Fairweather, 1993, Milem, Berger & Dey, 2000). Also, many faculty are concerned about the difficulty of fairly and effectively evaluating student work in teams. Lastly, engineering curricula are typically overcrowded with little room to incorporate additional material. Thus, while numerous factors provide ample motivation for incorporating project teams into engineering curriculum, faculty sometimes have insufficient skills and may be reluctant to devote the necessary time and effort to develop the skills needed to effectively teach teamwork to their undergraduate students. Thus the problem is as follows: members of industry have emphatically stated that teamwork is important; students, in order to maximize their employability, have expressed their desire for teamwork experiences in their undergraduate curriculum; ABET has responded by incorporating a criterion requiring undergraduate engineering programs to demonstrate that their students have the ability to work effectively in teams; college administrators, in response to ABET requirements as well as the demands of students and their industry constituents, have committed to providing these experiences and they, in turn, expect their faculty to deliver. While most faculty members wish to satisfy these demands, many have a wide array of other responsibilities, so teaching students to work effectively in teams and dealing with the problems associated with student teams can be a burden. Faculty must weigh the time and effort required against the benefits of providing these experiences for students, particularly when other essential activities are impacted.

Relevance of Study

While this study is intended to inform those involved in the engineering profession, the results may also encourage those in other disciplines to investigate the expectations that are placed on their faculty members as well. The accreditation criteria established by ABET for engineering programs are developed by a wide variety of representatives from academia and industry. In some instances, the criteria have shifted from the traditional engineering curriculum into areas that are unfamiliar and outside the comfort zone of many faculty members. One such area is the emphasis on project teams. This shift toward non-technical areas presents difficulties for many faculty members. Understanding the faculty perspective regarding the emphasis on project teams in undergraduate engineering education is important to many audiences. First, engineering faculty may find comfort in knowing that others find the shift in emphasis challenging and they may benefit from the knowledge and experience of their colleagues who have mastered the art of working with project teams in an educational setting.

The findings may inform administrators in colleges of engineering about creative and innovative ways in which some faculty teach students to work effectively in teams. Also, administrators may gain insights into the problems that these expanding requirements present to some faculty and may be inspired to create faculty development programs suitable for those faculty who struggle with managing student project teams. Lastly, the members of the accreditation organization for engineering programs may become more sensitive to the realities of the workload challenges that engineering faculty

face and may be motivated to continually assess the impact of additional requirements on engineering faculty.

In addition to the engineering community, a wider audience may benefit from the findings of this study. While this study focused on a specific field (Engineering) at a single type of institution of higher education (Research I Public University), the results may be of interest to those in other fields and institutions as well. As traditional sources of funding decline and the needs of prospective employers shift, the activities at institutions of higher education are transforming. Many professors at a wide variety of institutions are being asked to do more than ever before. They are expected to teach subjects that they may not have taught previously and they are expected to help students develop professional skills unlike ever before. Therefore, these individuals may relate to the findings of this study as well.

Statement of Purpose

The purpose of this study was to explore the variety of ways in which engineering faculty respond to the demands placed upon them as a result of the increased emphasis on project teams in undergraduate engineering education. A qualitative case study was deemed the most suitable methodology for this investigation because it was important to provide a forum for faculty to express their opinions and attitudes in a comfortable and relaxed environment. One-on-one interviews in the faculty members' offices encouraged study participants to respond freely to open-ended questions. The interviews, which were treated more like conversations than interviews, were conducted in a free-form manner. Faculty members were encouraged to expound upon topics of particular interest to them.

The background of the researcher as a practicing engineer and undergraduate instructor was conducive to two-way communication and facilitated lively discussions.

An extensive literature review provided a foundation for the study. When interviewing faculty, it was helpful to reference current studies that explored the impact of the criteria on programs and faculty as well as student outcomes. Equipped with a thorough knowledge of the pertinent literature, it was possible to explore the many factors that influenced the attitudes of engineering faculty regarding the increased emphasis on teamwork in undergraduate education.

CHAPTER II: LITERATURE REVIEW

Many researchers have focused on teamwork in higher education in general and in colleges of engineering specifically. In addition, a number of researchers have focused on the problems associated with the wide variety of roles that engineering faculty must fill. Following is a brief review of the most important literature related to these topics.

The pertinent literature can be divided into two broad categories: teamwork in higher education and faculty considerations. First, the literature that addresses the importance of teamwork and the factors, both external and internal, that provide motivation for engineering faculty to incorporate teams into their curriculum are discussed. Important external factors that motivate colleges of engineering to incorporate project teams into engineering curricula include: expectations of students to develop skills needed for their professional careers, prospective employers who express a desire to hire graduates with strong teamwork skills, and requirements specified by the formal accreditation organization for engineering programs. Important factors within an engineering program in an academic institution that provide motivation for faculty to employ teamwork in engineering curriculum are: cooperative learning, collaborative learning, and student integration. The literature in these areas is extensive.

With regards to the faculty considerations, the demands on faculty time are considerable. Five considerations related to faculty are addressed: a.) teaching, research and service responsibilities, b.) faculty time allocation c.) reward structures, d.) fair and effective evaluation of students' efforts on teams, and e.) management of an overcrowded curriculum. Most agree that project teams are an important component of undergraduate

engineering programs, but for many faculty, the increased emphasis on teamwork and effective communication presents many challenges.

Finally, the two important theories that inform my study will be discussed. Social Role Theory (Biddle & Thomas, 1979, Gilbert, et al., 1998, Gold & Douvan, 1997, Sheldon, 2004) provides a framework for evaluating the conflicts that faculty experience and Organizational Climate Theory (Forehand & Von Haller, 1964, Drexler, 1977) provides a framework for understanding the college and department climates that shape faculty role expectations.

External Motivations for Project Teams

Most institutions of higher education have limited resources to apply to a wide set of objectives. Because the safety and welfare of clients is always a primary concern for engineers, providing an in depth technical education is first and foremost. However, in recent years, several important external factors have influenced administrators to require faculty to devote a certain amount of class time to the development of teamwork and communication skills. These external motivations include: expectations of students to develop skills needed for their professional careers with companies that place significant emphasis on teamwork skills (Motiff, 2003), prospective employers (Black, 1994) and formal accrediting organizations (ABET, 2009).

Student expectations. Students recognize that higher education is a vehicle for advancing their professional opportunities upon graduation. Thus, students expect to develop specific skills that employers desire in the college graduates that they hire. In response to these expectations, most institutions of higher education are placing a

significant emphasis on students' professional competencies including critical thinking, problem solving, effective communication and teamwork (Shuman, Besterfield-Sacre & McGourty, 2005). Real life experiences help to prepare students for the workplace. Colleges and universities, in general, and engineering colleges, in particular, have begun to use project teams extensively. In engineering, project teams are often used to teach students the engineering design process. Each phase of the design process is enhanced by combining the unique knowledge, skills and abilities of the team members. Through the use of project teams, a wider variety of ideas are developed and better decisions are made (Katzenbach & Smith, 1993). In teams, students become acquainted with knowledge and skills of teammates providing them an opportunity to strengthen their own abilities (Dunne & Rawlins, 2000). Faculty members, administrators and employers agree that development of critical thinking, problem solving and effective communication are important skills for college graduates (Cabrera, Colbeck, & Terenzini, 1998).

Prospective employers. Now, more than ever, companies find that by combining the skills and knowledge of an array of employees, they are able to maximize efficiency (Guzzo & Salas, 1995, Katzenbach & Smith, 1993, Van Der Vegt, 2000). Team-based activities such as autonomous work groups, task forces, management teams and project teams are commonplace in today's organizations. Many large scale projects would be virtually impossible for one individual to complete. Therefore, project teams are formed to distribute the work among team members. It is expected that organizations will continue to rely heavily on teams in the future as job complexity continues to increase

(Van Der Vegt, 2000). Industry leaders indicate that new graduates must have the ability to solve unstructured real world problems in a team setting (Black, 1994).

Accreditation Board of Engineering and Technology (ABET). Since 1932, the Accreditation Board for Engineering and Technology (ABET) has been recognized as the official accrediting organization for engineering programs at institutions of higher education. To obtain accreditation, institutions must adhere to a set of quality standards know as accreditation criteria. The criteria address all aspects of engineering programs including program curricula, faculty and facilities. In 1996, ABET adopted a new set of standards called Engineering Criteria 2000 which, according to ABET, shifted focus from inputs (what is taught) to outputs (what is learned). EC 2000 specifies eleven criteria that programs are expected to assess and demonstrate regarding their students' achievements. The new criteria retain the emphasis on development of mathematical, scientific and technical skills while increasing the focus on other professional skills such as solving unstructured problems, communicating effectively and working on teams. Specifically, the 2007-2008 Criteria for Accreditation Engineering Programs includes Criterion 3d which requires engineering programs to demonstrate that their graduates have "an ability to function on multidisciplinary teams" and Criterion 3g which requires engineering programs to demonstrate that their graduates have "an ability to communicate effectively" (ABET, 2009, p. 2). EC 2000 also stresses the importance of ethical and contextual aspects of the engineering profession (ABET, 2009, p. 2). Thus, program administrators are required to include courses that employ project teams in order to obtain the highly regarded accreditation. The accreditation process verifies that students

have the opportunity to work in teams but may not always verify that they are taught the necessary skills required to work effectively in teams.

Internal Motivations for Project Teams

In general, administrators and faculty at institutions of higher education recognize the benefits of cooperative learning in which students work together in groups to create their own learning situations (Johnson, Johnson & Smith, 1998) as well as collaborative learning in which students are encouraged to work together to apply course material to answer questions, solve problems or create a product (Smith & MacGregor, 1992). The benefits of these methods are particularly evident in an engineering curriculum which is rich with problem-solving, critical thinking and design. Also, engineering programs typically suffer from low retention (Leslie, et al., 1998) so program administrators continually look for opportunities to encourage students to remain in their programs. Enhancing collaboration is one way to improve retention (Prince, 2004).

Cooperative learning. In cooperative learning, students work together cooperatively to accomplish shared learning goals. Each student achieves his or her learning goal if and only if the other group members achieve theirs. Students work together in small groups to ensure that all group members achieve at a satisfactory level (Johnson, Johnson and Smith , 1998). Johnson, Johnson and Smith (1998) summarized their findings regarding cooperative learning by saying, “cooperative learning does indeed work in college classrooms.” (Johnson, Johnson and Smith, 1998, p. 1). They indicate that student learning can be enhanced through group experiences. Interdependence develops when students believe that success depends upon the

coordination of the group members' efforts and that each member of the group must succeed individually in order for the group as a whole to succeed. They identify four areas of interdependence that contribute to effective cooperative learning: (a) goal interdependence, (b) reward interdependence, (c) role interdependence, and (d) resource interdependence. Goal interdependence develops when group members believe that their goals can only be met if fellow group members achieve those goals as well. Reward interdependence is related to the fact that rewards, which for most project teams, are good grades, depend upon the performance of the all of the group members. Role interdependence evolves as each member within a group accepts different responsibilities. Resource interdependence exists when information and other resources are spread amongst group members and must be exchanged in order for the group to succeed. Many educators believe that interdependence enhances learning and teaches important interpersonal skills that help students prepare for their future careers.

Active learning promotes student engagement by introducing activities into the traditional lecture format (Prince, 2004). Active learning, in combination with cooperative learning, has been found to enhance student learning in a number of studies (Tinto, 1997; Astin, 1987; Colbeck, et al, 2000, Bonwell & Eison, 1991; Millis, B. 1994). According to Merriam-Webster's Online Dictionary (http://www.merriam-webster.com/dictionary/teamwork), teamwork is work done by several associates with each doing a part but all subordinating personal prominence to the efficiency of the whole. Results of experimental as well as survey studies indicate that teamwork enhances comprehension and retention of complex subject matter (Kozlowski, 2007). In a study

that focused on the effects of interdependence on student learning, researchers discovered that students anticipated that their future careers would require them to work on teams and felt that working on teams had taught them valuable professional skills including improved communication, better conflict management and increased problem solving strategies (Colbeck, Campbell & Bjorklund, 2000). In course evaluations and student surveys, students indicated that team assignments were useful in acquisition of team skills and that learning of academic material was facilitated when working in teams rather than in competition with one another (Demetry and Groccia, 1997).

Collaborative learning. Collaborative learning is an umbrella term that refers to instructional practices that encourage cooperative learning (Smith & MacGregor, 1992). Students are encouraged to apply knowledge and skills learned in their coursework to solve open-ended problems or to produce a required output (Smith & MacGregor, 1992). Collective intellectual effort among students about a specific problem or task encourages social conversation and reflective thinking that leads to acquisition of knowledge (Bruffee, 1984). Student achievement, positive attitudes toward a subject area and emotional bonding with peers are positively influenced by cooperative and collaborative learning (Johnson and Johnson, 1994). Based on their meta-analysis of research focused on cooperative learning in higher education, Johnson, Johnson and Smith (1998) concluded that “The research on cooperative learning has a validity and generalizability rarely found in the educational literature” (Johnson, Johnson and Smith, 1998, p. 1). However, they indicated that group work only enhances learning if instructors provide proper guidance and structure assignments to meet specific conditions.

It is generally accepted that in order for collaborative learning to be successful, students should have some degree of guidance and instruction regarding the skills necessary for effective teamwork. Advocates of collaborative learning clearly specify the type of guidance that instructors should provide to students working in groups. This includes providing instruction on interpersonal skills, encouraging positive interdependence and providing assistance with managing conflict (Johnson & Johnson, 1994). Without this type of guidance, students often become frustrated and have negative reaction to group learning situations (Fiechtner & Davis, 1984).

Auburn professor, Herbert Rotfeld (1998), adeptly expressed the concerns of many educators. He said that few instructors focus attention on improving the function of classroom teams and often do not give sufficient attention to improving students' speaking, writing or group interactions. He further stated that although students are expected to engage in certain activities in a class, they may not develop the necessary skills to work effectively in teams. He worried that while students may have the experience of a group, actual education on working in groups often is not be provided. Colbeck, Campbell & Bjorklund (2000) performed a qualitative study that investigated the conditions that contributed to positive or negative group learning experiences for college students. Their goal was to gain insights into the ways and reasons students learned from group experiences even when faculty did not structure the projects according to the tenets of cooperative learning. They focused on the interdependence that developed as students worked together. They found that without faculty guidance, few teams developed goal or reward interdependence but most teams developed resource

interdependence. In other words, the students often did not develop common goals nor did they understand the importance of the success of each and every team member to the success of the team. However, they recognized their dependence on one another for resources such as materials, supplies and equipment. The students they interviewed believed that faculty lacked effective communication skills and doubted that faculty could teach students how to work in groups. Nevertheless, the students felt that they had learned valuable lessons from the group work experience and anticipated that the experience would benefit them in the future.

Academic integration. Research suggests that student retention, that is, the decision a student makes to continue his or her education, can be improved through greater social integration of students at institutions of education (Tinto, 1975). In a higher education setting, "social integration occurs primarily through informal peer group associations, semi-formal extracurricular activities, and interaction with faculty and administrative personnel within the college" (Tinto, 1975, p. 107). Tinto's work focused primarily on dropout from institutions of higher education, as opposed to dropout in the system of higher educational institutions. Unfortunately nearly all of the studies focused on retention in engineering, categorize those who leave engineering for another field and those who leave the institution of higher education altogether into a single group. However, with retention within engineering typically 50% or less (Leslie, et al., 1998, Zhang, et al., 2006), college administrators grasp at opportunities to retain as many students as possible (within the college) and recognize that group work may improve retention by promoting social relationships among students. A number of studies have

shown that group work in higher education enhances students' social networks which may lead to greater persistence and retention (Thomas, 2000). Social networks are the sets of acquaintances and friendships that define one's relations with others. Teamwork in an education setting allows students to expand their social networks. Tinto (1975) developed a Student Integration Model in which he proposed that the higher the level of social integration of a student at an institution of higher education, the greater the commitment to the institution and educational attainment goals. The theory assumes that a student enters an institution of higher education with an initial commitment to the institution based on a number of background variables. The theory proposes that the level of commitment changes over time depending upon the level of the student's social and academic integration. Successful integration leads to enhanced commitment to the institution and greater persistence toward educational goals.

Thomas (2000) performed an exploratory study investigating the effects of students' integration from a network perspective on student persistence and goal commitment. The study was designed to "explore the effects of social integration from a social network perspective: a perspective that enables determination of subgroup membership and of the characteristics of relationships to and toward a more appropriate empirical elaboration of the integration constructs central to these models" (Thomas, 2000, p. 592). In his study, Thomas used Tinto's Student Integration Model as a theoretical framework. His study was longitudinal in nature and focused on structural features of student relationships and subgroups and the relationship to student persistence. While his findings were somewhat mixed, in general his study supported

several key components of Tinto's model. Academic integration had a direct impact on intentions and persistence, as well as GPA, which in turn had a direct impact on persistence. This supports the viewpoint that teamwork can positively impact student outcomes by enhancing the social networks of those students involved.

Faculty Considerations

The increased focus on teamwork presents a challenge for many engineering faculty as they assume greater teaching responsibility as a result of the increased emphasis on teamwork and other professional skills but see no reduction in their responsibilities associated with teaching the foundational topics of mathematics, basic science and engineering science. (Lattuca, Terenzini and Volkwein, 2006). These recent findings suggest that the teaching demands on engineering faculty have expanded into new areas with no compensating reduction in other areas of responsibility. Several important considerations related to faculty roles as researchers and teachers (Hattie and Marsh, 1996, Braxton, 1996) influence the response of faculty to the increased demand to teach teamwork skills. All of these considerations are influenced by the organizational climate of the college and departments as well as the background characteristics of the faculty (Bellas, 1997, Leslie, McClure and Oaxaca, 1998, Olsen, Maple and Stage, 1995).

Intrinsic and extrinsic rewards affect faculty job satisfaction. Intrinsic rewards are those that result from the work itself while extrinsic rewards are related to the conditions under which the work is done (Olsen, 1993). In most institutions, the responsibilities (i.e. the work) of faculty are threefold: research, teaching and service. The way in which faculty allocate their time based on the demands of these responsibilities is an important

consideration to job satisfaction. A factor related to intrinsic rewards for engineering faculty is the challenge of teaching professional skills such as teamwork in an overcrowded curriculum. The importance and difficulty of providing fair and effective evaluations of students' individual work in a group setting presents unique challenges and is another factor that can impact faculty job satisfaction. Because compensation for engineering faculty usually falls well below that of their counterparts in industry, salary can be an important consideration for many engineering faculty. Typically, institutions of higher education place less emphasis on teaching than research in their reward structures so faculty are naturally inclined to devote greater efforts toward their research programs than their teaching.

Research, teaching and service. Marsh & Hattie (2002) discussed the relationship between research and teaching. Some believe that the relationship between research and teaching is symbiotic and mutually reinforcing and that teaching effectiveness and research productivity are closely related if not inseparable (Clark, 1997). Braxton (1996) focused on the similarities of the roles and underlying values associated with research and teaching and argues that the two are mutually reinforcing. Others argue, however, that research and teaching activities are antagonistic and that too much time devoted to research and publication can detract from teaching effectiveness while the demands of teaching can take important time away from research activities (Blackburn and Lawrence, 1995). Evidence of high quality research performed at research institutions without undergraduate programs and excellent teaching offered at tertiary institutions that perform little or no research supports the argument that research and teaching are unique

and distinct activities that should be addressed as separately (Hattie and Marsh, 1996, Feldman, 1987, Fairweather, 1993).

Traditionally, the three major responsibilities for faculty members are research, teaching and service. In recent years, faculty are involved in many activities that do not fall solely into these categories. For instance, entrepreneurial research activities and consulting occupy faculty time and have a negative effect on time spent on teaching (Lee, et al. 2004). However, when students are involved in these activities, greater time may be spent on teaching, if not in the classroom, possibly in more out-of-class settings which can be important to student development. As capitalism permeates higher education as a result of fiscal crisis, the role expectations of faculty change considerably and the relationship between teaching and research changes as well (Slaughter, 1985).

Reward structures. Although most administrators in higher education claim that teaching and student/faculty interaction is a major priority, many place considerably less emphasis on these activities than research in their evaluation and reward of faculty (Fairweather, 1993). Some claim that the emphasis on research in evaluating faculty is appropriate since research productivity is the only way to objectively evaluate faculty merit. Others note that some institutions claim that research is the only means for differentiating academic institutions and a primary way in which institutions achieve prestige (Park, 1996). Marsh and Hattie (2002) suggested that the motivation and reward structures for teaching and research are inherently antagonistic. While many engineering faculty have little or no training or experience in group work, they are expected to teach students teamwork skills. The motivation for faculty to invest time to develop the

necessary skills to effectively manage teams is minimal as reward structures and institutional and college missions continue to focus on research over teaching (Milem, Berger & Dey, 2000). At times the stated objectives of organizations are inconsistent with the reward structures.

Faculty time allocation. Beginning in 2002, a group of researchers at the Center for the Study of Higher Education at Pennsylvania State University performed a three-and-a-half-year study that evaluated the impact of Engineering Criteria 2000, the new set of standards issued by ABET (Lattuca, Terenzini and Volkwein, 2006). While the findings were numerous, an important finding was that most faculty reported a moderate to significant increase in their program's emphasis on teamwork and other professional skills associated with EC 2000 but saw no reduction in the emphasis on the foundational topics of mathematics, basic science and engineering science. These recent findings suggest that the teaching demands on engineering faculty have expanded into new areas with no compensating reduction in other areas.

