THE INCIDENT EFFECTS ON ENGINEERS AND ENGINEERING TECHNOLOGISTS IN PURSUIT OF A GRADUATE DEGREE

By

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ABSTRACT

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This dissertation describes the critical incident study performed on 66 practicing professional engineers and technologists in public and private organizations within the Dallas-Fort Worth, Texas metropolitan area who were enrolled in part time graduate education in 1996 and 1997. The study served three purposes: to identify critical incidents that motivate professional engineers and technologists to seek a graduate degree; to identify the critical incidents that motivate graduate student's curriculum choice; and to identify other factors that foster an engineer or technologists decision to pursue a graduate education. The study addressed three research questions: What are the critical incidents that motivate some professional engineers and engineering technologists to seek graduate studies? What are the critical incidents that influence professional engineers and technologists to choose a curriculum in engineering, technology, or another discipline? What are the other factors that exist that influence professional engineers or technologists to pursue a chosen graduate filed of study? The significance of the study is for academia to find ways to encourage US students into engineering and engineering technology graduate programs and for business management to find means to retain professional engineers and engineering technologists in the workforce by understanding why these professionals choose to pursue graduate studies. The methodology the study used was the Critical Incident Technique developed by John C. Flanagan. Data were gathered through a Critical Incident Pamphlet and data analyses were performed through a Q-sort procedure. The data analyses showed the largest respondent group was 31 to 35 years old, Caucasian/White, and male; graduated in the 1980s in electrical engineering; and now pursuing graduate studies in computer science, for career development. The findings, conclusions, and the implications of the study are discussed. Recommendations are offered as an extension of the findings and conclusions.

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Chapter 1

INTRODUCTION

Technology is the machine that empowers the American economy. For this reason, American society and the nation's economy depend heavily on engineers and technologists. Not only do they plan and supervise industrial systems and information systems, but they also develop innovative technologies that provide for the future economic well-being of our country (Munday, 1973). For that reason alone, encouraging technical education is paramount to sustaining America's competitiveness in the global economy of the 21st century (Senate Committee Hearing, 1989). Atkinson (1990) observed that fulfilling the need for financial and human resources that are adequate to meet domestic and global demand is self-evident. Additionally, Atkinson noted the most serious need is persisting with excellence and global leadership in an era of limited resources. He maintained that these financial and human resource needs can only be met by producing world class engineers and technologists (Atkinson, 1990). However, with fewer American students projected to pursue careers in engineering (E) and engineering technology (ET), American industry, economic growth, international competitiveness, and national security may suffer profoundly (Atkinson, 1990).

Enrollments in engineering and engineering technology in American universities have fluctuated since the 1960s. From 1976 to 1982, enrollment boomed to an all-time high (Somers, 1991) annual rate of more than 3 percent per year (National Science Foundation, 1991). As a result, many colleges considered limiting enrollment (Barns, 1981). These enrollment constraints succeeded, and enrollment in E and ET programs declined. By the time the graduates from the 1982 enrollment boom hit the market, the size of incoming freshmen classes had dropped so dramatically that engineering schools had become alarmed again. Many educators wondered if the nation would face a scarcity of qualified professionals by the 1990s (Somers, 1991).

Beaufait (1991) offers four reasons to account for the declining enrollment. He maintains the primary reason for the decline is that interest in math and science among US high school students has faded. Additionally, he observed that students today are not taught the critical thinking skills necessary to succeed in E and ET programs, they are thus lured toward other disciplines. Still another reason could be that careers in E and ET may not be perceived as equally glamorous as careers in law and medicine. Beaufait concluded with the observation that, today's disposable society does not tempt young students to "tinker" with everyday items, thwarting curiosity and, therefore, any understanding of how things work. Regardless of the reason, the number of American students enrolling in E and ET programs continue to decline. E and ET undergraduate enrollment has dropped approximately 15 percent from 1983 to 1991 (Beaufait, 1991). The decline is compounded by the high attrition rate usually occurring between the freshman and sophomore years for students of E and ET, a rate that has increased from 11.9 percent in 1975, to 24.4 percent in 1980, and to 27.7 percent in 1990. In short, the situation has become critical (Manpower Commission, 1991).