Milem, Berger & Dey (2000) compared the way in which faculty spend their time in recent times compared to twenty years earlier. They found that faculty at all types of institutions spend significantly more time on research now than they did in earlier years. This is particularly true at doctoral and comprehensive institutions. Interestingly, they found that faculty at these institutions spend more on teaching activities now than they did in earlier years as well. They found that faculty at research institutions spend approximately the same amount of time on teaching activities now as they did in earlier years. Given that faculty are spending more time on research and teaching activities, it

would appear that faculty spend less time on informal interactions with students such as advising and counseling students. These findings suggest a detrimental effect on student project teams since the greatest benefit to students may be time spent outside of the classroom when faculty members are able to provide guidance to individuals and teams regarding specific aspects and concerns regarding teamwork.

Some researchers (Colbeck, 1998) believe that faculty find ways to achieve joint production of teaching and research. Others believe that teaching and research goals require faculty to engage in separate and distinct activities (Barnett, 1992). The allocation of time varies significantly by discipline (Lee, et al. 2004). Engineering faculty spend considerably more time on research and considerably less time on teaching than faculty in other disciplines. According to Lee, et al., faculty in all disciplines spend far more time teaching or preparing to teach than on research activities. Faculty time allocation is an important concern for faculty members who are concerned about satisfying the needs of many including students, administrators, policy makers, accreditation organizations, and outside industry as well as many others.

Assessment of student work in teams. Assessing the work of students working in groups presents a significant challenge to engineering faculty. Because much of the work on projects is completed outside of the classroom, it is difficult to assess individual contributions (Pitt, 2000, Nichols & Miller, 1994, Kagan, 1995). As a result, engineering faculty often assign a single grade for project teamwork. Because some students may contribute significantly more than others, critics claim that it is blatantly unfair to assign a single grade (Kagan, 1995). Group grades may, in fact, discourage good teamwork or

communication skills. For example, if the poor effort of an uncooperative student lowers the group grade, even the most cooperative students receive a lower grade. Some suggest that this results in highly negative attitudes that could eventually evolve into “grouphate”, a term that describes the strong dissatisfaction that many students feel towards working in groups which eliminates individual control over important factors such as grades (King and Behnke, 2005).

Peer evaluation methods (Kaufman, Felder and Fuller, 2000, Maranto and Gresham, 1998, Byrd and Hudgins, 1995) that have been proposed as a strategy for evaluating individual contributions have shortcomings. Some would argue that the faculty member abandons his or her instructional responsibility when peer evaluation methods are used (King & Behnke, 2005). Students typically are not well qualified to evaluate performance and will often be influenced by characteristics other than the quality of the contribution of their peers. For example, well-liked students, argumentative students or apprehensive students may be evaluated differently because of these traits. Peer evaluation strategies as well as other strategies to assess students’ work in teams presents many challenges for engineering faculty.

Overcrowded curriculum. Industry representatives, academic administrators and accrediting organizations are placing considerable emphasis on the development of professional skills including effective communication and teamwork. However, the expectations for technical coursework have not been reduced, and in some cases have increased. This overcrowding of the curriculum, along with rapidly changing technology and high demands for research and publication, has put considerable strain on many

engineering faculty. While ABET's newly implemented accreditation criteria, EC 2000, contain specific requirements for the development of professional skills, little has been done to alleviate the workload for faculty members (ABET, 2009). In addition, many faculty are resistant to devoting class time to development of teamwork skills in an already overcrowded curriculum. Some faculty believe that homework and lab work provide sufficient reinforcement of material learned in class and the limited time available for lecture should be devoted strictly to dissemination of information to students. These concerns are legitimate in that the typical engineering course is loaded with complex technical information, and faculty need to devote considerable time to developing and reinforcing the concepts (Felder, 1994). However, advocates of cooperative and collaborative learning argue that the time devoted to teaching teamwork and effective communication skills is justified due to the benefits of cooperative learning and believe that effective utilization of project teams can positively impact workload issues for instructors (Prichard, et al., 2006).

Theoretical Frameworks

Several theories and conceptual models, including Human Capital Theory, Collaborative and Cooperative Learning Theories and the Student Integration Model form the basis for the assumption that teaching teamwork to undergraduate students is a worthwhile endeavor. The primary focus of this study is to extend the understanding regarding the way in which faculty cope with expectations to perform in a wide variety of roles in a unique environmental setting. Thus, Social Role Theory (Biddle, 1979, Sarbin & Allen, 1968, Secord & Backman, 1974, Getzels & Guba, 1954) provides a theoretical

framework for understanding how faculty manage their diverse responsibilities and Organization Climate Theory (Forehand & Von Haller, 1964, Drexler, 1977, Katz & Kahn, 1966, Tagiuri, 1968) provides a framework for understanding the influences of the university, college, department and peers on the faculty laden with the responsibility of teaching students to work effectively in teams.

As role theory evolved, several widely accepted definitions for role were developed. Generally, a role is a set of norms that is organized about a function (Bates & Harvey, 1975). Some researchers' definitions relate more closely to the workplace and refer to a set of behaviors that belong to a specific office or position (Sarbin & Allen, 1968). Most role theorists agree that expectations which are learned through experience are the basis for roles (Biddle, 1986) but they differ on the modality of expectations. Some assume that expectations are norms, others view them as beliefs while others consider them to be preferences (Biddle, 1986). In general, role expectations predict how individuals performing specific roles are expected to behave.

Five distinct perspectives have appeared in role theory including: functional, symbolic interactionist, structural, organizational and cognitive (Biddle, 1986). Organizational role theory is most pertinent to this study in that it focuses on "social systems that are preplanned, task-oriented and hierarchical" (Biddle, 1986, p. 73). Roles are associated with identified social positions and based upon normative expectations which may be influenced by official demands of the organization as well as pressures of informal groups. Differences in norms can lead to role conflict which refers to a situation in which someone is expected to fill two or more roles that present inconsistent,

contradictory, or mutually exclusive expectations (Getzels and Guba, 1954). Typically, role conflicts produce role strain which is defined as difficulty in meeting given role demands (Goode, 1960). Also, one's behavior in a role may not always be consistent with one's own or other's expectations for that role (Secord and Backman, 1974). Expectations for engineering faculty are significant and continue to grow with rapidly changing technology, globalization, closer links between academic institutions and private industry and emphasis on helping students develop skills to prepare them for the workplace. In some cases, faculty may not be able to meet their own or other's expectations due to role conflicts.

Organizational climate has been defined in a number of ways. The first widely accepted definition came from Forehand and Von Haller and stated that organizational climate is "the set of characteristics that (a) distinguish the organization from other organizations, (b) are relatively enduring over time, and (c) influence the behavior of people in the organization" (Forehand and Von Haller, 1964, p. 362). Tagiuri proposed the following definition: "Organizational climate is a relatively enduring quality of the internal environment of an organization that (a) is experienced by its members, (b) influences their behavior, and (c) can be described in terms of the values of a particular set of characteristics (or attributes) of the organization" (Tagiuri, 1968, p. 27). Some researchers consider organizational climate a direct determinant of behavior in a main effect sense while others consider climate an indirect determinant of behavior in an interactive sense. Still others resist any suggestion of causality but consider

organizational climate as a predictor in the correlational sense (Woodman and King, 1978).

The concept of organizational culture is closely related to organizational climate and, like organizational climate, has been defined in a number of ways. Management scientists and practitioners tend to prefer a definition that is derived from the ideational school of anthropology that defines culture as the shared and usually taken-for-granted assumptions and values that inform communal action (Ashforth, 1985). Culture generally refers to belief systems, values and cognitive structures (Tagiuri, 1968). Studies of organizational climate typically focus on perceptions of behavior while studies of culture deal with shared assumptions and ideologies (Ashforth, 1985). Generally, climate is viewed as being more malleable than culture. As Ashforth stated, "the perceptions/inferences [of climate] are one step closer to the objective world than are assumptions and values [of culture]" (Ashforth, 1985, p. 841). Most agree that the distinction between perceptions and assumptions is subtle. In an attempt to describe the association between climate and culture, Ashforth states that "(a) the stronger the culture, the greater the impact on climate; and (b) it may be futile to attempt to understand climate without first considering the culture that may have given rise to it and likely sustains it" (Ashforth, 1985, p. 842).

Organizational climate can vary among different organizations as well as among departments within the same organization. Drexler (1977), in an extensive study of organizational climate, confirmed that differences in climate existed among organizations as well as among departments. However, the differences among departments were much

weaker than differences among organizations. For faculty members at institutions of higher education, the organizational climate with regards to research vs. teaching and service is a major consideration and influences the expectations for faculty members. While most institutions claim to place significant priority on both research and teaching, many do not support this claim with policies.

Chapter Summary

Utilization of project teams as a strategy for teaching important professional skills such as effective communication and teamwork has become an integral part of most engineering programs. External factors such as student expectations, prospective employers and accrediting organizations provide ample motivation for the inclusion of project teams in the engineering curriculum. Advantages of cooperative and collaborative learning and expanded social networks provide internal motivation for incorporating project teams in engineering coursework. While many institutions have attempted to encourage faculty to devote more time to teaching and service, most continue to place significantly greater emphasis on research in their reward structures (Milem, Berger & Dey, 2000). As the requirements to teach teamwork and effective communication increase and the requirements to teach technical skills remain unchanged, faculty find that the curriculum in some cases has become overcrowded. Because many faculty have spent little or no time working in industry, some have limited experience or knowledge about working in teams (Colbeck, Campbell & Bjorklund, 2000). As a result, many faculty assign team projects but provide little or no guidance to the students about how to work effectively in teams. Studies have shown that students gain more from project teams

when faculty provide specific instruction on teamwork and are available to guide students when conflicts arise (Colbeck, Campbell & Bjorklund, 2000). Social Role Theory and Organization Climate Theory both inform this study as faculty members respond to demands to serve in a wide variety of roles in a wide variety of environmental settings.

Faculty members are expected to play numerous and varied roles in organizational climates that are influenced by national and state policies, economic conditions and institutional leadership, among other things. In general, the demands on faculty tend to escalate so they must continually make judgments about how to allocate their time. This study investigated a specific example of the escalating demands on faculty; the requirement for undergraduate engineering programs to teach students to work effectively on teams. Factors such as student expectations, prospective employers, accreditation organizations, cooperative and collaborative learning, academic integration, overcrowded curriculum, assessment of student work in teams and reward structures all affect their decisions with respect to how their allocate their time. The review of the pertinent literature regarding theories, conceptual models and related studies served as a foundation for this study.

CHAPTER III: RESEARCH METHODS

The purpose of this qualitative study was to extend the understanding of the variety of ways that tenured and tenure-track faculty members manage the numerous roles they are expected to fill. To explore this topic, a case study of the tenured and tenure-track faculty members in the College of Engineering at a Research I University was conducted. Specifically, their response to the increased emphasis on professional skills, including teamwork and effective communication, in undergraduate education was examined. This chapter details the research questions and discusses the overall approach and rationale. The site and participate selection is reviewed and the method for data collection and analysis is described. Finally, validity, positionality and study limitations are addressed.

Research Questions

The primary research question for this study was:

How do faculty members manage the numerous roles they are expected to fill?

To fully explore this topic with the unique population included in this study, the following sub-questions were developed:

1. What is the organizational climate at the site at the college and departmental level and how does it vary? What influence does the climate have on faculty with respect to the various roles that they are expected to fill?
2. How do professors feel about teamwork in undergraduate education?
    a. How appropriate is the emphasis? What does it accomplish?
    b. In what ways do the students and/or professors benefit?

c. In what ways is this emphasis problematic for students and/or faculty?

d. How comfortable are faculty members with teaching teamwork skills?

3. What methods, strategies and teaching techniques do professors utilize to satisfy the requirements to teach teamwork?
4. How do background characteristics such as ethnicity, rank, gender and experience affect professors' opinions regarding the importance of teaching teamwork skills, their comfort with managing student project teams and their consequent efforts (or lack of) to satisfy the requirement to teach teamwork?
5. How do professors balance teaching roles with other responsibilities?

Overall Approach and Rationale

Qualitative methods were employed in this study for a number of reasons. As a graduate student, my primary goal was to broaden my horizons. I found courses focused on quantitative methods to be familiar and comfortable due to my background as an engineer. However, the courses that utilized qualitative methods were unfamiliar and, in some ways, strange. Thus, I made a conscious effort to identify a research topic that would be best addressed with qualitative methods. Developing a thorough understanding of the challenges that individual faculty members face with regards to their diverse set of responsibilities within the context of their unique environments would be difficult to accomplish through quantitative methods. Therefore, I chose to perform a case study utilizing qualitative research strategies to gain a sense of the climate of the engineering

college and departments and to explore the strategies and approaches faculty employ to manage the numerous demands of their professions.

Hathaway (1995) highlighted differences in the assumptions underlying empirical-analytic (quantitative) and interpretive (qualitative) research. Quantitative and qualitative research are distinctly different with regards to the epistemological (knowledge) and ontological (reality) assumptions underlying each paradigm. Unlike empirical-analytic research, which is designed to generate knowledge that is independent of a specific situation, interpretive research yields knowledge than can only be understood within the social context in which it takes place. With the aim to develop universal principles, quantitative researchers attempt to strip away idiosyncrasies of particular situations to determine what is generally applicable to all situations. Qualitative researchers, on the other hand, involve themselves in the particular situations in order to develop an understanding of the phenomena within the specific context from the perspective of the individuals under study.

Within the empirical-analytic paradigm, researchers are guided by a belief in an external reality with a goal to document laws that structure this reality. Thus the researcher's role can be described as that of an onlooker. In contrast, within the interpretive paradigm, reality is constructed by those participating in it and researchers engage in what is being researched to understand what is taking place.

The organizational climate pertaining to faculty roles varies greatly by institution, college and department. The perspective of individual faculty members with regards to their responsibilities for teaching specific skills and the strategies for doing so vary

greatly as well. To remove the social context in this research would deemphasize the importance of the characteristics of the environment and the faculty members' perspectives. Thus, to fully understand the essence of the engineering faculty members' experiences, qualitative research methods were selected to explore the faculty perspective with regards to the requirement to teach teamwork to undergraduate students in engineering.

Site and Participant Selection

The study was conducted at a Research I public university in the Southwestern United States (which will be referred to as SW University henceforth) with an enrollment of 36,805 students. The university prided itself on high quality research and excellence in education as described in the following excerpt from the "About Us" section of the university website:

> The university produces more than $530 million in annual research and is the state's only member of the prestigious Association of American Universities. This is a diverse community of people who thrive on innovation and collaboration. Our world-class faculty create discoveries that improve the human condition and fuel the state's economy. Our research enterprise provides undergraduate students with opportunities for hands-on experiences that can be found in few universities in the world. As the state's land-grant university, our research and resources enrich communities around the state and around the world.
>
> (http://www.arizona.edu/home/aboutua.php)

The College of Engineering at the university had eight departments with an enrollment of 2,694 undergraduate students. The college was ABET accredited and ranked in the top 50 programs in the US according to the US News & World Report rankings (http://colleges.usnews.rankingsandreviews.com/college/spec-doct-engineering). As a Research I institution, the emphasis on research was significant, however, the College of Engineering at this institution focused heavily on preparing students for productive careers in the engineering profession. The college strived to be at the leading edge of technology while providing excellence in education for both undergraduate and graduate students as conveyed in the college mission statement and strategic objectives: (http://engr.arizona.edu/)

College Mission

Through excellence in education and research, and in partnership with industry, government, and the citizens of [Southwestern United States], we will:

- focus on improving service to our students and other customers
- emphasize fundamentals for lifelong learning
- lead in improving the nation's strategically important engineering technologies

Strategic Objectives

Provide a world class education for our students:

- Lead in research that improves the nation's strategic engineering and environmental technologies

- Build productive and mutually beneficial partnerships with our external customers, suppliers and stakeholders
- Continuously improve the critical support processes which are key to the College's mission.

At the time of this study, the Dean of the College of Engineering had accepted a highly-regarded position at the National Science Foundation (NSF) and an Interim Dean had been appointed. The Interim Dean had previously been the Associate Dean of Academic Affairs and a search for the Interim Associate Dean of Academic Affairs was underway. By his own admission, the Interim Dean lacked in-depth knowledge regarding the extensive research functions throughout the college. However, it appeared the faculty and staff were generally satisfied with the appointment, regardless of his limited familiarity with the research activities in the college. It was apparent that he faced a significant challenge and most agreed with the University Provost who said that his "academic credentials, combined with his enthusiastic commitment to lead the college through the transformation plan, make him the ideal choice." (http://www.engr.arizona.edu/news/)

The university was going through a major restructuring, referred to as the Transformation Plan, which was prompted by a number of factors including a significant reduction in state funding of the public universities. The Transformation Plan (http://provost.arizona.edu/transformation_information) necessitated "reorganization, restructuring, and the consolidation of departments and units within colleges, and potentially across colleges" in order to "make fuller use of resources to meet obligations".

From the very beginning it was clear that it would no longer be “business as usual”. The overall climate at the University was clearly affected by this process. In a meeting with faculty and staff, the University President and Provost expressed sympathy and said they understood the frustration but emphasized the need for a “broad-based and swift evaluation of the University's administrative and scholarly functions”. The President stated, "I know there is a lot of anxiety, and I wish there wasn't" (http://provost.arizona.edu/weekly_updates_archived).

As part of the Transformation Plan, functional units were asked to prepare white papers outlining strategic plans to achieve the desired goals. The Faculty Senate Budget and Strategic Planning Committee (SPBAC) provided guidelines for these proposals. At the time of this study, 77 white papers had been submitted and the SPBAC had reviewed all of the proposals and had made recommendations regarding the next phase of the process.

Virtually all of the administrators, all of the department heads and many of the key faculty in the College of Engineering had devoted a significant amount of time formulating and/or contributing to white papers for the University-wide Transformation Plan. During interviews, several faculty members and department heads indicated that the process had been burdensome. According to Engineering Professor Kidd, the time devoted to the Transformation Plan was “much less than optimally productive” and the process was “very distracting”. At the conclusion of this study, the impact of the Transformation Plan on the College of Engineering was unknown. However, most administrators, faculty and staff within the college felt fairly confident that the college

would remain an independent entity. But there was little doubt that there would be significant budget cuts and it was unclear where or how the savings would be accomplished.

Appropriate selection of participants for a qualitative research project is imperative to the success of the study and generally should be purposeful (Patton and Patton, 2002). The goal of purposeful selection is to include participants that provide insight and understanding of the phenomenon under investigation (Bloomberg and Volpe, 2008). Of the numerous potential selection strategies, the following were employed for this study: criterion sampling, network sampling and purposeful random sampling. Initially, the Dean and Academic Dean of the College of Engineering and the majority of the department heads and assistant department heads were interviewed. The goal of these initial interviews was to gain a sense of the expectations of those in formal leadership positions in the college. Next, a criterion sample of faculty who utilized project teams in their undergraduate courses was interviewed. Finally, a purposeful random sample of faculty who taught undergraduate courses but who did not necessarily utilize project teams was included. To maximize variation, approximately an equal number of participants was selected from each of the departments in the College of Engineering. Finally, a conscious effort was made to include both female and male participants and to select participants with diverse cultural backgrounds.

The faculty members were identified through several means. First, the researcher had an association with many of the faculty members and was able to identify those that met the specified criterion. During the first set of interviews, participants were asked to

recommend others that might be suitable participants. To identify additional potential participants, the University Schedule of Classes as well as the Course Descriptions in the Academic Catalog were consulted. Courses with a significant design component lend themselves to group projects, therefore, instructors for these courses were targeted. Often, because of their significant industrial background, adjunct faculty members teach these courses. However, because adjunct faculty members typically do not have both teaching and research responsibilities, adjuncts were not included in this study. The potential candidates for the study were invited to participate via email. Fortunately, the response to the invitations was excellent and only those who readily agreed to participate after the initial email were included in the study. The Dean, Academic Dean, seven department heads and twenty-five faculty members participated in the study.

Overview of Information Needed

Typically, four types of information are required to fully understand the phenomenon under investigation in a qualitative study. These include: contextual, perceptual, demographic and theoretical information (Bloomberg and Volpe, 2008). Because the environment and culture of an institution influences the behavior of the members within the institution, it is essential to understand the contextual information. In this study, much about the context was learned through the study of the published information, particularly the university, college and departmental websites. Perceptual information, which refers to participants' perceptions related to the particular subject of the study, was gathered primarily through interviews. Perceptions are not facts but rather what people perceive as facts and may change depending on the context so it was

important to relate the perceptual information to the contextual information. Demographic information such as age, gender, ethnicity, educational background and career experience can help explain individual perceptions as well as similarities and differences in perceptions of the participants. Background information was ascertained from participants' curriculum vitae's which were generally available on the department websites as well as through questions asked during interviews with the participants. Finally, a thorough literature search was conducted to collect theoretical information regarding the pertinent frameworks and the relationship of theory to the topic of inquiry.

Data Collection Methods

An in-depth literature review was completed prior to the study to ascertain what is already known about the topic of inquiry. The literature was not data per se, but rather information that was utilized to inform the study. Data collection procedures in qualitative research involve four basic types: observations, interviews, documents and audiovisual materials (Creswell, 2003). In this study, interviews and documents were the primary sources of data.

For this study, interviews provided the best way to explore the perceptions of the participants in the study and allowed the researcher to "control" the line of questioning. An important limitation of interviews as a means for data collection was that the researcher's presence may have biased interviewees' responses. For example, most of the interviewees were well aware that the primary responsibilities of the researcher within the college were related to teaching, advising and mentoring of students. Thus, study participants may have withheld opinions regarding the importance (or lack of

importance) of those responsibilities to avoid offending the researcher. Also, people were not equally willing or able to articulate their perceptions regarding the topic of inquiry (Creswell, 2003). Nevertheless, interviews were an effective method for understanding the faculty members' ideas, attitudes and opinions and were the primary source of perceptual information.

Documents represent thoughtful information that has been given attention during compilation and can be readily accessed at a convenient time for the researcher (Creswell, 2003). A limitation of the documents utilized in this study was that some of the information was outdated and did not necessarily reflect the changing environment at the institution. Also, many of the college and department websites are the primary tool for marketing so much of the information was "scrubbed" to reflect the college or department in a positive light. However, these documents provided insights about the way in which the organization wished to be portrayed.

Prior to the interviewing process, college and department websites as well as ABET documents, marketing materials and other literature were reviewed to identify potential participants and to begin to understand the climate of the college with regards to the topic of inquiry. This document analysis helped to develop an overall understanding of the college's strategy for addressing the requirements to teach students to work effectively on teams and to gain a sense of the college's philosophy with regards to the emphasis on research versus teaching and service. Once potential participants were identified, curriculum vitae which were readily available on departmental websites were reviewed to collect background information. Data collected included approximate age,

academic background including type and location of institutions where the faculty member had studied and/or worked as well as information regarding experience outside of academia.

To collect perceptual information, semi-structured interviews were conducted with all of the study participants. These were one-on-one, face-to-face interviews conducted in the faculty member's or administrator's university office. After receiving signed approval for a voice recording via the IRB-approved Consent Form, the digital recording device was started. The open-ended interview questions are included in Appendix A. The interview questions were developed based on the information needed to address the primary and secondary research questions. Since the researcher had been an instructor in the college for many years, personal experience and knowledge of the topic proved very valuable in the process of developing the questions. To hone the interview questions, a pilot interview with a faculty member who is known to embrace the value of projects teams was conducted. During the interviews, questions were adapted in order to focus on the most information-rich topics for each individual participant.

Three examples of questions from the interview protocol for faculty members follow: 1.) What expectations are placed upon you with respect to teaching teamwork skills in your undergraduate engineering courses? This question was designed to explore the first sub-question regarding the expectations for faculty members and helped to ascertain the faculty member's perceptions regarding his or her roles and the organizational climate. 2.) When you have students working in teams, is your workload affected? If so, in what way? This question was designed to develop the foundation for

the second sub-question regarding workload concerns related to managing student project teams and helped to identify role conflicts. 3.) How do you feel about this emphasis on project teams? This question was intended to discover the faculty member's opinions regarding the importance of teaching teamwork and helped to detect role strain.

Following the interviews, the digital files were promptly transferred to multiple computers, one of which was a university server that was backed-up by IT personnel on a daily basis. The signed Consent Forms were filed for safe-keeping and a personal note of thanks was sent to each participant.

Data Analysis

Data analysis is a critical step in the qualitative research process. This section details how the voluminous data for this study was managed and organized in order to present the findings and how it was analyzed to facilitate the interpretation and conclusions regarding the findings. The process of data analysis is both deductive and inductive. The initial categories for the conceptual framework are developed deductively during the literature review. As the study progresses, patterns and themes emerge and coding occurs inductively (Bloomberg and Volpe, 2008).

Before data analysis could begin, it was necessary to determine how the large volume of data would be managed. Until recently, data management typically entailed mounds of papers, index cards, Post-it notes, flip charts and highlight markers. Fortunately, very sophisticated and effective software applications are now available to reduce the tedium of data management. For some, computers can be so engaging that they may detract from the important tasks that are necessary to complete a dissertation

(Wolcott, 2001). However, because the researcher works in a technical field and is very accustomed to using computers and software applications, it was decided at the onset of the study that a software application would be utilized to manage the data. First, it was necessary to establish the criterion for selection of a software package. The primary objective for utilizing a software application was to improve the efficiency of data management. While most qualitative research software offers extensive tools that allow the user to automate the data analysis process, the research did not intend to utilize these functions. Thus, the most important criteria were ease-of- use, efficient data management and effective linking of data to codes and themes. Various programs are available including ATLAS.ti, NVivo8 and Qualrus. A comparison of qualitative research software (Godau, Richards and Kuchartz, 2004) provided a comprehensive description of the packages. Based on this review, NVivo8 appeared to be an appropriate choice. In addition, the use of NVivo was prevalent and well-supported at the researcher's home institution. Therefore, a license for NVivo8 was acquired.

Creswell (2003) recommends six basic steps for data analysis in qualitative research. The tasks that were completed for the two types of data (Documents and Interviews) utilized in this study are described below.

Step 1: Organize and prepare the data for analysis.

- NVivo supports both internal and external data sources. Rich text format (RTF) or text-only files can be imported into NVivo. When a document is imported into NVivo, it is called an Internal source. Proxy document files can be created to represent and link to other file formats to create External

sources. For this study, all of the data were converted to a format that could be imported as an Internal source.

- Important University and College documents were downloaded from the official university website and imported into NVivo. These included: University Mission Statement and Five-Year Strategic Plans, State of the University of Address from the President's Office, pertinent "In the News" articles and Provost office communications regarding the Transformation Plan, College Mission Statement and Strategic Plan.
- Information from the Curriculum Vitae's of the study participants was extracted and input into an Excel spreadsheet. The spreadsheet was converted into a Text Document and imported into NVivo.
- Applicable Course Descriptions from the University Schedule of Classes were downloaded, reformatted as necessary and imported into NVivo.
- Assessment Activities at the department level which were available at the college website were downloaded. These included: Education Outcome Matrix, ABET Criteria Matrix, Curriculum Matrix and Outcome Assessment Matrix. Information pertinent to this study was extracted, summarized in Excel, converted into a Text Document and imported into NVivo.
- Teacher and Course Evaluation (TCE) data were accessed and extracted for each participant. Specifically, student responses to questions related to

the overall rating of the course, instructor effectiveness and value of out-of-class activities were noted. This data was imported into NVivo.

- All recordings of interviews were transcribed into Microsoft Word documents. The transcriptions were imported into NVivo.

Step 2: Read through (or listen) to all data.

- Each downloaded document was read and reread. Interestingly, each reading, particularly after the download, uncovered new insights.
- Digital recordings of each interview were reviewed and compared to transcriptions. Transcription errors were corrected.
- At the completion of each interview, transcriptions were read multiple times to identify emerging patterns.

Step 3: Begin the coding process.

- NVivo allows the researcher to group sources into 'sets' which enhances the analysis, search and concept management processes. A set typically contains sources with a common characteristic. Some examples of sets defined for this study included: Department heads, Mechanical Engineering, Chemical Engineering, Females, etc. Individual sources can be placed in multiple sets. Thus, the transcription for an interview with a female department head in the Mechanical Engineering department would be included in three of the sets listed above. Appendix B provides a comprehensive list of the sets utilized for this study. The relational

functionality of the software dramatically reduced the labor-intensive document management activities.

- NVivo uses the term ‘nodes’ rather than ‘codes’ or ‘coding’ which is traditionally used in qualitative research to refer to the process of organizing material into “chunks” before bring meaning to those “chunks” (Rossman & Rallis, 1998).
- Nodes can be created in a number of ways in NVivo. Based on the literature review, initial nodes were created using the ‘Create node’ tool in the Node Explorer. Attributes were assigned to the nodes as needed.
- To begin the coding process, source documents were opened in the Document Browser. The process for assigning nodes to sections of text was straightforward. Multiple nodes could be assigned to the same sections of text. As the coding process began, additional nodes were created, some nodes were modified or merged and others were deleted. This could all be accomplished while in the Document Browser.
- Several options for viewing the node assignments are available in NVivo. For example, while in the Document Browser, the user can select ‘Highlight coding for all nodes’ or ‘Highlight coding for selected nodes’ from the View menu thus highlighting the text that has been associated with nodes. The user can also display ‘Coding Stripes’ which indicate which nodes have been assign to which words, paragraphs or sections.

Alternatively, the user can go to the Node Explorer to view all of the text that each node has been associated with.

- The coding of documents, particularly the interview transcriptions, was repeated multiple times to refine the nodes and to begin to identify emerging themes. NVivo has a variety of tools available for searching documents to automate the coding process. These tools were not utilized because the researcher believed that the process of reading and re-reading all of the documents was important to the analysis.

Step 4: Use the coding process to generate a description of the setting or people as well as categories or themes for analysis.

- As the analysis became more complex, additional tools were utilized. For instance, using NVivo, annotations were added to sources. This was equivalent to writing in the margins on hardcopy documents. Also, NVivo provides a convenient method for creating memos and linking these memos to text within sources. In addition, NVivo allows the user to link text in any document to text in any other document. This feature was helpful as themes began to emerge during the coding process.
- During the previous step, all of the nodes that were created were Free nodes which are stand-alone nodes that were not logically connected with other nodes. In the current step, the Free nodes were converted to Tree nodes which are nodes organized in a hierarchical structure with a general category, or theme, at the top (the parent node) and more specific, related

categories underneath (child nodes). Creswell (2008) recommends five to seven themes. He suggests that these themes should appear as major findings in the dissertation of a qualitative study. Appendix C shows the tree diagram for this study with the major themes at the top and the related nodes below. The themes that emerged for this study were: 1.) Climate of the College of Engineering and the engineering departments, 2.) Study participants' opinions regarding the importance of teaching students to work effectively in teams, 3.) Faculty members' attitudes toward student teams based on their personal experiences, 4.) Methods, strategies and techniques that faculty utilized with student teams, 5.) Influence of faculty members' personal attributes and background characteristics on attitudes toward project teams, and 6.) Competing roles, reward structures and workload issues.

- For the most part, the themes that emerged were all interrelated. Again using the tools available in NVivo, these complex theme connections were analyzed.
- No attempt was made to count the frequency of occurrence or the intensity of these themes. The analysis remained strictly qualitative in nature.

Step 6: Interpret the data and find the meaning of the data.

- At this point in the study, it was important to re-read much of the literature to connect the findings to what others had discovered regarding

this topic. It was also important to reflect on personal experiences, beliefs and attitudes to consider the influence of those factors on my interpretation of the data. Based on these efforts, conclusions were reached and new questions were raised.

Validity

While reliability (examining consistency of responses) and generalizability (external validity of applying results to new settings) play a minor role in qualitative research according to Creswell (2003), validity is viewed as an important characteristic of qualitative research. Validity refers to the accuracy of the data from the standpoint of the researcher, the participants and the readers.

A number of strategies were used to verify the validity of the findings of this qualitative study including: triangulation, member-checking, researcher bias clarification and peer debriefing. Triangulation strategies dictate the use of different data sources to build justification for use of predominant themes. Thus, document analysis as well as interviews with faculty members and administrators were incorporated into this study. Also, prior to final submission of the results, the findings of this study were reviewed with several of the participants to determine whether these participants felt that their opinions and those of their colleagues were accurately represented. During the course of my studies in the graduate program in the Center for the Study of Higher Education, I had ample opportunity to establish a peer group to review my work in exchange for reviewing theirs. Their feedback was invaluable and contributed to the validity of my findings.

Positionality

A concept useful to qualitative researchers in education that addresses perspective is borrowed from anthropological research. This concept makes a distinction between emic which represents the insider's perspective, and etic which represent the outsider's perspective (Lancy, 1992). A variety of roles are available for the qualitative researcher, including Interviewer, Nonparticipating observer, Participant observer, Collaborative partner, Teacher/researcher and Historian (Lancy, 1992, p. 15). In this study, I acted in some ways as a *Collaborative partner* where the researcher identifies completely with the subjects and acts as a peer and in some ways as an *Interviewer* where rapport between researchers and subjects is important but the relationship is not as strong. Because I have taught the same course as several of the study subjects, in many ways, I am an insider. I have opinions and biases about the importance of teaching certain skills and have significant knowledge about various teaching methodologies both as an experienced instructor and as a graduate student in the field of Higher Education. Thus, for the most part, I am respected as a peer in this arena. On the other hand, because I am an adjunct faculty, in many ways I am an outsider. The demands on my time differ greatly from those for a tenured or tenure-track faculty and my primary focus on teaching is quite unlike the focus of others whose career advancement depends greatly on generating and publishing original research. It was important to acknowledge these various roles and my positionality as I progressed through this research project.

Patricia Hill Collins (1986), a black feminist, wrote a thoughtful essay that introduced the concept of the "outsider within". The notion originated from the numerous

black women who achieved insider status as domestic workers in the homes of white families, but remained outsiders in spite of their intimate involvement in the lives of their "white families". Extending the concept to the academic world, the twice marginalized black woman has a unique perspective. Although I have never suffered the discrimination that many black woman in academia experience, as a female adjunct faculty member in the College of Engineering, I am, to a certain extend, an outsider within. In some ways, however, I feel more like an "insider without". I reap many of the benefits of an academician such as the opportunity to work among intellectuals, regular interaction with young minds, a flexible work schedule and an inviting workplace. And I do not have to deal with many of the challenges that academicians face such as the necessity to cope with university politics, the requirement to generate original research, the constant pressure to publish and occasionally unmanageable workloads. For some, the tradeoffs which include lower compensation and less prestige would be intolerable, but for me, those factors are not important. Thus "insider without" suits me and offers an opportunity to critique the organization from a unique perspective.

Limitations

As with most qualitative research, the generalizability of the findings of this study are limited. Because the study was restricted to a single Research I university, it would be difficult to extrapolate the findings to other Carnegie classifications. Also, this study focused on the faculty perspective and did not attempt to consider the student perspective. As with most qualitative studies, I have biases that influenced my approach to the study as well as my interpretation and conclusions regarding my findings. I am a member of the

faculty at the site where I conducted my study and an experienced practitioner in the engineering and engineering management fields. Thus, I clearly have biases about the importance of teaching communication and teamwork skills to our students. It was important for me to remain open-minded during the research process and to acknowledge my biases when interpreting the results. Although the study has limitations, it is expected that some of the conclusions will relate to the experiences of tenured and tenure-track faculty in fields outside of engineering who are also challenged by the numerous roles that they are expected to fill.

Chapter Summary

This chapter detailed the research questions and discussed the overall approach and rationale for the research design. The fundamental differences between quantitative and qualitative research were discussed and the researcher's motivation to choose a topic suitable for qualitative research was explained. The site of the study was described and the rationale for the site selection was given. Some important current events at the site were described and the impact of these events on the study participants was noted. The efforts to recruit suitable participants for the study were detailed and a description of the composition of the group of participants was provided. An overview of the different types of information (contextual, perceptual, demographic and theoretical) needed was included. The decision to utilize two sources of data: interviews and documents, was justified and the steps to collect the data were discussed. The section on data collection methods included specific examples of the documents that were collected and the interview questions that were asked. The data analysis section described the decision to

use qualitative research software and detailed the steps taken to organize, code and analyze the data using the tools in the software application. Finally, validity, positionality and study limitations were addressed.

CHAPTER IV: FINDINGS

The purpose of this qualitative case study was to explore the variety of ways in which faculty handled the numerous roles they were expected to fill. In particular, the inquiry focused on the response of engineering faculty to the increased emphasis on project teams in undergraduate engineering education. This chapter presents the findings of the study. First, important characteristics of the University and the College of Engineering setting are discussed. This information was obtained primarily from the official university website. Next, the findings resulting from the document analysis and the semi-structured interviews with the deans, department heads and tenured or tenure-track faculty are detailed. Six general themes, which paralleled the research questions, emerged during the analysis, thus the findings are categorized in that manner. The themes and the corresponding research questions are shown in Table 1.

Table 1: Research Questions and Emergent Themes

Theme:	**Research Question:**
1. What is the organizational climate at the site at the college and departmental level and how does it vary? What influence does the climate have on faculty with respect to the various roles that they are expected to fill?	Climate of the College of Engineering and the engineering departments
2. How do professors feel about teamwork in undergraduate education? a. How appropriate is the emphasis? What does it accomplish?	Study participants' opinions regarding the importance of teaching students to work effectively in teams
2. How do professors feel about teamwork in undergraduate education?	Influence of faculty members' personal experiences on their attitudes toward student teams

b. In what ways do the students and/or professors benefit? c. In what ways is this emphasis problematic for students and/or faculty? d. How comfortable are faculty members with teaching teamwork skills?	
3. What methods, strategies and teaching techniques do professors utilize to satisfy the requirements to teach teamwork?	Methods, strategies and techniques that faculty utilized with student teams
4. How do background characteristics such as ethnicity, rank, gender and experience affect professors' opinions regarding the importance of teaching teamwork skills, their comfort with managing student project teams and their consequent efforts (or lack of) to satisfy the requirement to teach teamwork?	Influence of personal attributes, background characteristics, and professional experiences on attitudes toward project teams
5. How do professors balance teaching loads with other responsibilities?	Competing roles, reward structures and workload issues

As you will note, the findings in this study were numerous. While it would be possible to consolidate many of these findings, the researcher elected to report each finding separately during this phase and reserved the consolidation efforts for the analysis and interpretation phase. As will be seen in Chapter Five, the analysis led to six concise and manageable conclusions. Appendix D provides a summary of the findings and Appendix E provides a matrix that links all of the findings to the corresponding conclusions.

For a number of reasons, no attempt was made to quantify the qualitative data collected. Much has been written about qualitative research data analysis and efforts to "quantitize" qualitative data by utilizing word or phrase frequencies to assess the amount of evidence in the data that supports a particular finding (Maxwell, 2005, Tashakkori & Teddlie, 1998, Boyatzis, 1998). Although coding of qualitative data is inherently subjective, many researchers have been successful in performing qualitative-based quantitative analysis (Chi, 1997, Baxter, 1996, Ward, 2007). However, for this study, quasi-statistical methods have been avoided for the following reasons. First and foremost, the interviews were conducted in a free-flowing manner. If a participant was particularly interested in a specific topic, much of the conversation revolved around that topic and other topics were, by and large, ignored. For this reason, quantifying the data could be misleading. Secondly, the researcher, likely due to a background that has been primarily quantitative in nature (engineering), was most comfortable with a more traditional inductive analysis for evaluating qualitative data. Qualitative terms such as: couple, few, some, many and most are used throughout the chapter to suggest patterns and are not intended to imply any precise effect sizes.

As indicated the specific findings are grouped into the following six themes that paralleled the research questions: 1.) Climate of the College of Engineering and engineering departments, 2.) Study participants' opinions regarding the importance of teaching students to work effectively in teams, 3.) Influence of faculty members' personal experiences on their attitudes toward student teams, 4.) Methods, strategies and

techniques that faculty utilized with student teams, 5.) Influence of personal attributes, background characteristics, and professional experiences on attitudes toward project teams, and 6.) Competing roles, workload issues and reward structures.

Theme 1: Climate of College of Engineering and the engineering departments

An important objective of this study was to investigate the climate of the College of Engineering pertaining specifically to the emphasis on project teams in undergraduate education. Review of the college website and interviews with the senior administration led to the following finding:

Finding 1.1: Officially, the College of Engineering administration indicated a commitment to incorporate teamwork into the undergraduate curriculum however the behavior did not necessarily reflect the commitment.

Based on the official college website, it was apparent that the College of Engineering had established an official commitment to teamwork in the curriculum. The following Strategic Objective was detailed on the website: (http://engr.arizona.edu/)

> <u>High-quality, broad-based education</u>
>
> Strive to provide high quality broad based education that will prepare students for productive careers in an increasingly diverse and technological society by insuring that graduates have an ability to function on multi-disciplinary teams:

Engineering graduates will be able to function effectively on teams using their knowledge of: 1.) team dynamics, 2.) team communication, 3.) social norms, and 4.) conflict management.

> As demonstrated by: 1.) successfully completing Engineering 102 team projects, 2.) performing at a professional level on a capstone design course, 3.) completing undergraduate team lab exercises, 4.) being involved in undergraduate research experiences, 5.) working as a co-op or student intern, 6.) effectively completing team-based reports in the above activities, and 7.) performing evaluations of team accomplishments.

Through these statements, the College of Engineering formally established their commitment to teach undergraduate students to function effectively on teams.

A senior administrator indicated that the motivation for incorporating teams into the engineering undergraduate curriculum was twofold. First and foremost, the motivation was to satisfy the needs of industry. Secondly, he noted the necessity to utilize project teams to meet the accreditation criteria established by ABET. A senior administrator stated:

> I think we would be doing this even if ABET didn't say you actually have to do this. And the reason is, when we send questionnaires out to industry, and we do that all the time, and we say 'where can our students use the most help', it comes back 'be better communicators and it's important that they learn how to work on teams'. And so we would be responding to that industry need regardless of whether ABET told us to or not. Now, it doesn't mean that our industry partners don't think our math and science and engineering stuff isn't important. We're pretty good at that.

Another senior administrator concurred:

> If you're solving any kind of relevant problem today, it is not a problem that is solved by just one engineering discipline. It takes multiple disciplines, and so working in teams to be able to solve problems…is pretty important.

Although the college website and the comments of the senior administrators suggested a strong belief in the importance of teaching teamwork in the undergraduate curriculum, the climate of the college did not reflect this belief:

> If you're a research-active faculty and you want to get tenure or full professor then the thing that you have to focus on solely is research and funding and graduating graduate students. Undergraduate education is not the priority. (Professor Kittredge)

Few tangible indicators of the college commitment to teaching students to work effectively in teams were apparent. To teach teamwork skills requires more than simply incorporating team assignments into classes. It requires many faculty to develop new skills. However, the college did little to encourage the faculty members to develop these skills. No professional development opportunities were provided by the college nor were any incentives offered to persuade faculty to seek out opportunities outside of the college:

> I never had any training on teaching teamwork or anything like that. (Professor Liu)

Additionally, faculty members felt little motivation to devote time to improving their skills as educators. The reward structure clearly influenced faculty to devote their time to their research efforts rather than teaching:

> You can get tenure or full [professor] and have mediocre teaching evaluations but you cannot get tenure or full [professor] with a mediocre research portfolio. (Professor Kittredge)

Unfortunately, faculty who were devoted to teaching felt little recognition for their efforts:

> The educational stuff is just because I'm interested, not because it seems valued, except by the students. (Professor Pearce)

Finding 1.2: None of the faculty members indicated that they felt pressure from the College of Engineering or their departments to include project teams in their courses, however some were guided in that direction.