Alarming as it is among undergraduates, the enrollment crisis is even more acute at the graduate level (Tobias, 1990). While at most universities the undergraduate requirements alone are very demanding. The graduate degree presents its own hurdles, such as forcing students to retake outdated math and computer science classes (Tobias, 1990). Tobias (1990) wrote that the message to students "is discouraging to all but a favored few, and the model unyielding" (p. 9). She added that,

> Unless they are unusually self-motivated, extraordinarily self-confident, virtually teacher and curriculum-proof, indifferent to material outcomes, single minded and single tracked, in short, unless they are younger versions of ourselves, many otherwise intelligent, curious, and ambitious young people have every reason to conclude there is no place for them.
>
> Science, like all professions, needs to reproduce itself non-biologically. But by seeking attributes and attitudes much like their own, scientists inhibit recruitment from outside familiar channels (p. 9).

Further, Tobias wrote, ". . . to narrow a vision of what kinds of attributes, behaviors, and life styles the true scientist displays inhibits students [from] attempting to complete graduate studies in science, engineering, and technology" (p. 10). Consequently, programs in E and ET today have become as inaccessible as the Bachelor of Science (BS) degree of the 1930s (Eisenstein, 1990).

The future demand for E and ET graduate degrees is difficult to assess; however, the American Association for Advancement of Science (AAAS) has endorsed a report that projects a shortfall of 150,000 BS degrees in science and technology between the years 1995 and 2010 (Atkinson, 1990). Additionally, the National Science Foundation believes that this shortfall will widen over the next two decades (National Science Foundation, 1989). In 1991, the National Science Foundation reported that "the adequacy of the supply of new engineers during the 1990s continues to promote concern" (p. 2).

The shortfall projections hold true for the graduate level E and ET enrollment (National Science Foundation, 1991). The question arises, are American educational institutions and industry to be blamed for this decline in E and ET enrollment? Eisenstein (1990) reports a strong perception by many prospective graduate students that getting a Ph.D. is more like getting into an exclusive country club, rather than being a reward for hard work, perseverance, and creativity. Many other prospective graduate students indicate that the reward for obtaining a graduate degree is not worth the cost and effort (Tobias, 1990). Thus, graduate school enrollment continues to decline (National Science Foundation, 1991).

Although Atkinson's research (1990) shows that graduate degree conferral rates for engineers and technologists have remained relatively constant for the last 30 years, these flat conferral rates may be misleading. In fact, of all graduate degree conferrals, non-US students currently account for approximately 25 percent of the undergraduate degrees, 33 percent of the graduate degrees, and over 50 percent of doctoral degrees (National Science Foundation, 1991). The fact that the number of annual graduates of American born students has not increased in a generation in which science and technology pervade everyday life should be disconcerting. Moreover, less than half of these foreign graduates remain in the US to work (Senate Committee Hearing, 1989).

Coupled with the increasing non-US student E and ET graduation rates of the last 20 years, the US has significantly fewer E and ET graduates in the manpower pool than in 1970. Any reasonable analysis of the realities of global competition should be discomforting. The high US student drop-out rate in university E and ET programs should be alarming (Atkinson, 1990). Feisel (1990) noted that "universities must find a way to participate in post-degree education" (p. 1). In other words, American educational institutions must find the means to increase the number of engineering professionals who are prepared for a life-long endeavor in engineering and technology (Feisel, 1990).

American academics are not the only group concerned about student decline. Industry is also concerned. At the 1992 National Academy of Engineering (NAE) awards banquet, Norman Augustine, then Chief Executive Officer (CEO) of Martin Marietta Company, stated that engineering and technology professionals have failed to convey the message that these disciplines are exciting (Braham, 1992). Prompted by Augustine's remarks, the American Association of Engineering Societies (AAES) formed a task force to study images of engineers and technologists in an effort to promote them. The task force found that other professionals fail to hold engineers and engineering technologists in high esteem; the public does not understand what engineers and technologists do; and high school students have difficulty in selecting a specific E or ET field from the multitude of different disciplines (Braham, 1992).

The work place itself may also detract from the E and ET professions. Adelmen (1994) noted that most engineering organizations do not take advantage of the latest technology. Further, they do not define what the company wants in the future. And they do not push for innovative ideas. Finally, they develop an organizational structure that discourages workplace creativity. As a result, while many undergraduate students never even choose to study E and ET, many professional engineers and technologists choose to change careers and leave the field altogether. Such career changes have resulted in over 2,000 losses of highly skilled engineering personnel yearly (Picket, 1995).