Although the official position of the college indicated a strong commitment to teaching students to learn to work effectively in teams, the faculty were not particularly influenced by the college's position. The faculty members felt a great deal of autonomy with regards to their approach to teaching as can be seen in the following statements:

> I chose to, no one has told me to…you can conduct your course any way you want or any way you see fit for that course, no one's really telling you what to do. (Professor Guerrero)

> I think as long as we cover like 75 percent of what's described in the course description, we should be fine. So that's my understanding. (Professor Lee)

> It has usually been - here's the course, here's how it's been done before and then, sometimes, you at least need to do this. So you get a little bit of direction. (Professor Jenson)

Lab courses often necessitated the use of teams because of resource and time limitations:

> Part of the reason for working in these teams is that these are lab courses. I don't have time to supervise them all on an individual basis. (Professor Lord)

> If you have 15 students, you know, scheduling 15 hours is not very productive. (Professor Kittredge)

> Any time we have labs, we don't have enough resources so they always have to pair up…everybody works in groups. (Professor Jenson)

> It would be impossible to get everybody through the lab…It takes maybe three or four hours, so could you imagine even at with a 40-student class? It's still hard to get through all the labs in one semester if there's three or four labs. (Professor Graves)

Finding 1.3: It was generally accepted that teamwork would be emphasized in the freshman level Introduction to Engineering class (Engineering 102) and in the senior level Capstone Design course, regardless of who taught the course.

As many as twelve or thirteen sections of Introduction to Engineering were offered each semester. In order to maintain a level of consistency and to benefit from the synergy of everyone teaching the same material, all of the instructors were expected to use project teams.

> So this is at least one place where you could say, okay, we are doing this in every department throughout the entire college, at least we have one place where we're really giving that, and so I think that from an administrative point of view, [a plus] of doing it is that they know at least that they're satisfying that requirement. (Professor Sharma)

Some faculty members for Engineering 102 may have preferred not to use project teams, but because the class was designed to have students work in teams, none of the faculty opted to redesign the course. To teach the course differently may have been frowned upon by the course coordinator, but more importantly, it would have required significant effort to redesign the course so the faculty members rarely considered that option. In some cases, there was a reluctance to teach courses, such as Engineering 102, that strongly emphasized skills such as working on teams that were considered somewhat vocational. One department head said "There's strong reluctance to do that kind of course." Apparently many faculty members felt their time was better spent on activities they viewed as more important. Certainly, the reward structure did not promote

significant effort devoted to undergraduate education nor were these efforts respected among their peers. Thus, they didn't want to be bothered with the entry-level class which tended to include a lot of "busy work". Another individual in a leadership position said, "There are some that are really good at 102 and want to teach 102, unfortunately there's a higher fraction of faculty who get assigned 102 because they don't do anything else well." He added, "And that to me is the real tragedy of having people in that course that don't want to be there…It just drives people away."

Finding 1.4: Most departments had additional courses scattered throughout the curriculum that incorporated project teams but some departments found it difficult to find room in the curriculum for courses that utilized project teams.

In some cases, courses were well-established and utilized teams. Faculty members who inherited responsibility for existing courses which incorporated project teams typically continued to use project teams:

> [In one course,] the main emphasis was this group project so that they wanted to really make sure that the group project was still there. They wanted to integrate some stuff so there was definitely some direction in terms of how to teach that. (Professor Jenson)

> I think its sort of a class that is better oriented toward teamwork because it can be broken down in such a way that there is something that they can sort of individually do and sort of own a part of that teamwork, but then they still have to deal with the issues of integration. So it works very well in that course. (Professor Carson)

Some of the departments had very little emphasis on teamwork outside of Engineering 102 and the Senior Capstone Project. The faculty members in these departments generally felt their students would benefit if more courses included project teams:

> Some of the departments - it seems like they get it in Engineering 102 and then they get it in [the Capstone Project] and it doesn't happen anywhere in between. (Professor Wilton)

> There should be something like 102, but there should be something in between and then the Capstone. Engineering 102, course in between within the department, and then the Capstone design should go beyond departments - college wide - or even outside of the college. (Professor Demopoulos)

> I thought that giving it to them as freshman was very good. Now I do think that it would be a really good idea to reinforce some of those skills and some of those ABET learning goals, because I think that in many curricula you only get it at the front and the back. (Professor Kittredge)

Although they believed that students would benefit from additional courses that incorporated project teams, most did not feel there was room in the current curriculum to add any courses:

> Now if we want to increase more team project type of environment, team teaching, then there is really no place where we can sacrifice the units to do that. (Professor Chopra)

A senior administrator had a differing opinion. He felt that teamwork could be melded into current coursework without adding additional units:

> I think teaching team skills and communication skills is one aspect of the curriculum that is not only value-add but it can be done without new courses in team building or new courses in communications.

Theme 2: Study participants' opinions regarding the importance of teaching students to work effectively in teams

As expected, the opinions regarding the importance of teaching students to work effectively in teams varied greatly.

Finding 2.1: There was a strong belief that students would be expected to work in teams in the workplace after they graduated.

Most of the study participants had a clear understanding of what the majority of their students would be doing upon graduation. The majority of graduates would go to work as engineers in industry and they would often be expected to work in teams:

> I mean, our constituents are telling us the same thing, they want to get team projects. So we've been going through this idea of a team project for as long as I've been here and trying to get something that worked…And I think we're finally getting something that we think works. And our guys, our practitioners have been asking for it for a long time. (Professor Arnott)

Some discussed conversations they had with students that confirmed their beliefs:

> I was just talking to a student who's graduating. He was saying how, in his job, he has to get to know so many different things and so many

> different people and I say, yeah 20 years ago that was not the case. (Professor Demopoulos)

Others referred specifically to former students that were currently in the workplace:

> Because that's how our students work in industry…And I see what our alumni are doing…at every company you've always got one or two cowboys that sit off in an office by themselves and just grind away at something, but there's only one or two of them out of 1,000 or 2,000. Everybody else is working in teams. (Professor Higgins)

Still others based their views on their personal experience working in industry:

> The fact is, in the work environment, you frequently are working with total strangers who you know nothing about, who may be very productive or very unproductive…you still have to be productive in order to get your job done and your performance evaluation depends on success, not how well you can get along with everybody. (Professor Kittredge)

One faculty member had a different impression of the use of teams in industry. Professor Wilding said:

> I started asking our graduates and none of them were in teams. I mean, I had a student tell me he was on the [name excluded] team and I said 'How many thousands is that?' He said, 'Well, I don't know, but it must be huge'.

Finding 2.2: Many faculty felt that it was important to provide team experiences in undergraduate education to prepare students for industry but some felt that the focus on professional skills would detract from teaching more important subjects such as the fundamentals of mathematics, basic and engineering sciences.

Because the use of teams in industry was so prevalent, many of the engineering educators felt that it was important to give students an opportunity to develop teamwork skills during their undergraduate education because they recognized that their students had a wide variety of backgrounds and experiences and had unique educational needs:

> I have a lot of students who have very different personalities and they have a lot of conflict resolution that they have to go through…I've had some students that have come back and said that they did learn, not only the tools but working with others and that helped them in their internships and their jobs. (Professor Jenson)

Other faculty members took a more general perspective, suggesting that students could, for the most part, all be treated in a similar fashion:

> I think it simulates for them the condition and the situation of what it will be like for them in the future in industry. So I think in that regard it's very beneficial for them. (Professor Guerrero)

Some faculty members were concerned that too much emphasis on professional skills such as working on teams would impact the college's ability to teach the more important technical fundamentals of mathematics, basic sciences and engineering sciences:

> We used to have like 133 or 134 [credits] for graduation in engineering and now the state legislature says to make it within 128 units and engineering found out that it is not easy to cover everything in that 128 units. (Professor Chopra)

Finding 2.3: Most of the study participants were mildly supportive of ABET's criteria specifying that undergraduate engineering programs must demonstrate that their students have the ability to work effectively on multi-disciplinary teams.

All of study participants were aware of the ABET requirement regarding teams. Most of the faculty members had opinions about the accreditation requirements but did not seem particularly worried about meeting the criteria. Professor Chopra said, "I mildly support this idea of team projects, but I'm not a strong supporter of it." He, like many of the faculty, felt that providing students with a firm foundation in technical areas was of greatest importance. He was concerned that focus on professional skills could interfere with other educational efforts that he considered more important. Professor Carson had a fairly neutral stance. He indicated that some emphasis on professional skills was reasonable but it was clear that he too felt it was important that these efforts not detract from teaching the more important technical topics. He said:

> I think it's okay right now. I probably personally see it a little more focused on their ability to do their work as an engineer so they're more quickly able to jump into the workforce, but I don't think the requirements that we're putting on them in terms of the, you know, communication, the

> documentation, it's not too extreme to the point that they're losing out on learning other skills. (Professor Carson)

A couple of faculty members were strongly supportive of the criteria. When asked about whether it was appropriate to have a formal requirement that colleges of engineering demonstrate that their students have some of these skills like working on teams, Professor Kidd responded, "Absolutely. I think it's really appropriate and I think it's important that you engender that." Another supporter, Professor Kittredge, felt that the top-down approach was necessary. She said:

> It's true that many faculty think its pretty obnoxious that ABET comes down and says you have to do this, this and this and, you know, it kind of feels like parenting or nagging on some level, but I think that if you don't have it, it will never get done. And I think that by requiring it, it forces people to do things and to have conversations and to pursue lines of discussion that open up…what is ideally the right thing to do?...what are the right ways to work in teams?...what are the right ways to communicate?...how do those things impact your life, your success, the success of your company, of your industry, of your professional career or whatever? And so I think there's a lot of value to it, so no, I don't think it's a bad thing. I think you have to mandate it in order to affect change. It has to come from the top. I really believe that. (Professor Kittredge)

Professor Pickering was supportive of the use of project teams in undergraduate education if implemented prudently but was strongly opposed to the ABET criterion,

primarily because it specified “multi-disciplinary teams”. He said, “That’s asinine, because it’s not multi-disciplinary teams. You’re dealing with four people with the exact same skill set and saying, you’re this, you’re the expert in this, you’re the expert in that. It doesn’t work”. Professor Gonzales, who by and large supported the ABET requirements, agreed that the multidisciplinary aspect was somewhat problematic. Regarding the ABET requirements, he said, “they’re very common sense and something that should be in the program. With respect to the multi-disciplinary…it’s really hard to do in practice. I mean how do you, if you want to make it really multi-disciplinary that is, how do you have students of different disciplines working together, that’s a little harder”.

Most faculty members felt that the ABET requirements were adequately satisfied by the content in Introduction to Engineering and the Senior Capstone Project and, as such, they were not particularly worried about meeting the requirement. Few of the faculty felt concerned about the requirements to teach professional skills. The faculty, even those who believed that teaching students to work in teams was a worthwhile activity, appeared apathetic about the requirement and considered the ABET accreditation process nothing more than an administrative burden:

> The sense I get is that some of those sorts of professional skills that are emphasized by ABET are thought of as being focused on in particular classes. So like Engineering 102 or like the Senior Capstone, so those are two places where they certainly get that. And so my sense is that in faculty discussions our discussions mostly revolve around making sure

> that all those things are covered somewhere, but not necessarily every skill in every class. (Professor Kittredge)

Professor Embrie, an Assistant department head, was concerned about the difficulty of assessing whether the ABET requirement was met as revealed in the following statement:

> I mean how do you demonstrate or document, and I even asked one of the evaluators one time…I said, 'Well if you go up for your ABET evaluation in two years, how are you going to document this?' and they didn't have an answer. When we're dumping it at them, we're exposing them, but are they learning it? I mean, the whole ABET thing is, 'are they learning or have they learned these things?' and I'm not sure what it says as far as the multidisciplinary team … I mean how do you verify that? (Professor Embrie)

When asked how he determines if the students have learned how to work effectively on teams, Professor Guerrero, an instructor for Introduction to Engineering, said, "I don't think, in my courses, I really barely try to assess [whether students learn to work effectively in teams]." Interestingly, this faculty member favored teamwork in undergraduate education, but placed no value on assessing the ability to effectively teach teamwork. Another Engineering 102 instructor, Professor Liu, implied that it was just a formality when he said, "I think we do a checkmark. We covered it. Did we cover it, you know, did we give them a couple lectures, throughout their curriculum? …that's about the extent of what we do to prove that we've done it…I think, for the most part, departments kind of say, well we use teams, therefore we meet the requirement."

Clearly, his attitude was contrary to ABET objectives to move the focus from what is being taught to what is being learned. Substantial literature suggests that merely telling students about teamwork in "a couple lectures" is unlikely to make them effective team members (Lewis, Aldridge & Swamidass, 1998, Feitchner & Davis, 1984, Felder, 1994).

Finding 2.4: Some faculty members thought that important interpersonal skills could be learned through experience and that undergraduate courses were a suitable place to teach these skills while others did not.

A wide range of opinions regarding the feasibility and appropriateness of teaching interpersonal skills through teamwork experiences were apparent. Some faculty members were strong supporters; some were mildly supportive while others were adamantly opposed. No differentiating characteristics were identified among the various groups.

Interpersonal skills such as effective communication, cooperation, coordination, adaptability, leadership and conflict resolution that might be refined through project teamwork were discussed by the following professors:

> I think even the weakest benefit, even if they don't have any benefit in their learning outcomes - just going through [the experience of working on a team]. I mean, to me, that's the number one reason to be in college…I think giving these students these experiences is - I'd trade that for doing teacher's work any day. (Professor Gomez)

> I think that we realized that we can't possibly prepare a student for absolutely everything that they will face technically in their career. But

> what we can prepare them for, and show them, is how to learn and how to survive. I think if we show them that, then if they need more of the technical part, they'll figure out how to get it. But I think if we err too far on the side of just science and engineering fundamentals we'll be losing the big piece, which is to show them that there are these other skills that are probably more important to have over your career because they're the bridge to these other things. So we might not show you these other areas, but at least we built the bridge to get there and I think that's probably more important than exhausting the list of fundamentals. (Professor Graves)

Some faculty members discussed specific skills, such as leadership, that students developed as a result of working on teams:

> Almost always, somebody steps up as the leader of the group, which I think is another great reason to be in groups. You learn about yourself and you learn about other people. (Professor Wilton)

> Well part of what we do here, I think, is preparing students for life, you know, in addition to teaching them engineering and how to make use of their math skills and physical sciences to attack problems that relate directly to engineering. I like to think that many of our graduates are going to be leaders in society as well. (Professor Lord)

Effective communication with those outside of the engineering profession was noted as a critical skill for students preparing for their careers:

> ‘Even though you’re all engineers there might be people on your team at a company that may not be engineers. They may be lawyers or you might have somebody looking at environmental or business or some other aspect and you’ll have to find a common language and that’s often very difficult, finding that common language so you can communicate effectively.’ So they see it on a small scale, even though they’re all engineers, they do see it on a small scale. But it’s really to prepare them for industry or even graduate school. (Professor Graves)

> To survive in the business environment, you not only have to have a skill as an engineer, but you have to be able to convey that skill to someone who’s a non-engineer…and being able to communicate…articulate what you’ve done to someone who’s not an engineer is pretty important. (Senior Administrator)

Some faculty members were unsure whether teams at the undergraduate level helped students improve their interpersonal skills and doubted that it was important or necessary to focus on teamwork skills in the undergraduate engineering curriculum:

> And so, of course, people should know how to interact in a team environment but maybe only 25% can be taught, the students can be trained at the university environment and 75% will have to be individual. Some of these things, like management, team things, these are something people inherit. So I don’t know, you can only kind of nourish them…the main thing is that this little exposure of trying to force them to work in a

> team environment, it gives them the experience whether it really improves one's capability of working in teams, I don't know, I'm not so sure. (Professor Chopra)

> You know, to be honest, I don't think you learn it by taking senior design class or a little design project in Engineering 102. I mean, you know, by this time in your life you either know how to get along or you don't. (Professor Pickering)

Neither of these faculty members placed much value on professional skills in engineering education. They viewed it as too vocational, something they shouldn't waste their valuable time on. Interestingly, both of these faculty members completed their graduate work at highly prestigious universities. Both were confident in their beliefs, making bold statements, such as "some of these things, like management, team things, these are something people inherit" and "you either know how to get along with people or you don't" which, in their minds, may have justified their attitudes. Neither felt the topics were worthy of serious consideration. Rather, they rationalized their beliefs by suggesting that these skills could not be taught, that they were inherent abilities. This attitude ties to another finding (Finding 2.2) that many faculty members believed that too much focus on professional skills would detract from teaching more important subjects.

One faculty member, who declined to be recorded during the interview, felt that teamwork skills are quickly and easily learned by graduates once they are out in the work place because there are financial and professional rewards for being an effective team worker. He felt that it was more important to focus on the fundamentals of math, science

and engineering for students in their undergraduate education. This faculty member was highly regarded in his field. His attitude, in some ways, contradicted prevalent opinions regarding effective teaching, but because he was such an expert in his field, administrators, peers and students tended to overlook his shortcomings. In fact, they were not considered shortcomings, but rather idiosyncrasies. It was as if he was admired even more because he stayed above all the nonsense of people getting along, he was on a higher plane.

Professor Graves had a different opinion about how and when people learn to get along. He said, "Nobody has an innate ability to work in a team necessarily. In fact, for most of our undergraduates, we teach them just the opposite most of the time. So we have to really teach them how to function properly in a team."

Theme 3: Influence of faculty members' personal experiences on their attitudes toward student teams

Faculty members, for the most part, had very similar experiences with student teams. For example, many struggled with team composition; although some gave it very little thought and assigned teams randomly. Most occasionally learned about teams that were experiencing conflicts, but some chose to ignore these while others offered assistance. Most were concerned about fairness in grading. Again, some made considerable effort to achieve fairness while others assigned a single grade disregarding differences in individual contributions. A couple of faculty members made significant effort to evaluate the effectiveness of using project teams in their courses but most made little or no effort to assess the outcomes of the teaming experience. Thus, very diverse

attitudes toward working with student teams emerged. The past experiences of the faculty members, in some cases, seemed to influence their attitudes.

Finding 3.1: Most faculty members acknowledged that it was somewhat difficult to the simulate teamwork in industry because of the nature of the tasks, the limited skill sets of the students and the brief amount of time available. However, most felt that they were able to create an acceptable likeness to the real world.

A primary motivation for giving students an opportunity to work on teams was to prepare them for industry. It was difficult to exactly replicate the industrial environment, but most believed that the effort to emulate the conditions in the workplace were adequate:

> You know it does simulate it to some extent. At least in the area that I do most of my research, which is embedded systems, in industry you get a point where these components will have some sort of low level hardware design and they'll have some software and they usually split them up and the teams sort of work in parallel on each and then at some point they do have to come together. And this is where you get a lot of these issues that come about in terms of well, I made one assumption and you made the other assumption and now it doesn't work because we assumed different things. And so then they have to make those corrections. And so this definitely comes up in industry and so for [our class] the dynamics of that integration are maybe not to the complexity we get in industry but they're

> at least indicative of the types of problems that are dealt with. (Professor Carson)

Some of the faculty members noted the differences between the university and the "real world" but discounted those differences as inconsequential:

> Some of it is always going to be artificial because we really can't create - I don't know if we'd want to create - the same pressures that you have in industry. … The evaluation we give is a grade and in industry it's not quite that way. It's completely different how you're assessed. So I think we only can do so much, but I think what we can do is at least get them thinking in that direction and show them that it's important. (Professor Graves)

> The only part of it that does not simulate industry is that in [the Capstone Project] that may be short or long, or deadlines may be more strict, consequences may be much worse than getting a lower grade. So, beyond those though, it's pretty realistic because they're interacting with industry sponsor/mentor and the requirements are often industry related, not so much the kinds of things they're used to in theoretical or lab courses. (Professor Sharma)

Finding 3.2: Most faculty members had limited knowledge of the theories of cooperative learning but readily expressed opinions about the benefits (or lack of) in undergraduate engineering education.

It seemed that very few faculty members had more than a superficial knowledge of the theories of cooperative and collaborative learning, but expressed their attitudes about the topic with considerable confidence nonetheless. This suggests that these faculty members did not view their teaching as research-based. Had the discussion been related to a relatively unfamiliar technical topic, it is unlikely that they would have expressed their opinions with such a high level of confidence. One faculty member who had a depth of knowledge in the theories of cooperative learning had clear evidence of it amongst his students:

> When they do teamwork, they tend to work together, outside of my efforts, and ask each other lots of questions. (Professor Pearce)

For several, the benefits to both the students and the faculty members seemed obvious:

> I think it's a natural fit, in the pedagogy, because actually the students learn better when they are in a team. From one another and it makes it easier for them as well I think because they can bounce off ideas from one another. There is a cooperative learning or collaborative learning that occurs…even synergistic I would say. For an individual student to work with an open-ended project like that, at their level, would be probably too intimidating or overwhelming. But when they have people to talk to and, you know, they can brainstorm, it gets easier for them, it's more manageable. (Professor Guerrero)

Some faculty members related how their students benefited from group work especially when the tasks were sufficiently challenging. This finding coincides with another finding

(Finding 3.5) that faculty members felt that students only benefited from project teams when the nature of the task was suitable.

> No matter how good you are, you always encounter difficulties at some point and by sharing those difficulties and working through those difficulties with another, also interested student, then both of them learn. And that's the theory and that's what the empirical work shows. That's why I do it and it does work -- I expect to see that and that's what I see, of course. It's not a valid experiment but I do see that they do benefit. (Professor Gomez)

> I think it can help students understand the problems each of them are having. So if one student has a problem, the other one is able to help them. I think that in the end, you know, it helps the students to sort of figure 'oh, I see where the problem is' and they learn from that instead of just sort of working at it and trying to work around the problem without actually understanding why that's happening, whereas another student might have that intuition and help them out. So I think those are some of the benefits that come about from it. (Professor Carson)

Engineering students often work in study groups when solving homework problems. Many faculty noted that cooperative learning often occurred in informal groups:

> The homework problems are difficult and … sometimes two heads are better than one, in terms of trying, you know, you try it that way I'll try it

> this way and see if we get the answer. That definitely helps. (Professor Pickering)

One participant in a leadership position questioned whether faculty believed that students benefited from cooperative learning on their project teams. He said, "I'm not sure that the faculty is convinced there's a lot of cooperative learning going on. I mean, the complaint always is, how do we know who's doing the work, I mean, there's skepticism in the process."

Some indicated that the additional burden of working with a team in some cases outweighed the benefits of cooperative learning:

> It always takes longer man hours to do a project with a team and you get a different result when you do it with a team, whether it's better or worse that would be real hard to evaluate. But a lot of what's going on is the team puts an additional communication burden upon them. (Professor Higgins)

Professor Pickering repeatedly expressed concerns about the value of project teams for students. However, it is important to note that he was a strong advocate of quality education and devoted considerable time to his students, he simply doubted whether team projects were the best use of student and faculty time. He said:

> I was talking to a student last Friday walking back to the department and he said, 'What you get out of it is a lot less than what you put into it, so it's a huge amount of time and you learn a little bit in terms of maybe what they want you to learn on the design or maybe working with people'. But

> it's a long run for a short slide as opposed to another class where you might learn a lot. (Professor Pickering)

Finding 3.3: Some faculty members thought it was sometimes beneficial for gifted students to experience working with less talented or less motivated students but often, the most gifted students suffered. On the other hand, many felt that weaker students often benefited from working with stronger students.

Without exception, faculty recognized a very wide range of students, ranging from "slackers" to gifted students. Faculty members expressed significant disdain toward slackers who were students that consciously did very little work with hopes of benefiting from the efforts of others.

> If you get on a team with slackers, you're getting some life experience and I'd say to the top students, the ones that are conscientious and productive, this is going to happen to them over and over again after they graduate…I say, 'well, look you're a great student and you're going to make a great engineer and you're going to be very productive and savvy. You're going to bump into this over and over and over again'. (Professor Lord)

Stronger students often did not know how to deal with weaker students and faculty members resented when their best students were negatively impacted by less motivated students.

> We attract a lot of the Type A type of people who, you know, want to -- they see themselves as CEOs someday and they don't, you know, they don't look too kindly on having a few, you know, a slacker bringing their

> grade down because they want to go to Stanford for grad school or MIT for grad school. One B and you're out of the running, so you get that. (Professor Pickering).

Some faculty members thought that the stronger students sometimes carried the weaker students. According to Professor Gomez, "they benefit because they get through it." Several other faculty members agreed:

> It sure pulls a lot of marginal students through. You know, you can say they're getting a free ride if you want, but that's what life is. (Professor Higgins)

> Mostly those who are having difficulty working independently, they team with the other students. But the very bright ones, they just do it by themselves, they don't need any help in those courses. (Professor Chopra)

Finding 3.4: Faculty members had not given much thought to whether project teamwork promoted social networks or whether enhanced social networks helped improve the retention in engineering, but most were willing to comment on the topic.

As with other topics addressed during the interviews, faculty members commented quite readily about project teamwork and social networks even though they had given the topic little thought in the past. The majority of the study participants who commented said that they thought project teams helped students form social networks, particularly early in the college careers.

> Both of them have reported to me that some of the people they were on the team with in Engineering 102 have remained part of their circle of friends as they've moved through college. So I do think as freshman there is an additional social benefit that it helps you network very quickly in your first semester in college… So the things you're dealing with on a social level are very similar and so yeah, I think it definitely leads to social networks. (Professor Kittredge)

> They started out, didn't know each other at all, and by the end of the year they were very good friends, you know, I can see that they will be lifelong friends from there on. (Professor Liu)

Others noted that the students generally seemed to like working on teams because of social aspects:

> They like the teams. Because most human beings are social creatures and they would rather talk with another person than go and read a book or solve equations. (Professor Higgins)

> You sort of get the sense that, you know, they all feel sort of linked with each other. And usually towards the end of the deadline they're spending so much time in the lab, you know, it seems to sort of help in a sense of 'it's not just me against the world.'…You know there's this group of people that are all in there together…I think the sense of community and

> working together…it makes things a little, you know, more enjoyable. (Professor Carson)

However, Professor Pickering doubted whether students understood networking from a strategic point of view. He said, "I don't think students know much about networking at all. They really don't." Professor Jenson believed that students who didn't establish networks were more at risk of leaving engineering:

> If the student's motivated, then they will look for that network and they will look for the help. If the student doesn't want to, there's nothing I think you can do and those are the students I think that are more at risk of dropping out or not finishing. (Professor Jenson)

Finding 3.5: Faculty members consistently expressed the importance of including teamwork only in courses that were suitable for project teams.

Faculty members universally agreed that student teams were appropriate for design courses and laboratory courses that included open-ended problems:

> I see the teamwork for the students as a natural thing for this kind of project…For an individual student to work on an open-ended project like that at their level would be probably too intimidating or overwhelming. But when they have people to talk to and you know, they can brainstorm, it gets easier for them, it's more manageable. I think that was the most important realization I had about teams, it's a natural fit as a pedagogy for design projects that are more or less open ended. (Professor Guerrero)

> So the motivation in [this course] is really that the types of projects that they're dealing with. They're dealing with a lot of stuff that's sort of all thrown at them at the same time. They're dealing with, you know, software. They're dealing with hardware and they're trying to get everything together. So the problem is that if they're just working on their own, they really don't have the ability or the time necessary to dedicate to taking care of everything by themselves, so the teams work out very well. (Professor Carson)

Some felt certain that teams were not suitable for the classes they taught. Several faculty members clearly believed that project teamwork would not enhance the educational experiences for the students in their classes. However, the fact that these faculty members did not use project teams was not necessarily an indication that they were opposed to them but rather that their courses were not amenable to project teams:

> This particular class, because it's a more basic concept type of class…it doesn't have a lot in terms of practical projects where we give them a project and say, okay, solve this or figure this out and come up with an optimum. We're trying to give them the tools they need to be able to take that step. It's not as amenable to teams because of the fact that you're trying to give them individual tools now. (Professor Kidd)

Professor Pickering was thoughtful about the appropriateness of project teams. He promoted informal collaboration amongst his students and recognized the benefits they

realized from those collaborations. However, he objected to imposing requirements to work in teams when the nature of the course did not warrant the use of project teams.

> It's the nature of the course. I don't mind people collaborating, you know, working together to solve homework problems, but there is no sort of design project that multiple people can work on, so the subject doesn't come up like I've made a conscious decision to have or not to have team projects. (Professor Pickering)

Finding 3.6: While some faculty members seemed rather apathetic regarding the specific logistics of using project teams, nearly all of them had opinions about the influence of team composition.

Most faculty members felt that the team composition was a critical factor in determining the value of the experience as well as the likelihood of the success of teams but few were able or willing to do much about it. Of those who thought team composition was important, many didn't really know what factors were most important in creating teams and had insufficient knowledge about how to form the teams so they chose characteristics that they suspected might be important. Professor Pearce discussed his personal experiences as an undergraduate student:

> I learned two things about teamwork when I was an undergrad. I learned bitterness and regret because the ways that the teams were formed were not acceptable…I only had one team that actually worked well out of all my undergrad teams…so I knew I wanted to capture that when I came here and I knew that teamwork was good for students. (Professor Pearce)

Others talked about the outcomes with various team compositions. Professor Lui found that personal relationships could be affected by experiences working on teams. Thus he felt that students should not be given the responsibility of determining team composition:

> I have seen teams that formed mainly because they were very good friends. But then after that year of working on the project together then they're not friends any more. I found the other extreme too where, you know, they started out, didn't know each other at all and by the end of the year they were very good friends. (Professor Liu)

Professor Kittredge, a female faculty member was very concerned about the impact of team composition on female students. Through experience, she discovered that women often performed a disproportionate amount of administrative work on teams when they were in the minority:

> I really tried to put groups of women on teams and, by and large, that got very good reviews. I actually talked to female students and took them off to the side and said, 'What do you think about this? Did you think this was the right thing to do? What did you feel like?'…In a team with only one woman…a lot of times the woman got, you know, relegated to writing the reports and doing all the grunt work, while the guys did all the fun work and that I really, really didn't like. (Professor Kittredge)

Finding 3.7: The effect of team project grades on students' individual grades was a major concern for most instructors who assigned project teamwork.

It was apparent that most faculty members were very concerned about grading teamwork. As Professor Arnott said, "It's not an easy task, it certainly isn't, especially when you start looking at the overall project and what people contributed." Because most of the work on teams was performed outside of the classroom, it was difficult to assess individual contributions to projects. Faculty were concerned about fair treatment of students:

> I don't really know how to deal with this grading…I see it's unfair for some and it seems unfair and I don't know how to tell them, you know, that this is important just to get to brainstorm…(Professor Demopoulos)

Professor Pickering, who, on the surface, seemed apathetic, expressed his genuine concern for students in his thoughtful comments about the impact of group grades on individual students:

> In academia everyone [usually] gets the same grade on a project and so if people tend to slack off then I hear nothing but complaints from students about who's in their team group on the senior design projects. My only familiarity with it is hearing the complaints from the students that work in my labs saying, oh we've got so and so in our group and he's already got his job lined up and so he's just on auto-pilot and doesn't care about grades, et cetera, et cetera. (Professor Pickering).

Finding 3.8: The most common conflict that faculty members dealt with was "slackers".

Although faculty members perceived that conflicts amongst team members were rare, all of them disliked handling them. As Professor Carson said, "sometimes these problems do come up. It's never something you want to deal with." A senior administrator commented on the faculty attitude towards dealing with conflicts:

> I think the difficulty for our faculty is when they're put in the middle and they don't really know how to deal with it - one of the students doesn't really work well on the team; the student isn't meeting deadlines - and so what happens then is the students start to complain, you know, 'So and so isn't doing what they said they'd do, what do we do now, sir?'…I think the faculty are largely conflict avoiders, and that's the kind of stuff they can't deal with very well…it's the dealing with the conflict and they just don't want to be bothered in some sense, you know.

By far the most common complaint from students was about team members who did not perform up to acceptable standards. Some reluctantly accepted that it was probably good for the students to experience the negative aspects of teamwork:

> I guess that's part of life. There's always somebody on the team that is the slacker - and I'm pretty sure that happens on the teams that we have. (Professor Lord)

In some cases, the problems were more related to different approaches rather than to a particular student. Professor Jenson recognized that differing abilities among teams

members presented problems for both the brighter, more gifted students as well as the weaker, less ambitious students:

> The ones that don't work out very well I guess you could categorize it as two types. One where the students don't want to really participate, then there's the other groups where one person gets frustrated or they're just much more motivated, so they end up just doing all the work. Not because the others aren't necessarily willing to help just because, you know, they have motivation to get things done or they really like the projects and said let's just jump in and do all this stuff. And so by the time the other students get around to saying oh, I'd love to help. Well, that's already done. (Professor Jenson)

Theme 4: Methods, strategies and techniques that faculty utilized with student teams

Many faculty members referred to specific methods, strategies or techniques that they have used while working with project teams. Among other things, they addressed team composition, dealing with conflicts, grading and peer evaluations.

Finding 4.1: Some faculty had strategies to make their students feel important and valued.

Some faculty members were very concerned about the student experience. Consistent with research, most of those who were deeply concerned about treatment of students were women. Professor Bramble talked at length about her efforts to treat students well. Unlike many faculty, she successfully devoted considerable energy

towards teaching while maintaining a substantial research program. She described her conversation with another female faculty member who suggested a strategy for remembering students' names and improving team bonding:

> Professor Yodsuwan made a very good recommendation that I employed this year. When the teams get together, she said, take a photograph [so you can refer to it as needed]…when it comes to teaming, when it comes to Engineering 102, when it comes to the bigger goals as a college; retention in engineering and even in maybe the discipline, I think that the little extras like taking the photo and getting to know their names…I teach my tech electives and the students are like amazed that I know their names. That's shocking to me. (Professor Bramble)

Another female faculty member expressed her commitment to improving the student experience. Throughout the study, women faculty repeatedly expressed sensitivity to the impact of their teaching efforts on their students:

> I think about it all the time, making sure that I'm treating people with an equal level of respect throughout the class. And so I think that's quite successful, because I know that on the evaluations I get very, very high ratings on that metric. (Professor Kittredge)

Finding 4.2: The effort faculty put forth to determine team composition varied greatly.

Some felt that the teams should be randomly formed to simulate the way teams are formed in industry while others thought specific criteria, which varied among the

faculty, should be considered. Still others thought that teams should be allowed to self-form. It appeared that the different approaches were based on past experience or advice from peers rather than knowledge or recommendations from experts in the field.

> No it's always random, in my case, it's always random. I know some professors, they try to mix and match students, maybe number of women and men or whatever fashion, but me, I disregard that entirely and my rationale for that is that in industry a lot of times you don't get to choose who you work with. (Professor Guerrero)

Some believed that teams were more successful if the students were allowed to form their own teams. It is possible that these faculty members chose this method hoping that conflicts among team members would be minimized. Also, by allowing teams to self-form, faculty, in some sense, were relieved of responsibility for conflicts that did arise:

> I want three or four people on a team, you form your own teams and it works. I mean usually people pick their friends…they are more comfortable if they get to choose their teams. (Professor Higgins)

> I specifically tell them that you should partner up with somebody who has the same level of motivation and desire to put forth in the class as you do. I think it's a lot better, I mean just from the approach that if you're going for an A and the other person just wants to pass the class with a C, you know, usually what ends up happening is one person's going to do all the work just because he wants to get his A. (Professor Carson)

Others felt that allowing teams to self-form did not simulate industry adequately:

> Some instructors will have the kids just pick their own teams and let them do whatever they want, basically. That's probably not a real model in industry, that doesn't happen. Uh, you don't really just get to pick. (Senior Administrator)

Professor Bramble explained a strategy that seemed to work for several of the faculty, she said, "when I make the teams, I actually assign it based on schedule." In this strategy, faculty attempted to form teams that had compatible schedules to minimize the difficulty of finding a convenient meeting time which is often a major problem for student teams. Professor Wilding "tried to develop a logic based on geography" so that students living on-campus were teamed together and those living at opposite ends of town were not teamed together. In one department's senior design class, other criteria for determining the team makeup were utilized. According to the department head:

> They do not get to choose, they're formed…they submit their interest areas and then the faculty chooses them based upon making sure each group gets someone who's interested in each area and then sort of looks at the GPA's and mixes up the highs and the lows. (Professor Arnott)

Gender and/or ethnicity were sometimes considered when forming teams. The following comment shows the concern that Professor Kittredge, a female faculty member, felt for females and minorities that were underrepresented in the engineering profession:

> I actually did try to put teams together as much as possible where you had more than a critical mass of women... what the kids experience then, is if there are a bunch of guys who are on a team with women for the first time,

> I think that there's definitely an advantage, or even with cultural diversity, you know, I'm kind of focusing on women, but its equally true of minorities. (Professor Kittredge)

An emeritus faculty member, through years of experience, had concluded that some ethnic/gender mixes could be problematic:

> I generally tried to put two women together on a team if I could and I also avoided putting middle-eastern guys with American women.

(Note: this opinion was unique and atypical of other comments but confirmed the finding that some faculty depended on past experiences in making decisions regarding team composition.)

A couple of faculty members used team formation as an opportunity to discuss learning styles and team dynamics with their students:

> I usually have them take some sort of survey that shows what kind of learner they are…so I start off in having the students do this and then reporting to me what [type of] learner they are…I take all that information and I present the class as a whole, as an aggregate, and I just show that 'here the class is', and then, I show them my results…So then you go through the structure of how the team should be composed…That's typically the way I approach the team learning in a lecture course, but its not over one lecture. It takes some time to develop this. (Professor Graves)

Professor Pearce was an exception in many ways. He was a truly motivated educator. He was very versed in the education literature and devoted significant effort to maximizing his teaching effectiveness:

> I had a thought of pairing them based on skills…if it's a presentation, you need someone who's an extrovert, you need someone who can do PowerPoint, who's pretty good at it and maybe visual. You need someone who can do the math and then you got a whole slew of people who are jack-of-all-trades that don't want to categorize. So I created those categories and the groups actually functioned really well…the students seemed pretty happy with it and it seems to have gone well, so I've always paired students by ability and skill sets. (Professor Pearce)

Finding 4.3: Many different approaches to grading were apparent.

Some faculty members awarded the same grade to all team members but acknowledged that it was often unfair to the stronger students. Others attempted to adjust grades based on individual efforts. It was not clear why faculty chose one strategy over another strategy, however, fairness to students and amount of effort for the faculty member seemed to be important considerations.

> So when [another professor] and I co-teach design, typically everyone gets the same grade. We kind of go back and forth on the philosophy I think. She seems to be of the opinion that the team rises or falls as a whole and if there's one person who doesn't carry their load - well, the other people made the team successful. (Professor Pearce)

Professor Jenson recognized that it was unlikely that individual contributions on every project would be equal so she encouraged students to balance the work over the course of the semester:

> At this point I give it 50/50 [for two-person teams] so I don't have them do ratings. Other professors do but to me it tends to take more time and it tends to get more confrontational when they want to argue that I did 40 and you did 60 or I did 45 and you did 55. So I try to say, you know maybe if your partner is not as involved in the first project maybe they can take more of a lead in the second project since it's multiple projects over the semester. (Professor Jenson)

Other faculty members tried to adjust grades on group assignments to account for individual contributions. In some cases, instructors used peer evaluation techniques. Only one faculty member referred to the extensive literature on the subject. The rest seemed to use common sense and practical experience for developing this methodology and had very little basis for their approach.

> If I've met the team often enough I usually have a good idea of whose been contributing, but often I'll have each individual report on whose contributed what and I'll just look at how many reports are there and I'll try to come up with some way to assess a score to each of the contributions. And what I've found is students are usually pretty honest when it comes to that. (Professor Graves)

While grading the capstone project, one department attempted to simulate the way in which professionals in industry account for individual efforts on projects. It was apparent that the methodology had evolved over many years and Professor Arnott was satisfied that they had found an effective way to account for individual contributions:

> We ask people to say how much they contributed and what weight they have and we have them submit time sheets from the semester and all sorts of things. So we have a pretty good idea of what's going on and we also have a project manager for each of the teams. Usually one of the brighter students takes responsibility. He or she is less involved in the technical aspects of doing the calcs for individual sections. But he's well aware of who's working and who isn't. (Professor Arnott)

One faculty member waited until the final exam to ask for peer evaluations. This avoided the potential of negative peer reviews adversely affecting team relations during the course of the project:

> On the final exam, the last page is rating your teammates. So if there is a team mate that doesn't participate they can give them zero points or if somebody is really weak they can give them only a few points and then I take that page and I use it – only for outliers, if everybody's, you know, kind of weighted around the same, it's fine, but if there's an outlier then I dock them and I say, 'Look, your teammates rated you very poorly because you didn't participate' and it hurts their grade. And I think that's important. And I actually tell them, that if they don't participate, your

> teammates are going to have an opportunity to let them know. (Professor Wilton)

Some said that it was a lot of extra work to account for individual performance on teams and therefore chose not to do so. This is consistent with the finding that there was little motivation to invest the required effort, even if it was in the best interest of the students' education:

> But I would say recent years I've gotten lazy. I used to, up until a couple years ago, I used to ask for peer evaluations also...And then at the end of the semester, I would look at all those, look at those data and that was part of the grade. (Professor Lord)

> I don't do [peer evaluations or individual weighting] because I just haven't put in the business process to do it. I just haven't. I feel like I should though. (Professor Gomez)

Some said that their students didn't like to or know how to evaluate their peers and implied that they did little to teach them how to effectively perform a peer evaluation:

> Well a long time ago, with Engineering 102, I tried having the teams evaluate their performance. And if there's four of you on a team you got 100 points, assign them according to what you think the contribution was of each person and then they ask, well what do you mean by contribution, is it how many hours they spent or how many good ideas they put in or what the product was that they produced? And I would usually just wave my hands and say do whatever you wanna do and a lot of the teams would

> just, if there was four people they would just say one fourth, one fourth, one fourth, one fourth. So I didn't see that the students appreciated doing that and I didn't get anything out of it. (Professor Higgins)

Since evaluating peers is an important part of the engineering profession, Professor Graves planned to teach his seniors how to effectively perform a peer evaluation:

> Next semester I'm teaching the seniors who are ready to graduate in a course of process control and what I'd like to do there is they'll do various projects but I'm going to have peer reviews of the projects and I will review the peer reviews. In other words, I want to see how they review their peers and I'm going to put an assessment on the review. (Professor Graves)

Some felt they needed to have some form of documentation to justify giving a team member a lower grade than their teammates:

> When I do the project, I tell them that you have to tell me every week what you're doing. So they have to give me a piece of paper that says this week I did this, this, this…So that there's evidence that I'm not going to give you a higher grade or the same grade as the other, because you haven't done anything…When they write a report they actually have to tell me who is responsible for this section, who is responsible for this section and who is the one that added everything together. So they have to be very specific about that, so that I know what the contribution of each member is. So everything is, you know, laid out like that. (Professor Liu)

Finding 4.4: It was apparent that faculty members disliked dealing with conflicts among team members and most of them tried to 'make it go away'.