If education and industry are to meet the projected engineering and engineering technology needs of the future, the decline in E and ET enrollment must be resolved. Several studies have attempted to address the decline in E and ET undergraduate enrollment. Freeman (1971) studied the econometrics of trying to predict engineering enrollments and Beaufait (1991) looked at the dropout rates of undergraduate students. But the decline in E and ET graduate school enrollment has received very little attention. Moreover, an explanation as to the reasons why so many professional engineers and technologists re-educate themselves and leave the engineering field also remains to be explored. A few concerns are clear: Are sufficient quantities of trained professionals available to meet future needs? Will adequate manpower with knowledge of the E and ET technologies be available in 10 to 20 years? Are the impact and loss of core skills in engineering on America's world technological leadership understood? Finally, are the effects of these current signals on the future generations in E and ET known? (Picket, 1995).

Some possible answers to the decline in the graduate E and ET program enrollment may be obtained by identifying why some E and ET professionals have pursued graduate studies in other fields, why they have chosen certain curriculum, and what critical events confirmed their choices. Knowing the answers to some of these questions may help educational institutions and working organizations reduce these professional losses and increase college and university enrollment (Feisel, 1990).

Statement of the Problem

Atkinson (1990) noted that America needs financial and human resources to meet its domestic and global needs. "The most serious problem is maintaining excellence and global leadership in an era of limited resources" (Atkinson, p. 426, 1990). By producing world class engineers and technologists, America can potentially maintain world technological leadership. To enhance the country's position, American educational institutions will need to find ways to increase the number of American engineering professionals who are prepared for a life-long endeavor in E and ET (Feisel, 1990). The first step for these educational institutions in developing such a commitment is to identify current professional migrations among practicing engineers.

The problem of this study was to try to identify why professional engineers and technologists choose to pursue a graduate education. Knowing the reasons for graduate education choice may provide background on how to retain engineers and technologists in these professions.

Purpose of the Study

The purpose of this study was accomplished to identify the reasons why professional engineers and technologists choose to obtain a graduate education. By analyzing what motivates American engineers in their choices of curricula, this study may suggest directions for educational programs that, if addressed, could increase the enrollment of American students in E and ET disciplines. At the same time, this study may identify organizational behaviors and working structures that could possibly reduce the depletion of E and ET personnel. This study addressed the following specific purposes:

1. To identify the critical incidents that motivate professional engineers and technologists to seek a graduate degree.
2. To identify the critical incidents that motivate professional engineers and technologists to choose a curriculum in engineering, technology, or in another discipline.
3. To identify other factors that foster an engineer's or technologist's choice to pursue a specific graduate field of study.

Research Questions

This study concentrated on the critical reasons cited by professional engineers and technologists within the study sample that affected their choices to pursue a graduate degree program. The following research questions formed the basis of this study:

1. What are the critical incidents that motivate some professional

engineers and engineering technologists to seek graduate studies?

2. What are the critical incidents that influence professional engineers and technologists to choose a curriculum in engineering, technology, or in another discipline?

3. What other factors exist that influence professional engineers or engineering technologists to pursue a chosen graduate field of study?

Significance of the Study

This study is approached as a means to understand why fewer American students enroll in E and ET graduate programs and why professional engineers and technologists leave the profession. While shortages and overages of critical human resources in the E and ET careers is not a new phenomenon, the high demand associated with them is new. As modern society demands more technology-oriented products, the demand for E and ET careers becomes vital. When the demand for more technology is compared against the flat graduation rates in E and ET programs over the last ten years, the demand takes on critical proportions. The decline in American E and ET graduate degrees makes the outlook for US technological leadership appear dim (Stewart, 1991).

In recent years, one of the most controversial issues with university faculty and business leaders has been finding a means to encourage more American students to pursue either the E or the ET curriculum. The US Senate Committee Hearing (p. 2, 1989) wrote: "We need to do more to encourage US students to enter the science and engineering fields. Encouraging education in those fields is essential to maintain US competitiveness in the global economy of the 21st century." Many factors have attributed to the decline of US students pursuing E and ET degrees. A US House Subcommittee, in the meantime, identified two factors that attract E and ET students and four factors that reduce attrition. The factors attracting students are: "a) the job market, b) academic preparation and high school achievement" (House Subcommittee Hearing, p. 10, 1989). The factors affecting attrition rates are: "a) university attention to student completion, b) intervention programs and peer support, c) student research participation, d) good teaching" (House Subcommittee Hearing, p. 10, 1989).

In an article for *Fortune Magazine* (Stewart, 1991), Polaroid Chief Executive Officer (CEO) Mac Booth stated that "intellectual capital has always been the most visible and most valued asset in the leading edge of science and engineering" (p. 44). Booth cited four steps that a knowledge-based corporation should follow in managing its intellectual assets. "First, find your intellectual assets. Second, match your intellectual assets to your long-range strategic plan. Third, compensate acquisition of critical employee skills. Lastly, create an organization that can share knowledge effectively" (Stewart, p. 45, 1991).