Most faculty members found conflicts among team members very trying and wished only to avoid them. Because there was little incentive to devote effort to teaching students the interpersonal skills required to work effectively on teams, most faculty members tried to eliminate problems among team members as expeditiously as possible. A couple of faculty members had occasions when they thought it was in the best interest of the students' to split up the group:

> So one of the groups, I actually ended up splitting them apart and had them work by themselves because it was just too distracting, they didn't get anything done. (Professor Jenson)

> Every semester I have somebody come in and they complain about somebody and I say, 'well you can fire them…if you wanna fire somebody on your team, you can do it, but you have to do it legally, just like any company would have to do it. That means you gotta put it in writing - this is what you are supposed to do, by this date, and you give it to them and everybody signs it…you do that for a month and then you fire them'. (Professor Higgins)

Others felt it was important to keep the groups intact, even when they had conflicts. However, the faculty members did not appear to have sufficient knowledge about how to help the team become more effective. Nor did they invest effort to learn strategies for helping the teams:

> I just tell them, 'look, that's part of being on a team and we always find a way to deal with it'. I've never broken up a team, even the teams that don't work very well. I've never broken up a team and said okay, we really have to stop this because its gotten so unproductive that -- I try to turn it back on them and say well, in industry often you have to work with people that are not -- that you didn't choose and you have to find a way to work with them. You may not like them, you may not respect them, but that's what you've got. You've got to figure out how to do it. (Professor Graves)

Professor Kittredge described what she told a group of students that was having problems and how it seemed to help:

> 'Sometimes you get people who are very productive and brilliant. Sometimes you get people who aren't and either way your success depends on the success of the project and you have to work around it. You have to figure out ways to work with these people and make it productive. So you know at this point all of your grades are resting in part on your ability to make this team work...this is not an episode of "Survivor" and you don't get to vote team members off the island. We're done, you know, this is it. This is your team.' They actually related to it…in an oblique way, it was kind of an effective statement, but the result

> was that, by the end of the semester, they were working together as an incredibly successful team.
>
> (Professor Kittredge)

Some chose to change the groups throughout the semester even if no specific conflicts had arisen. This is consistent with findings that faculty resented when stronger students suffered from having weaker students as teammates:

> My main motivation for doing that is I didn't want anybody to get stuck with the same slackers all the time. In fact, this semester I had two projects and, on the second project, I think I intentionally picked some students I thought weren't doing much and put them all on the same team. (Professor Lord)

Theme 5: Influence of personal attributes, background characteristics, and professional experiences on attitudes toward project teams

Although the sample size was small, some patterns emerged suggesting that faculty member attributes and characteristics such as age (i.e. rank), gender, ethnicity, locale of higher educational training and experiences in their educational and professional careers influenced attitudes toward student project teams.

Finding 5.1: Junior faculty, who were generally younger than the senior faculty, were comfortable with using project teams in the courses they taught, likely because they had substantial experience working on teams as students and in their research efforts.

Three of the study participants were junior faculty. That is, they were on a tenure track but had not yet received tenure. All three of them were proponents of using teams in undergraduate education and had experienced a lot of teamwork in their research:

> Everything I've done, I mean sure there are individual type projects but still in the grand scheme of things it's always groups and the more people you know and the better that you can work with them, it's going to serve you in the long run. In academia, I would say three out of four projects that I'm working on now are in groups. So it's not just me and my student, it's usually multiple advisors, multiple students. (Professor Jenson)

> I feel like its part of my academic interests actually, part of my personality. I've always worked in teams. I've always worked in companies when I was an undergraduate and its part of my understanding of what a university is. I take the word university to be universal. You're supposed to really learn a lot of different things, not just technical skills. (Professor Gomez)

Finding 5.2: Most, but not all, of the senior faculty members who had been teaching for many years, found working with project teams somewhat taxing.

The number of senior faculty members that participated in the study was small. The general attitude seemed to suggest that most of the senior faculty wanted to continue to do things in the same manner as they had done them in the past. They seemed to be looking for ways to streamline, not complicate their teaching efforts, which project teams often do. One faculty member was particularly jaded:

> I have office hours but mostly they don't care and stop by my office randomly and when I'm in the middle of something, it's a problem because I have research and other commitments also...so I don't have an obligation to provide a 24-hour service - it is not Pima College…Many of them, they don't care, but then, I don't care either...If you have a project in your class, it is a real pain in the ass for you. (Professor Jankowski)

Finding 5.3: Women faculty members seemed to place considerable value on teaching students professional skills including effective communication and teamwork skills.

The number of female faculty members in the College of Engineering was small and, as a result, the number of women participants in the study was also small. The few women that participated in the study all seemed to feel that helping students to develop strong professional skills, as well as strong technical skills, was very important:

> In every class, I have an ethics discussion for a part of a class. At least one, maybe two classes every single semester and that comes out on the very first day when I hand out the syllabus and I talk about ethics and cheating. It comes out in every single exam review so there's always discussion. I bring in articles. (Professor Kittredge)

> I try to teach Engineering 102 to prepare all of them for career changes, you know, because they're going to have to make those decisions on their own. They're not always going to have the instructor. So I think when you assemble the teams you've got to make them big enough that so it's

> more diversity in attitudes, as opposed to diversity in training. (Professor Bramble)

Professor Yodsuwan said she has been using project teams for her entire career, "Even long before ABET required it...just because I believe in it, just because I'm that type of learner and all the theory and all the workshops that I've been to, it just speak to me because I'm that type of personality, wanting to interact". Professor Bramble expressed similar sentiments when she said, "I think it's because of the kind of person I am…thinking about how teams work and trying to get the best out of people is just part of what I'm made of".

On her Teacher/Course Evaluation, Professor Yodsuwan received a comment from a student indicating that he would prefer a more traditional lecture-type format. Although she normally received outstanding evaluations, her impression was that:

> There are [some] students who just say, stop socializing, start teaching. So there are students who do not believe…there are those who just want to come in and want the usual hard business - push, push, push, read what you need me to know, recite it and I will regurgitate it. (Professor Yodsuwan)

Finding 5.4: In general, faculty members who were raised and educated outside the US had less experience working on teams as students.

Approximately one-third of the study participants were educated outside the US. Based on the limited sample, it appeared that in some regions of the world, professional

skills such as teamwork were viewed as vocational and not suitable topics for research scientists and engineers. One department head said:

> They don't have the experience and from the very beginning this is the kind of thing that they liked. This is the kind of thing that they wanted to do. So from the beginning, they liked the school, more advanced science than going and working in industry. The other factor, of course, is, more and more, we don't have U.S. citizens…[we choose from a] pool that's mostly people from China, India, etc., I mean they're very good students but their educational system starts with very theoretical things anyway...they don't have senior design capstone projects, they don't have 102, they don't have any of this stuff, I mean its considered culturally…they don't consider this important…in those cultures, building anything with your hands isn't considered a prestigious thing to do. I say this confidentially…[I know this] because I come from that kind of upbringing. (Professor Sharma)

The lack of focus on teams in higher education in other regions of the world may have been related to the stage of technological advancements in the country. Until the latter part of the 20th century, companies in the United States typically used functional organizations in which projects were divided into segments and assigned to functional areas. More recently, the use of project team organizations in industry has become widespread in the US as the technology of the products and services produced become more complex. (Morse and Babcock, 2007) In many regions around the world,

companies still employ primarily functional organizations and thus institutions of higher education have not begun to emphasize project teams.

More than half of the faculty who were educated outside the US were proponents of having students work in teams. In fact, two of the strongest advocates of incorporating teamwork into undergraduate engineering education were educated outside of the US. In both cases, the faculty were educated in less technologically advanced countries where industry may still use traditional functional organizations. These faculty members may, in fact, admire the movement of the US toward project teams as opposed to faculty members from other countries that perceive focus on teamwork as too vocational.

> First you ask the students to work individually and they get their scores and then you group them in teams and then you get the scores of the team…you can make comparisons then between individual performance and team performances. And I think 99.99% of the time their performance is much better in a team than individuals. That's what convinces me actually. (Professor Guerrero)

> I emphasize the teamwork. I assign team quizzes and teamwork and things like that and then I taught 102 that way after that, you see. So to answer your question I have been teaching using the team-learning all along. (Professor Yodsuwan)

Finding 5.5: Faculty members with extensive industrial experience, by and large, had a heightened opinion about the importance of teaching teamwork skills to undergraduate engineering students.

The majority of the study participants had spent almost all of their careers exclusively in academia. A senior administrator commented about the lack of industrial experience:

> 25 years ago you might look at a department, an engineering department and see half the faculty had some kind of engineering industrial experience and half maybe that didn't. Now it's very rare to have faculty with significant industrial experience...So you can understand that they don't necessarily immediately appreciate the need to have their students have a skill set that they didn't have to have.

A few of the participants had significant industrial experience and most of them had first-hand knowledge of the extensive use of project teams in industry:

> What about simulating industry? Absolutely yes. I worked in industry for 12 years and my husband worked at Raytheon and, you know, you get what you get and you got to make it work... I definitely think it emulates industry. (Professor Bramble)

> Our role is not the whole engineering team, but just one part of it...the role of defining the project and bringing the parts together and making things work…and you work with other engineers. That's why the [Capstone Project] is so great. You wonder why I've been a big proponent and supporter of it. That's the greatest part of it...now it's multidisciplinary and they are not with their friends. (Professor Wilton)

Finding 5.6: Very few faculty members had any type of professional development to prepare them to teach effectively or to manage student project teams.

For the most part, faculty members learned how to teach using project teams through trial and error:

> I never had any training on teaching teamwork or anything like that…I didn't have that, but over the years, you know, you look at things and then you find well, okay, there's certain things that are not going to work if you do this and then you don't do this and so on. (Professor Liu)

Both Professor Liu and Professor Wilding were very senior faculty that had spent the most of their career at SW University suggesting that the lack of emphasis on teaching within the college had existed for a very long time:

> I had no training, that's certainly for sure. I had no training to become a faculty member, other than observing. (Professor Wilding)

Several of the administrators and department heads felt that most of the faculty members would benefit from education-focused professional development but offered no concrete suggestions as to where the faculty might go for this training, nor were there indications of any incentives to do so. Some comments were:

> I think with some very small training, the faculty could probably be pretty good at avoiding a lot of these kinds of things by doing things like what you've talked about: What's the contract for the team? What's the goal? Or, what is the team really trying to do? If we set some of that stuff up early, then we have fewer problems later. (Senior Administrator)

> But if they were coached or told how to deal with some of those issues, I think it could be done. (Department Head)

One of the faculty members had attended a workshop early in her career that strongly influenced her approach to teaching with teams:

> The university teaching center had one of those workshops about effective teaching that emphasized active learning and teamwork …and I like that idea a lot and actually I fine tuned it and I have been using that since ’93 ’94…so that workshop was presenting these idea of accountability in the grade and let them evaluate each other in the team…So I think that is a very good system to kind of balance it out, give enough incentive for them to work together but put in their contribution in the team. (Professor Yodsuwan)

It was clear that self-motivation, not incentives from the college prompted her to attend the workshop. A couple of faculty members had read much of the literature regarding project teams:

> So we have to really teach them how to function properly in a team… this is nothing that I’ve necessarily developed. I’m just taking advantage of all the research that’s been done... I’ve read some of the general literature in getting people to work on teams, but its mainly been engineering focused… he wrote a book about engineering and teaching engineering and I read that early on in my career and I’ve used that quite often. (Professor Graves)

One faculty member had been highly recognized for excellence in teaching. He was very knowledgeable about the literature and had published numerous articles regarding engineering education. With regards to publishing in this arena, he found that his efforts went mostly unnoticed, except by the students:

> The things I do like going to the [professional society conference]; I gave two technical talks and one on educational stuff. The educational stuff is just because I'm interested, not because it seems valued, except by the students. (Professor Pearce)

Finding 5.7: Some faculty members incorporated teams into their classes just because they felt it was the right thing to do for their students.

Quite a few of the faculty members, through their experiences, had reached the conclusion that students benefit from working in teams at the undergraduate level, and that was sufficient motivation for them to incorporate teams into their courses:

> I'm always interested in if somebody tells me that there is a better thing to do for the students, I would listen to it and I would, you know, evaluate it and see if it is indeed good for our students and try to implement that, or do that, for our students. So I would, you know, welcome that actually. So that would be my sort of attitude towards this. (Professor Liu)

Professor Guerrero used project teams in all of the courses he taught. He acknowledged that it was sometimes difficult to simulate the "real world" but felt that students could easily differentiate between the two and generally appreciated the opportunity to work in teams during their undergraduate education:

> I always look at it on a positive side. I think it's really beneficial for the students. I mean they are aware, of course, they're not working for industry, but they're students in a classroom and they know that this is a classroom exercise. (Professor Guerrero)

Finding 5.8: Faculty members often experienced teamwork while working on research projects and grants.

Although the majority of the faculty members that participated in the study had very little industrial experience, most of them had worked in teams while doing research at the University:

> Even at the faculty level, let's say I want to go out and get a large grant, you know, more than a couple hundred thousand dollar grant, I got to be able to work with others. Nobody's giving millions and millions of dollars to one person. And so, the ability to form successful teams is going to be critical, even in the academic environment. (Senior Administrator)

> Even the research projects that we have, I would say, it's fairly rare that one person works on their own project. In isolation - that's not as common anymore. (Professor Graves)

Theme 6: Competing roles, reward structures and workload issues

Faculty members are expected to perform many functions including: research, teaching and service. These competing roles, which are influence by formal reward structures, can lead to workload issues.

Finding 6.1: Many of the faculty members felt that the teaching demands on faculty, specifically engineering faculty, seemed to continually increase.

A number of external factors influenced the teaching requirements for engineering undergraduate education. These included demands from industry as well as developments in technology:

> We get a lot of pressure from industry who say, at various times, you need to do more of this and more of that, and they never say you need to do less of this. It's always, add more and more to the curriculum. (Senior Administrator)

A couple of faculty members mentioned that some of the material in their departments' curriculum had become obsolete and should be eliminated. It appeared that there would be trade-off opportunities if administrators and department heads devoted greater effort to optimizing the curriculum:

> Well, every year they have to add something on because, you know, you have to now do the math cad stuff. And now people think oh, you need to have some quantum or chemistry modeling or something like this and that. You know they're keeping up with new tools that come up and nobody wants to get rid of the old stuff. You know well, that's fundamental. You can't get rid of controls and other things that kind of become the step child, nobody uses them anymore, you know, they're just classic control theory which is a little bit useful, but it's very antiquated in terms of the way things are done today. But people don't want to get rid of it. A lot of

> schools have but you always have, maybe a third of the faculty saying oh, you can't get rid of one of the fundamentals of the discipline, so it's the legacy. We keep having to carry the legacy along and add new things. (Professor Pickering)

Finding 6.2: The balance of research, teaching and service was of paramount importance and faculty members found it necessary to constantly balance their time.

As Professor Bramble said, "the biggest commodity for faculty is their time". Traditionally, the balance of research – teaching – service for a faculty member at a Research I institution is 40–40–20. Several participants commented on this balance:

> So everybody's got a work responsibility that's divided in some proportions between research, teaching and service and so the usual model one talks about is 40-40-20. All right the really active research person may be, 60-30-10 or 50-30-20, who knows? But you could also have somebody who is maybe 50 percent teaching and 30 percent research, but I don't think you're gonna have somebody who's 70 percent teaching and 10 percent research and 20 percent service that's gonna get tenure at a place like this. (Senior Administrator)

It was generally understood that as long as the teaching efforts of research faculty were maintained at minimally acceptable levels, careers would not be adversely affected. It was also understood that careers could be negatively impacted if too much time was spent on teaching efforts detracting from research activities:

> On paper there's a 40-40-20 split between research, teaching and service. Yet in reality, that's certainly not the way you advance in the profession. Teaching is undervalued. It's clearly not 40 percent of what, in fact, you are judged on for moving up through your tenure status through your faculty steps or through professional society steps - much, much more heavily weighted toward research. Probably on the order of 50 to 55 percent research, probably 30 percent teaching, you know, 10-15 percent service. (Professor Kidd)

Some of the participants described the challenges of trying to maintain an appropriate balance of the research, teaching and service functions. This confirms an earlier finding that most faculty felt that demands continually increased with few offsetting decreases in responsibilities:

> You know it's more like 60-60-40. (Professor Gonzales)

Many faculty members articulated concerns that the priority was clearly on research and that time spent on teaching activities could be detrimental to research activities:

> You know what you have to do, it's bring in monies from proposals. You have to write papers. You have to do research and when teaching takes up more time, then research suffers. There's a one-to-one correlation between that. You can't write proposals, so not only does your research suffer this year, but it will suffer in out-years as well because you don't have as much money coming in two or three years down the road if you're not doing as much research or you're struggling to write lots of proposals

> because your research pot got small. Then the year you are writing a ton of proposals you are not writing papers and so that means if you're not getting your publications out you're not building up your portfolio for tenure or full [professor]…if you don't have enough funding, you can't bring in students to do your research, on and on, so it's a domino effect that's enormous. (Professor Kittredge)

> In this department, we teach three courses a year [standard for researchers in the College of Engineering] and, you know, maybe even more than that…it barely leaves you time for the rest of the stuff. (Professor Gonzales)

Some seemed to handle the multiple roles very well:

> I think it's still okay. It's manageable, it's still manageable. (Professor Lee)

> I think some people do a better job if they're both teaching and researching. I enjoy both and I think I wouldn't be quite as happy if I didn't have my feet in both camps. (Professor Kidd)

Finding 6.3: A number of faculty members indicated that they really enjoyed teaching and placed as much emphasis on teaching as research but few found significant synergy between research and teaching at the undergraduate level.

It was apparent that some of the faculty members took pleasure in their teaching responsibilities as well as their research responsibilities. Professor Malik indicated that

he finds great pleasure in working with students when he said, “I love teaching”. Professor Liu expressed similar sentiments when he said, “I value teaching almost just as much as research. In my book, they carry equal weight”. One of the department heads felt that, although challenging, it was possible to gain recognition and prestige in the field of engineering education:

> That’s the challenge to these people that are doing this, you know, step it up another notch, you know, and kind of develop a leading edge approach also in engineering education, you know, it takes a lot of effort. It’s just like doing research in engineering, if you’re going to do scholarship in engineering education - that’s going to take extra efforts. To really be in that type of national, international recognition in the engineering education area, you really have to put a lot of time into it. (Professor McCauly)

Research and teaching at the graduate level sometimes overlapped, in that faculty could discuss their research and create projects for their graduate students based on their research. However, because students at the undergraduate level did not have sufficient background, it was not easy to find opportunities to incorporate research efforts into undergraduate courses. Thus, teaching at the undergraduate level and research were largely distinct and separate activities. When queried, most faculty members did not feel there was much overlap between their research efforts and their undergraduate teaching:

> I think the [overlap of research and teaching] is hugely overstated - I guess that would be the diplomatic way of putting it…I think there are more than enough cases of just great non-research teachers, you know, that are just

> teaching fellows in universities and things and vice versa, researchers that don't teach at all. (Professor Kidd)

Finding 6.4: Faculty members acknowledged that recognition and the reward structure placed greater emphasis on research than on teaching.

An important factor that influences the way that faculty choose to allocate their time is the reward structure:

> They'll still quote you something like 40-40-20, you know, 40 percent teach, 40 percent research, 20 percent service and I think that's the average load when you're actually a [tenured] faculty. So for the junior faculty, they usually say the service shouldn't be 20, it could be less than that, but then, so it's saying your time is equally split between teaching and research and I think in reality, you know, you end up spending more time on the research just because that's more of what's evaluated. (Professor Carson)

It was clear that the faculty accepted that there were few financial rewards for being a good teacher and that it had been that way for a very long time:

> There's no incentive [for teaching] so yeah, so you know, if the incentive was put back in I think you'd find more people wanting to do that. (Professor Bramble)

Tenure-track faculty realized that excellence in teaching would have little impact on tenure evaluation; however, all seemed committed to being excellent teachers primarily out of personal pride:

> You get this sort of this hint that, you know, the teaching doesn't matter as much when it comes to tenure as long as you do a good enough job…and personally I don't find that too appealing to myself. I try to do a good job at whatever I end up doing. (Professor Carson)

One junior level faculty member took his job as a teacher and a mentor very seriously. He discussed a difficult conflict one of his student teams experienced:

> It's much better for them to go through this experience, which was painful for them, here. I feel it's a big part of my job for them to go through these things here, so that they don't make the same mistakes after graduating. And that's priceless. (Professor Gomez)

Finding 6.5: The opinions of faculty varied greatly with regards to the impact of student project teams on their workloads.

Several faculty members found that their workload was increased significantly when they included project teams because it was necessary to help manage the team interactions with little or no training or knowledge on how to do so. Interestingly, few seemed to take the initiative to learn how to use project teams effectively. This was further evidence that many were not motivated to devote significant effort to their teaching activities. However, even some of those who were committed to providing a positive team experiences found their workload related to project teams to be significant:

> It's worse, much worse. Teaming is much worse and it's probably one of the reasons why you don't see it more, because it's true if you're a teaching faculty it's just more teaching. But if you're a research faculty as

> well it really makes it hard, because the amount of overhead that goes on with the teams is huge. You have the social overhead, you have some parenting skills that have to come into play, literally, you know. There's far more in the way of organizational skills. So the [extra work for] faculty is much worse and what it really does, is it eats into your time for doing [other things], as faculty, you're not rewarded for developing good team students. (Professor Kittredge)

A couple of faculty members noted that much of the extra work was related to the fact that the assignments usually involved complex, open-ended design problems:

> I don't think it will lighten up the load all that much, because you have to meet with them once a week and work on designs together and work on things together and so that's a must. Whereas, if I compared to other classes...we don't even meet. If anything, I think there would be more with the teamwork - working with the team. But then this maybe is the nature of the design project…I think it's a comparison between the design project class and a lecture class, so it may be that. (Professor Liu)

> The problem has to be well thought-out, enough that the students really do derive some understanding and some value. (Professor Graves)

Others felt that their workloads were reduced considerably when students worked on team projects. Several discussed the practical matter of grading. Professor Guerrero chuckled when he said, "I mean, one report per team as opposed to individual reports." Dr. Lord agreed, "If I have a class with 15 students and then break them up into teams I

end up reading a lot less reports". Professor Wilton noted that the work was less as well, "If I have four people on a team, it's not a quarter of the work because the reports are more substantial, but I think it reduces it in terms of grading reports and things". Some faculty members mentioned the benefits of cooperative learning in terms faculty workload:

> Typically, then, if I have groups of six, I'll see one-sixth of the students even for the most difficult assignment, because that one person will take the information back to their group and so now I've freed up a lot of my time. (Professor Pearce)

> Instead of having every single student come to my office to double-check a problem, I get those representative students coming to check. So that does save some time. (Professor Jenson)

Still others thought that the workload was approximately the same, but different in terms of the type of effort required:

> I think that it balances out. I mean, it's less of the boring work of grading. There are fewer assignments to grade, but one of these conflicts, and they always arise, takes up, you know, an hour or two hours or they can take up more time than that. And so I don't think it reduces the workload. I do think that the work is more effective as I said. (Professor Gomez)

> So it's one of these zero sum games. So if you have the groups, you spend a lot more time sort of helping the groups and managing the groups and

> dealing with some of these group dynamics, but then, the gain on the other end is that, you know, there's only a half or a third as many projects that you sort of have to, you know, worry about grading. (Professor Carson)

Finding 6.6: Participants had mixed attitudes about whether it was essential that tenured and tenure-track professors performed effectively in all of their varied roles. Opinions were mixed as well about the prevalent use of adjunct professors and lecturers.

At Research I universities, such as SW University, most of the tenured and tenure-track faculty have both research and teaching responsibilities. Typically, tenure-track faculty (assistant professors) strive to be promoted to tenured positions (associate professor or professor) within a limited period of time by demonstrating a strong record of published research, teaching, and service. Once tenured, associate and full professors have permanent appointments that allow considerable flexibility. Most institutions hire adjunct professors and lecturers (typically short-term contract employees) to teach courses for which they do not have sufficient or suitable permanent faculty to teach. Some of the study participants felt that it was essential that all professors (assistant, associate and full) be good at both teaching and research, but others were not convinced. However, all agreed that unless the reward system was restructured, it would be very unlikely that a tenured or tenure-track professor who did not have a strong research portfolio would thrive at this type of institution:

> I think, whether you like it or not, the university's reputation and its stature in the academic community is determined by one's contributions to

> new knowledge. But that doesn't mean that you then can be satisfied with crappy teaching. To me that's sort of the minimum requirement. You have to have people in academia who can teach. They should be doing research, but they should also be able to teach, and if they can't teach then they shouldn't be here. (Senior Administrator)

Professor Kidd challenged the viewpoint of the Senior Administrator. He felt that faculty members should be able to focus on the areas that interested them most and should be adequately rewarded:

> I disagree with this the feeling that you have to have both components in a faculty member to do a good job…If the system were such that it gave equal credit and equal opportunity for advancement if they only did research or if they only did teaching, I think they would probably choose that, and rightly so… It's not that you have fewer people, but that you're actually putting people doing what they do best and what they have a passion for most. The person that doesn't really have a passion for teaching and likes just dabbling in research, let them do research and somebody that does have that passion [for teaching, let them] pick up the difference. So it's still just the same number of bodies, they're just able to focus on what they appreciate most. (Professor Kidd)

The number of permanent faculty on staff had declined in recent years and, as a result, the number of adjunct faculty members had increased. Some felt that it was problematic

in some ways, while others indicated that it was a reasonable approach for dealing with staffing problems and skill set requirements:

> I'm disappointed, actually, at the level of hired guns that we have for 102, but there's a more pragmatic reason for that right now and it's budgetary. You know what's going on at this university and its been going on for a long time and, when you go from 155 faculty to 135 faculty, departments prioritize where they want to have their faculty investing their time in teaching. You've got a research agenda and a teaching agenda and I'm not necessarily supporting this, but I can understand when a department says the first thing I have to do is make sure all of my required courses for a student to graduate are covered. (Senior Administrator)

Professor Lui thought it was unfortunate that some of the important educational responsibilities had shifted away from tenured faculty. Previously he had been involved in all aspects of the senior capstone project but in recent years he no longer participated in the final project. It was clear that he missed the responsibilities but recognized there were few rewards for those efforts:

> I don't have to grade a report for the Capstone design class…Well I don't like it…I like to work with our students and if I'm putting all this time into working with them, I want to be able to, you know, sort of judge too…In fact a lot of our faculty members didn't like that…And then, I don't know if [the industry mentors] know what they're doing. I mean, they may be really good in whatever area that they're working on right now, but there's

> a lot more to it than just that part, you know? So I don't know if our students are really getting their fair share of education here. (Professor Liu)

Assigning faculty to courses can be challenging, particularly as course content expands to satisfy new requirements adopted by ABET. A Senior Administrator conceded that, in some instances, tenured faculty were not the best qualified instructors:

> But then, in the end, when you're dealing with these realistic design projects, who better to teach them than someone who's had that experience? It would be nice if we had faculty like that but, if you don't, I'm not apologetic about going out and hiring somebody from [Company A] or [Company B] or [Company C] who can come in here and give those students that experience. You can say well you're running your university course with a bunch of adjuncts. The way I look at it is we have decided to go out and hire the best possible people to teach in those areas where they have expertise. And it's a perfect case where the tenured full professor isn't necessarily the best person to teach somebody in a particular area. (Senior Administrator)

Chapter Summary

This chapter presented the findings of the study, organized into six themes which paralleled the six primary research questions. Data were gathered from documents, primarily found on the University website and through semi-structured, one-on-one interviews with the study participants. The wide variety of opinions and attitudes were

portrayed in the numerous quotes provided. An attempt was made to provide a balanced representation of the views of the study participants. To show the diversity of responses, quotes that illustrated dramatically differing attitudes and opinions were included.

CHAPTER V: CONCLUSIONS AND RECOMMENDATIONS

The purpose of this chapter is to provide conclusions regarding the findings described in the previous chapter and to make recommendations for future study. The goal is to present a holistic picture combining the findings with theory and related studies. While the findings in this study were numerous, the interpretation of these findings clearly leads to the following six key conclusions:

1. Officially, the University and the College of Engineering articulated support for the use of project teams in undergraduate education, but the prevailing climate did little to promote efforts related to effective teaching.
2. Those faculty members who advocated the use of project teams felt that opportunities to provide students with these experiences should be selected and managed carefully in order to bring sufficient value to the students and to justify the effort required.
3. The two biggest concerns for faculty working with student teams were related to the individual accountability, fairness to students and workload concerns.
4. A couple of study participants were strong advocates of ABET Criterion 3d which requires programs to demonstrate that students have an ability to function on multidisciplinary teams. Some were vehemently opposed, especially as it pertains to “multidisciplinary” teams. However, many gave the criterion minimal thought and viewed accreditation as strictly an administrative task.
5. Faculty members at SW University had participated in little or no formal training to improve their teaching. Both administrators and faculty members

indicated that faculty members would likely benefit from some professional development activities related to teaching, however the climate, established by the administration, did not promote those efforts.

6. The commitment to providing students with quality educational experiences, specifically teamwork, varied greatly. Too often, faculty were unwilling to commit sufficient time or effort to make project teamwork a worthwhile learning experience for students.

Appendix E provides a matrix that links the conclusions to the corresponding findings. Explanations for each of the conclusions follow.

1. **Officially, the University and the College of Engineering articulated support for the use of project teams in undergraduate education, but the prevailing climate did little to promote efforts related to effective teaching**.

Organizational climate refers to the relatively enduring set of characteristics that make an organization unique and influence the behavior of people in the organization (Forehand and Von Haller, 1964). The official position of the College of Engineering strongly supported the use of teams. The following Strategic Objective found on the College of Engineering website (http://engr.arizona.edu) illustrated the commitment:

> Strive to provide high quality broad based education that will prepare students for productive careers in an increasingly diverse and technological society by insuring that graduates have an ability to function on multidisciplinary teams.

The administrators expressed similar commitment to project teams during interviews. A senior administrator described why he felt it was important for the college to teach undergraduate students to work on teams:

> [At] almost all interesting engineering firms right now, you're not going to be off in a corner working by yourself. So you need to be able to learn how to get along with people, learn how to interact and collect data from people, learn how to give data to people so that it's useful, learn how to meet deadlines, learn how to volunteer for tasks so that you're perceived as a valued member of the team. And if we want our students to be successful in that professional environment, then they better be ready to work with others.

Satisfying industry constituents seemed to be a major priority and there appeared to be little doubt in the minds of the administrators about the necessity to teach students to work effectively in teams. Many of the faculty members also supported the use of project teams:

> I think you have to have teams because that, in fact, is what they'll be working on if they go into engineering practice. So it's absolutely, paramountly, important that they do function well in teams. (Professor Kidd)

> In industry you're not going to work on your own. You're going to work with a group of people towards an objective that, you know, that

> pertains to the whole group, not only yourself. So where do you get that part of the training?
>
> (Professor Gonzales)

The climate at the department level, in general, advocated project teams in the undergraduate curriculum but it was clear that efforts to incorporate projects should not detract from more important activities, namely research. Little was done to encourage faculty to develop skills to effectively teach or manage teams. In fact, the reward structure encouraged faculty to devote the majority of their efforts to research. Developmental opportunities related to teaching were not readily available and very few of the faculty members took the initiative to develop the necessary skills through means other than trial and error. This finding was particularly surprising for a group of intellectuals who typically devoted considerable time educating themselves when faced with a new problem. Unfortunately, this state of affairs at SW University was likely related to a climate that viewed teaching as a less prestigious endeavor. Literature suggests this problem is prevalent:

> *We are not functioning as professional teachers in the way that we function as professional researchers.* Most engineering professors do not read education journals, attend education conferences, or belong to ASEE. They do not develop innovative methods themselves or try proven methods developed by others…Why should they? The system offers few incentives to do these things and imposes severe penalties if

> taking the time to do them cuts down on research output. (Felder, 1994, p.107)

2. **Those faculty members who advocated the use of project teams felt that opportunities to provide students with team experiences should be selected and managed carefully in order to bring sufficient value to the students and to justify the effort required.**

In a survey of students who were asked about their best and worst group experiences, the relevance of the assignment had the greatest impact on whether the experience was positive or negative (Fietchner & Davis, 1984). In his work with student teams, Professor Graves noted, "the trust between the students and myself will be broken pretty easily if I just give them some exercise that's obvious it wasn't really well thought out." Faculty members uniformly agreed that project assignments must be designed in a way that is suitable for teamwork. They felt that it was crucial for the magnitude and scope of the project to be sufficient to warrant the contributions of more than one individual. They also believed that integration of individual tasks within the project should be fundamental to the project success. These opinions were consistent with the tenets of cooperative learning which stipulate that group work enhances learning only if positive interdependence exists among the students (Johnson & Johnson, 1994). Faculty members concurred that the effort required to develop projects for teams was considerable as discussed by Professor Kittredge, "When you have teaming projects, typically there's a lot of overhead on the faculty to develop useful projects, not just crummy projects…it's a lot more

work…to get it to be actually a successful assignment". Most believed that the benefits of team experiences for their students made the extra effort worthwhile.

Project teams were widely-utilized in the entry-level Introduction to Engineering course and the Senior Design course. The primary objective for incorporating project teams in these courses was to allow students to work on design projects that were more complex and interesting than those that could be assigned to a single individual. In addition to the primary objective, the college wanted to teach students about teamwork and project management. Researchers at Auburn University found that it was important to focus strongly on teaming to give students a productive teaming experience:

> If you want your students to learn teaming skills, then promoting effective teaming must become an explicit focus of how you structure team projects. Just as faculty now structure aspects of team-based student projects to insure that students learn project management skills, faculty must also structure aspects of the teaming experience to insure that students learn teaming skills. (Lewis, Aldridge & Swamidass, 1998, p. 150)

In some cases, faculty at SW University provided this structure, while in other cases they did not. This fact contributed to Conclusion 5 which states that many engineering faculty at SW University would benefit from some formal professional development focused specifically on working with student project teams.

As discussed, most faculty were concerned about team composition. In an ideal situation, team members should have unique, complimentary skills that are essential to the success of the project. In an academic setting, more often than not, the skill sets of the students are very similar. Thus, the appropriate strategy for composing teams is less apparent. For the most part, faculty members used trial and error or advice from peers when developing a strategy for team composition. Very few of the faculty members were familiar with the literature regarding team composition. Some faculty members felt that students should be allowed to select their teammates while others felt they should not. Of those who chose to assign teams, some thought they should be assigned randomly while others thought they should be assigned based on some characteristic such as academic or personal strengths or weaknesses, gender, ethnicity, geography or schedule. A good deal of literature addresses the gender and/or ethnic balance of teams, most agreeing that a "token" female or ethnic minority on teams should be avoided (Kanter, 1977, Jackson, et al., 1995, Tonso, 2006). Professor Graves, one of the few faculty members who took the initiative to study the available literature, felt that it was important to help the students understand the implications of having students with different learning styles on their teams:

> So I try to [help the students become] aware of what kind of team they're on and get them to start talking about this. So once they see that, then it's a much easier argument that, okay, so if you have

> differences in the way you approach things, you probably want to try to organize your team to be efficient in some way. (Professor Graves)

A number of studies have shown the benefits of evaluating students' personality types and forming teams based on the results (Goby & Lewis, 2000, Clinebell & Stecher, 2003, Hendry, et al., 2005) consistent with the strategy employed by Professor Graves. In general, the most suitable strategy for forming teams remained a question in most faculty members' minds but the climate did not promote efforts to explore the topic in any serious manner.

3. **The two biggest concerns for faculty working with student teams were related to the impact on individual students and workload concerns.**

Faculty members were bothered by the fact that some students realized few benefits from project teams and worse, some had very negative experiences. Almost without exception, when difficulties arose, the problems were related to a team member who was not doing the quality or quantity of work expected by one or more of his or her teammates. As Professor Demopoulos said, "Some of them worked, but not the entire team. Five people wouldn't. Two would do most of the work…and the rest would follow and do little things here and there." When dealing with this type of problem, some faculty members tried to appeal to the students' sense of fairness and professionalism. Professor Jenson gave the following suggestion to a student, "If your partner is not as involved in the first project maybe they can take more of a lead in the second project, since it's multiple projects over the semester" and Professor Wang advised his students, "You need to learn how to be professional, okay. So since

you will be receiving the same grade and, you know, (I try to tell them in a positive manner) okay, so let's be professional and let's be fair, all of you will get the same grade so you are expected to contribute a lot".

Most faculty members that participated in this study assigned a single grade for group work but had some concerns about the fairness of group grades. In "Group Grades Miss the Mark", Spencer Kagan (1995) argued that group grades are blatantly unfair, debase report cards, undermine motivation, convey the wrong message, violate individual accountability and are responsible for parents', teachers' and students' resistance to cooperative learning. He believed that a single grade should never be assigned to student project teams. Some faculty members at SW University agreed and chose to adjust individual grades based on the contributions of each student. Professor Pearce said, "I like to have some personal responsibility. So it's not unusual for me [to give a student] a full grade or two different from their partners if it is clear and documented that there was someone who either did it all or someone who did nothing, because in the real work force, they will be fired if they don't contribute and so I want to begin that accountability".

King and Behnke (2005) acknowledged the challenges of grading group performance but felt the practical value of developing students' teamwork skills justified the efforts to overcome the difficulties. They provided practical suggestions about ways to minimize some of the potential problems associated with group grading:

> Perhaps the most powerful tool at the disposal of the instructor for palliating the disadvantages of group work is the "cards on the table" approach. By engaging students in forthright discussions about the difficulties and rewards of group work, a number of advantages accrue. First, students can be persuaded to accept the practical values of developing skills in teamwork. Business and industry place such a high premium on these skills that the argument should be relatively easy to make. Second, students should be inoculated against potential problems. Students are less likely to attempt free riding when that practice has been discussed, exposed, and condemned in class.
>
> Finally, students appreciate receiving due notice concerning class activities and grading methods. Participants will be less likely to complain or challenge grades if they have had fair warning and fair opportunity to question and discuss grading procedures…[The goal is] to help students understand that the values of group work involve trade-off's between the benefits and complications. If students are convinced by this cost/benefit analysis, they will enter into group work with greater enthusiasm and commitment. (King & Behnke, 2005, p. 60)

Workload issues were also a significant concern to faculty. As Felder said, "*Good research and good teaching each take a lot of time. Doing both takes more time than most professors have.* It is no secret that research is a major time

sink…That excellent teaching takes just as much time and intensity of effort is not well appreciated." (Felder, 1994, p. 106) In the case of project teams, the efforts required to create an effective project and to successfully manage student activities on the project are very time-intensive. At SW University, some of the faculty did not believe that the benefits to the students justified the added workload to the faculty members.

4. **A couple of study participants were strong advocates of ABET Criterion 3d which requires programs to demonstrate that students have an ability to function on multidisciplinary teams. Some were vehemently opposed, especially as it pertains to "multidisciplinary" teams. However, many gave the criterion minimal thought and viewed accreditation as strictly an administrative task.**

According to the ABET Criteria for Accrediting Engineering Program for the 2009-2010 Accreditation Cycle, ABET Criteria 3 states that programs must demonstrate that their graduates have achieved specified outcomes. (See Appendix F for the complete listing of ABET Criterion 3). The outcomes are statements that described what students are expected to know and be able to do by the time of graduation. In addition, the criteria states, "There must be an assessment and evaluation process that periodically demonstrates the degree to which the program outcomes are attained" (ABET, Inc., 2009). It further defines that "Assessment is one or more processes that identify, collect, and prepare data to evaluate the achievement of program outcomes and program educational objectives". Pertinent to this study,

Criterion 3d specifies that programs must demonstrate that students have “an ability to function on multidisciplinary teams”.

In response to this criterion as well as other motivating factors, SW University implemented team projects in courses throughout the undergraduate curriculum. In the Engineering Change 2000 study (Lattuca, et al., 2006), 52% of faculty surveyed reported some increase or a significant increase in the use of groups in class since first teaching their course. Program chairs were much more likely than faculty to credit ABET and industry with having a moderate or strong influence on curricular changes to their programs while 82% of faculty took personal credit for changes they made in their courses which suggests that most faculty members did not feel strongly influenced by the accreditation criterion.

Although administrators felt confident claiming that students had experienced working on teams, they felt less confident claiming that the students had the ability to “function” on teams. For the most part, outcome assessment regarding Criterion 3d - ability to work on teams - was based on exit surveys administered to students upon graduation. As one department head said:

> I mean, how do you demonstrate or document, and I even asked one of the evaluators one time…I said, well, if you go up for your ABET evaluation in two years, how are you going to document this and they didn’t have an answer…When we’re dumping it at them, we’re exposing them to it, but are they learning it? I mean the whole ABET thing is ‘are they learning or have they learned these things?’ and I’m

> not sure what it says as far as the multidisciplinary teams…I mean how do you verify that? (Professor Embrie).

Another department head, Professor Arnott, said, "When we went through ABET and checked off our teamwork boxes, it's really 102 and our senior design project…In most of our design classes we do team projects but it's really here's the project but we don't spend a whole lot of time teaching team skills". This suggested that the department was focused on successfully navigating through the administrative process of ABET but wasn't necessarily committed to implementing program changes to improve the learning outcomes.

Outcome assessment has been discussed at great length in the literature. A group of researchers was commissioned by ABET to assess whether EC2000 was having the desired effect on the learning outcomes of engineering graduates. In order to assess differences between 1994 and 2004 engineering graduates, the researchers asked students to self-report on their ability level at the time of their graduation. According to the research team:

> A growing body of research over the past 30 years has examined the adequacy of self-reported measures of learning and skill development as proxies for objective measures of the same traits or skills. When self-reports are aggregated to compare the performance of groups, they are generally considered to be valid measures of the skills under study. (Lattuca, et al., 2006, p. 6)

When EC2000 was established in the late 1990's, SW University implemented self-reporting strategies to evaluate achievement of program outcomes for their ABET evaluations. Given that the research team which was commissioned by ABET, Inc. chose to utilize self-reporting, one would assume that this strategy was deemed suitable. The ABET, Inc. website included extensive publications, workshops, seminars and a variety of other tools to assist programs in their assessment efforts. As will be discussed in Conclusion 5, SW University may benefit from the available resources in its continuing efforts to establish outcome assessment and continuous program improvement strategies.

For some, the inclusion of the term "multidisciplinary" in Criterion 3d was problematic. Professor Pickering emphatically objected. He said, "That's asinine because it's not multi-disciplinary teams. You're dealing with four people with the exact same skill set and saying, you're this, you're the expert in this, you're the expert in that." Others agreed that the "multidisciplinary" component could be challenging. The Dean of the College of Engineering said, "I wish more of our departments could buy into [the college-wide multidisciplinary senior project], but for those that don't, I can appreciate why they can't, because sometimes it's hard to form fully interdisciplinary design projects for certain engineering disciplines". (Senior Administrator)

Realistically, undergraduate engineering programs may find it difficult to incorporate multidisciplinary team experiences for all students, however, it is not an unreasonable target and programs should continue to strive to meet this goal.

Programs most certainly should endeavor to give students several opportunities to work on student teams, and when possible, expose them to multidisciplinary teams. In a sample course assessment matrix presented by Felder, a prominent educator and researcher in engineering education, the following outcome was included:

> "Outcome 6: Ability to perform effectively in both single-discipline and multidisciplinary teams" (Felder and Brent, 2003, p. 11).

The implication of this desired outcome is that teaching students to work effectively on teams is essential and suggests that giving students an opportunity to work with students from other engineering disciplines is an added benefit.

5. **Faculty members at SW University had participated in little or no formal training to improve their teaching. Both administrators and faculty members indicated that faculty members would likely benefit from some professional development activities related to teaching, however the climate, established by the administration, did not promote those efforts.**

Estimates of the amount of time faculty devote to professional development vary greatly possibly due to the vague definition of professional development. Some may view an occasional perusal of the *Journal of Engineering Education* as professional development while others believe that only more formal activities such as participation in workshops or seminars qualify as professional development. In the Engineering Change 2000 study (Lattuca, et al., 2006), 20 – 25% of faculty surveyed indicated that their teaching-and-learning-related professional development efforts had increased over the previous five years (Lattuca, et al., 2006). However, in the

current study, very few indicated that they had participated in formal workshops or seminars on teaching and learning, particularly those focused on student teams. Professor Wilding's comment exemplified this finding, "I had no training, that's certainly for sure. I had no training to become a faculty member, other than observing."

Considerable evidence of the benefits to students of faculty development related to teaching exists. In a survey of students who participated in group projects, the most frequently cited response when asked about the most negative aspect of their group work experience was that the instructor was either incompetent or shirked their responsibility (Fietchner & Davis, 1984). In general, students benefit when faculty devote more time and effort to professional development activities related to teaching.

> …faculty decisions and actions are influential not only when faculty are interacting with students (for example, in classes, advising appointments, or in co-curricular activities such as undergraduate research or design projects), but also when students are not present. With the latter, the content that faculty choose to emphasize in their classes, the ways they design their courses, and the impact of what they learn in professional development activities related to teaching, learning and assessment is an indirect but nonetheless influential factor affecting student learning. (Chen, Lattuca, Hamilton 2008, p. 11)

Teaching and managing student project teams appears to present special challenges to engineering faculty, thus it would seem prudent to disseminate

information about the experiences of other practitioners through seminars, workshops, or one of the emerging technologies such as blogs or webinars. Of course, faculty members are very cautious about how they use their time. As Professor Bramble said, “the biggest commodity for faculty is their time”. Therefore, it is imperative that instruction geared for faculty is efficient and time-effective. Because the faculty members’ enthusiasm for training is low, it may be appropriate to provide some incentive to achieve a satisfactory level of participation. To justify such spending, it would be necessary to clearly articulate the tangible benefits for the faculty, students and college overall.

6. **The commitment to providing students with quality educational experiences, specifically teamwork, varied greatly. Too often, faculty were unwilling to commit sufficient time or effort to make project teamwork a worthwhile learning experience for students.**

Differences in personal characteristics appeared to influence the opinions and attitudes of faculty members with regards to teamwork in undergraduate education. Some groups, particularly those with extensive industrial background, female faculty members, and educators who spent part of their careers at less research-intensive institutions seemed to be particularly receptive to the responsibility of teaching students to work in teams. Other groups, such as those educated in some regions, such as the middle east, and very senior faculty members seemed somewhat resistant to these responsibilities. The resistant faculty members generally fell into two categories: those that questioned the value given the amount of effort required and

those that felt ill-equipped to handle the responsibilities. For example, one faculty member, born and educated outside the US, who consistently had high evaluations from students, felt that the undergraduate years should focus exclusively on the fundamentals and was opposed to devoting time to professional skill development in undergraduate education. Interestingly, the courses he taught were not well-suited to team assignments. There would be little value in trying to persuade a resistant faculty member to incorporate teams into his course if he was highly effective with a more traditional lecture style of teaching. On the other hand, different tactics would be appropriate for those faculty members who were resistant because they felt ill-equipped to handle the responsibilities. For example, one faculty member, also born and educated outside the US, seemed to find value in providing team experiences to students, but when referring to the teams in his section of Introduction to Engineering, he said, “Teams either worked or they didn’t”. He admitted that he normally did not take an active role in helping those teams that were dysfunctional. He seemed unsure about how or if he could influence the teaming experience. Studies have shown that this is not an uncommon problem.

> The conditions for group learning in higher education settings rarely meet the standards advocated by cooperative learning scholars. Few faculty have either extensive experience working in groups themselves or formal training about how to manage groups. As a result, many well-intentioned faculty assign group projects without providing

> students the information and guidance prescribed by cooperative learning advocates. (Colbeck, et al., 2000. p. 61)

Research suggests that teaching practices have a strong influence on professional competencies. A study compared the effects of personal characteristics and teaching practices in the development of professional competencies by undergraduate engineering students. Teaching practices were identified as the most important influence on gains in group, problem-solving and design skills (Cabrera, Colbeck & Terenzini, 1998). These findings support Conclusion 5 suggesting that some of the faculty members would benefit from professional development efforts focused on improving faculty interaction with and feedback to students. Unfortunately, opportunities for professional development focused on education and student interaction were rarely available within the college and the general climate discouraged faculty from devoting time to those endeavors.

Recommendations for Future Research

The results of this study provided interesting insights and suggestions for ways to continue to improve engineering undergraduate education. This study, however, was limited to tenured and tenure-track engineering faculty at a single public Research I institution. Comparison of this group to other groups such as non-tenure track faculty or faculty at another type of institution that is less research-focused may provide interesting insights regarding the unique characteristics of the engineering discipline in a research-intensive environment. It would also be interesting to compare the attitudes and behaviors of faculty in engineering with faculty in other colleges.

Although grading of student group work has been studied extensively, many questions remain: Is it fair for students' grades to be influenced by the efforts (or lack) of others? What is the best way to provide fair and useful feedback to student teams that will promote cooperative learning while holding students accountable for their own work? What is the value of peer evaluations and how can they be utilized effectively? A qualitative study of these topics would lead to some valuable knowledge regarding this important topic.

Even in this relatively small sample size, several faculty members who were very effective working with student teams were identified. However, these teachers had little incentive to share their knowledge or experience. An effort to finds ways to disseminate the wisdom gained from their experiences would be beneficial.

Although multidisciplinary teams are, in theory, a good idea, in practice, they present some difficulties. For the most part, undergraduate students do not have a strong foundation in their discipline until late in their undergraduate careers. Thus, opportunities to place students on multidisciplinary teams are limited. Further investigation about the practicalities of multidisciplinary teams in undergraduate engineering may be warranted.

Finally, faculty members concurred that it was essential that project team assignments be well-designed to be effective. However, little has been written about what qualifies as a "well-designed" project. A study to investigate how practitioners go about creating projects would be fruitful since many faculty members could potentially benefit from a methodology for developing projects that are suitable for student teams.

Implications for Practice

Faculty members are being asked to do more than ever before. As professionals, they have a responsibility to evaluate the expectations placed upon them and to provide insightful feedback to those who establish the requirements. They are more qualified than any other group of individuals to recognize the needs of the various stakeholders and to provide guidance to those who establish the directives. Stakeholders include administrators, students, parents, government, industry, ABET and their communities.

Administrators should identify opportunities to reward teaching excellence and should encourage faculty to develop the necessary skills to be effective teachers by providing education-focused professional development as well as incentives to promote independent efforts to improve teaching effectiveness. Improved internal communication among faculty regarding educational strategies and methodologies should be facilitated so that faculty who have developed effective teaching techniques can share them with their peers. The reward structure, which clearly advocates research over teaching, should be re-evaluated periodically to assure that the desired balance of research, teaching and service is achieved through suitable incentives. Finally, synergistic opportunities to combine research and teaching activities should be pursued.

ABET should recognize that the amount of time that faculty have is finite. Thus, when new requirements are added, it is imperative that the organization consider the ramifications. Ideally, requirements that have become outdated or obsolete should be eliminated as new requirements are added. The faculty and administration at colleges of

engineering and representatives of industry should be consulted to identify opportunities to streamline the requirements and to promote educational balance.

Representatives from industry can provide guidance to universities about the effectiveness of their efforts to prepare students for their careers. Their perspectives are an important influence on decisions regarding the strategies for teaching professional skills. When individuals with industrial experience participate in activities at the university, faculty members can benefit by working closely with practitioners who are accustomed to working in environments similar to those that the students will join upon graduation.

APPENDIX A: INTERVIEW QUESTIONS

Research Question: How do faculty respond to increased emphasis on project teams in undergraduate engineering programs?

Questions for Faculty

Background Information:

- How long have you been an instructor at your institution? Other institutions?
- What type of preparation have you had as an instructor?

Questions Related to Topic:

- What expectations are placed upon you with respect to teaching teamwork skills in your undergraduate engineering courses?
- By whom and in what way have these expectations been communicated (encouraged, strongly recommended, mandated, etc.)?
- Why do you think engineering programs are placing increased emphasis on teamwork for undergraduate students?
- How do you feel about this emphasis on project teams?
- When you have students working in teams, how is your workload affected?
- How do you balance these responsibilities with your other responsibilities?
- For you as an instructor, what are the advantages and disadvantages of student project teams?
- What are the advantages and disadvantages of project teams for students?
- How comfortable are you when working with student teams at the undergraduate level?
- How do you determine team composition?
- How do you encourage students to work effectively on teams?
- What classroom activities do you incorporate to teach teamwork skills? Can you provide specific examples?

- How often, if ever, do you meet with student teams?
- Can you describe any situations where you became aware of conflicts within the student teams? Did you become involve and if so, how did you handle the conflict?
- In what ways do you evaluate whether a project team assignment has been successful?
- How do you assess individual performance when students are working on teams?
- If you had unlimited time and resources available, what would you do differently with regards to student project teams?

Questions for Administrators

Background Information:

- How long have you in your current position?
- What positions have you had prior to this one? For how long?

Questions Related to Topic:

- What are the goals and expectations of your college (or department) with respect to teamwork skills?
- What are the primary motivations to incorporate project teams for undergraduate students?
- How do you feel about this emphasis on project teams?
- In what ways does the emphasis on project teams affect the workload of faculty?
- How do you think that faculty members balance these responsibilities with their other responsibilities?
- How do you want faculty to balance these responsibilities with their other responsibilities?
- What does your college or department offer to faculty to help them prepare to teach these new skills to students?

- How do you determine whether your college (or department) is succeeding in their efforts to teach students to work effectively on teams?

- If your college (or department) had unlimited resources, what would you do differently with regards to student project teams?

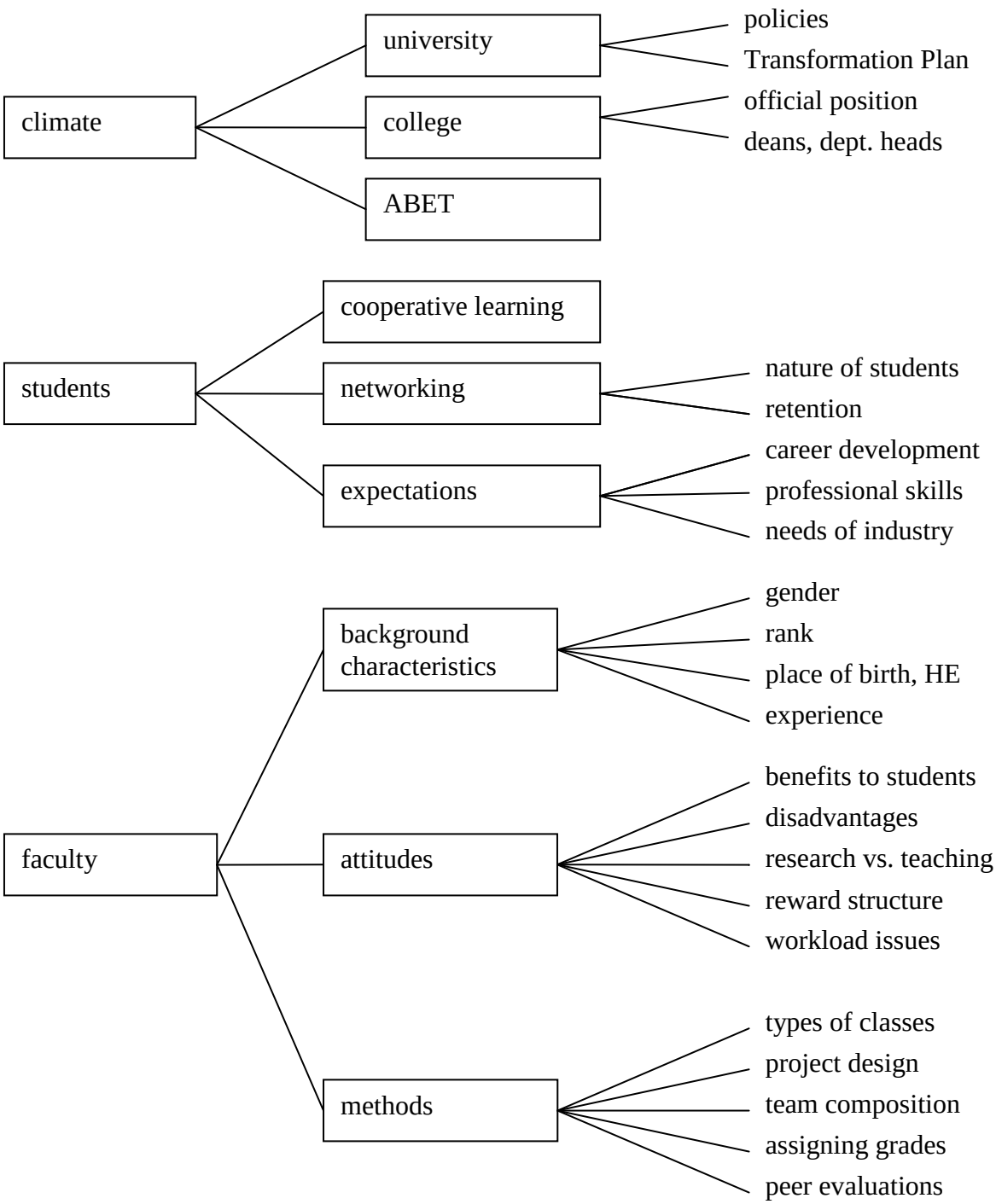
APPENDIX B: LIST OF SETS

The following list of sets was utilized during data analysis:

1. Gender
    a. Female
    b. Male
2. Position
    a. Dean or Associate Dean
    b. Department Head or Associate Department Head
    c. Faculty
3. Rank
    a. Assistant Professor
    b. Associate Professor
    c. Professor
4. Place of Birth and Childhood
    a. US
    b. Other
5. Location of Higher Education
    a. US
    b. Other
    c. Combined
6. Industrial Experience
    a. Significant
    b. Minimal
7. Education-focused Professional Development
    a. Significant
    b. Minimal
8. Teamwork in University Research Activities
    a. Significant
    b. Minimal

APPENDIX C: TREE DIAGRAM OF NODES

The following diagram illustrates the nodes utilized during data analysis:



APPENDIX D: SUMMARY OF FINDINGS

Theme 1:	**Climate of College of Engineering and the engineering departments**
1.1	With regards to the Transformation Plan, faculty members felt that some changes were needed, however, many were skeptical that the restructuring would have positive results.
1.2	Officially, the College of Engineering administration indicated a commitment to incorporate teamwork into the undergraduate curriculum however the behavior did not necessarily reflect the commitment.
1.3	None of the faculty members indicated that they felt pressure from the College of Engineering or their departments to include project teams in their courses, however some were guided in that direction.
1.4	It was generally accepted that teamwork would be emphasized in the freshman level Introduction to Engineering class (Engineering 102) and in the senior level Capstone Design course, regardless of who taught the course.
1.5	Most departments had additional courses scattered throughout the curriculum that incorporated project teams but some found it difficult to find room in the curriculum for courses that utilized project teams.
Theme 2:	**Study participants' opinions regarding the importance of teaching students to work effectively in teams**
2.1	There was a strong belief that students would be expected to work in teams in the workplace after they graduated.
2.2	Many faculty felt that it was important to provide team experiences in undergraduate education to prepare students for industry but some felt that the focus on professional skills would detract from teaching more important subjects such as the fundamentals of mathematics, basic and engineering sciences.
2.3	Most of the study participants were mildly supportive of ABET's criteria which specified that undergraduate engineering programs must demonstrate that their students have the ability to work effectively on multi-disciplinary teams.
2.4	Many faculty members thought that important interpersonal skills could be learned through experience and that undergraduate courses were a suitable place to teach these skills while others did not.
Theme 3:	**Influence of faculty members' personal experiences on their attitudes toward student teams**
3.1	Most faculty members acknowledged that it was somewhat difficult to the simulate teamwork in industry because of the nature of the tasks, the limited skill sets of the students and the brief amount of time available. However, most felt that they were able to create an acceptable likeness to

	the real world.
3.2	Most faculty members had limited knowledge of the theories of cooperative learning but readily expressed opinions about the benefits (or lack of) in undergraduate engineering education.
3.3	Some faculty members thought it was sometimes beneficial for gifted students to experience working with less talented or less motivated students but often the most gifted students suffered. On the other hand, many felt that weaker students often benefited from working with stronger students.
3.4	Faculty members had not given much thought to whether project teamwork promoted social networks or whether enhanced social networks helped improve the retention in engineering, but most were willing to comment on the topic.
3.5	Faculty members consistently expressed the importance of including teamwork only in courses that were suitable for project teams.
3.6	While some faculty members seemed rather apathetic regarding the specific logistics of using project teams, nearly all of them had opinions about the influence of team composition.
3.7	The effect of team project grades on students' individual grades was a major concern for most instructors who assigned project teamwork.
3.8	The most common conflict that faculty members dealt with was "slackers".
Theme 4:	**Methods, strategies and techniques that faculty utilized with student teams**
4.1	Some faculty had strategies to make their students feel important and valued.
4.2	The effort faculty put forth to determine team composition varied greatly.
4.3	Many different approaches to grading were apparent.
4.4	It was apparent that faculty members disliked dealing with conflicts among team members and most of them tried to 'make it go away'.
Theme 5:	**Influence of personal attributes, background characteristics, and professional experiences on attitudes toward project teams**
5.1	Junior faculty, who were generally younger than the senior faculty, were comfortable with using project teams in the courses they taught, likely because they had substantial experience working on teams as students and in their research efforts.
5.2	Most, but not all, of the senior faculty members who had been teaching for many years, found working with project teams somewhat taxing.

5.3	Women faculty members seemed to place considerable value on teaching students professional skills including effective communication and teamwork skills.
5.4	In general, faculty members who were raised and educated outside the US had less experience working on teams as students; however, they were not necessarily less comfortable with using teams in their courses.
5.5	Faculty members with extensive industrial experience, by and large, had a heightened opinion about the importance of teaching teamwork skills to undergraduate engineering students.
5.6	Very few faculty members had any type of professional development to prepare them to teach effectively or to manage student project teams.
5.7	Some faculty members incorporated teams into their classes just because they felt it was the right thing to do for their students.
5.8	Faculty members often experienced teamwork while working on research projects and grants.
Theme 6:	**Competing roles, reward structures and workload issues**
6.1	Many of the faculty members felt that the teaching demands on faculty, specifically engineering faculty, seemed to continually increase.
6.2	The balance of research, teaching and service was of paramount importance and faculty members found it necessary to constantly balance their time.
6.3	A number of faculty members indicated that they really enjoyed teaching and placed as much emphasis on teaching as research but few found significant synergy between research and teaching at the undergraduate level.
6.4	Faculty members acknowledged that recognition and the reward structure placed greater emphasis on research than on teaching.
6.5	The opinions of faculty varied greatly with regards to the impact of student project teams on their workloads.
6.6	Participants had mixed attitudes about whether it was essential that research professors performed effectively in all of their varied roles. Opinions were mixed as well about the prevalent use of adjunct professors and lecturers.

APPENDIX E: CONCLUSIONS AND RELATED FINDINGS

Conclusion:	**Related Findings:**
1.) Officially, the College of Engineering supported the use of project teams in undergraduate education, but the prevailing climate did little to promote efforts related to effective teaching.	1.1,1.2, 2.1, 2.2, 5.8, 6.4
2.) Those faculty members who advocated the use of project teams felt that opportunities to provide students with these experiences should be selected and managed carefully.	1.4, 1.5, 3.5, 3.6, 4.2, 6.2, 6.5
3.) The two biggest concerns for faculty working with student teams were related to the impact on individual students and workload concerns.	2.4, 3.3, 3.7, 3.8, 4.3, 4.4
4.) Some study participants had specific opinions about ABET Criterion 3d (programs must demonstrate that students have an ability to function on multidisciplinary teams) but many gave the criterion minimal thought and viewed accreditation as strictly an administrative task.	2.3, 3.1, 5.5, 5.7, 6.1
5.) Faculty members at SW University had participated in little or no formal training to improve their teaching and would likely benefit from some professional development activities related to teaching, however the climate did not promote those efforts	1.3, 5.2, 5.4, 5.6
6.) The commitment to providing students with quality educational experiences, specifically teamwork experiences, varied greatly and was found to be inconsistent in keeping with the spirit of ABET and the stated objectives of the College of Engineering.	3.2, 3.4, 4.1, 5.1, 5.3, 6.3

APPENDIX F: ABET CRITERION 3

Criterion 3. Program Outcomes

Engineering programs must demonstrate that their students attain the following outcomes:

(a) an ability to apply knowledge of mathematics, science, and engineering
(b) an ability to design and conduct experiments, as well as to analyze and interpret data
(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
(d) an ability to function on multi-disciplinary teams
(e) an ability to identify, formulate, and solve engineering problems
(f) an understanding of professional and ethical responsibility
(g) an ability to communicate effectively
(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
(i) a recognition of the need for, and an ability to engage in life-long learning
(j) a knowledge of contemporary issues
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Program outcomes are outcomes (a) through (k) plus any additional outcomes that may be articulated by the program. Program outcomes must foster attainment of program educational objectives.

There must be an assessment and evaluation process that periodically documents and demonstrates the degree to which the program outcomes are attained.

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