While industry and education work to stop engineering shortages, the university must provide the initial resources. The supply adequacy of new engineers and technologists during the 1990s continues to be a concern. Industry must find the means to retain college graduate engineers and technologists. Through 1989, the engineering work force extended its long growth trend at an annual rate of approximately 2 percent per year (National

Science Foundation, 1991). During the early 1990s, employment rates in non-manufacturing jobs have increased faster than engineering and manufacturing jobs (National Science Foundation, 1991). Moreover, these changes are expected to continue through the 1990s. This rapid change paired with the potential shortage of qualified engineers and engineering technologists is a major concern for the US economy as it enters the technology-driven 21st century (National Science Foundation, 1991).

The extraordinary and continuing global political changes of the last half decade are forcing fundamental reassessment of the policies used to attract students to E and ET programs (National Science Foundation, 1991). Sagan reported to a 1989 Senate Committee Hearing that, after Sputnik I, America responded with a wide range of outreach programs to attract E and ET students. Now that the Soviet Union has diminished as a technology threat, one of the fundamental problems facing the US is how to attract new E and ET students. "It is unlikely that there will be another critical event that will motivate the US as a country the way Sputnik did" (Senate Committee Hearing, p. 16, 1989).

The decline of American students at the undergraduate level in E and ET, from 12.6 percent in 1982 to 9.6 percent in 1990 (National Science Foundation, 1991), has led to fewer American graduate students. A 1989 US Senate Committee reported that only five percent of US undergraduate degrees are in science and technology, while Japan has 20 percent and Germany has 37 percent. Something should be done to turn the tide and attract US students to E and ET programs (Senate Committee Hearing, 1989).

In his study on scientific and technical careers, Rever (1973) suggested that one area of education needing additional study is the graduate school population. He wrote ". . . we know very little about graduate students. If it can be said that we know little about technically oriented students, then it can be said that we know almost nothing about the developmental processes and outcomes during the graduate school years" (p. 146). In paraphrasing John Dewey, Gutek wrote that ". . . education should be based on a continuum of ongoing experience that unites the past and the present and leads to the shaping of the future" (p. 289, 1988). Clearly, career development does not stop with adult life, but continues throughout the adult life span. "It would then be worthwhile to encourage research devoted to the understanding of development during the graduate school years" (Rever, p. 146, 1973). Also related to career development is what Rever calls "path jumpers," students who complete one path of study and then change to another, dissimilar path. Rever reasoned that "by observing the factors involved in such radical changes, perhaps the understanding of career development will be enhanced" (Rever, p. 146, 1973).

This study benefits both college and university faculty as well as engineering business management. By identifying the critical incidents that influenced practicing professional engineers in their decisions to acquire a graduate degree in their chosen path of study, potential changes may be made to stem the decline of American E and ET losses. With the data on why graduate students choose studies in engineering or in other fields, educational institutions and business enterprises alike may become more affective in attracting and retaining qualified engineering students and degreed engineers.

Once graduate schools know the critical events that shape the educational choices by engineers and technologists, they can adjust their curricula. Through an examination of such decisions, significant insight can be gained into how best to address required institutional and business changes. The results of this study can set the stage for improving E and ET curricula. Additionally, the data obtained in this study can provide valuable answers to the questions posed by the Senate Committee Hearing (1989) and by the Polaroid CEO (Stewart, 1991). These data can provide the opportunity to make relevant program changes to meet the goals set forth by the US Senate to alter E and ET student losses and by the American business community to keep engineers and technologists in the work place.

Scott Adams, an engineering manager and creator of the Dilbert cartoon strip about engineers, believes that most engineers within large corporations are ". . . squeezed into their little cubicles and their creativity is forced outside the organization" (Meisler, p. 1, 1995). This internal suppressing may be one reason for corporate losses of practicing engineers, but other quantifiable reasons are needed.

Methodology of the Study

Rever (1973) stated a need to study graduate students for their perceptions about graduate studies. The present study queried graduate students for precisely that information and used the Critical Incident technique, based on Flanagan's Critical Incident methodology (1954), to identify why professional engineers and technologists chose to obtain a specific graduate education. The critical incident data for this study were gathered through this process:

1. Selection of the subject group.
2. Development of the critical incident pamphlet.
3. Distribution of the critical incident pamphlets.
4. Collection of the data.
5. Analysis and treatment of the data.
6. Interpretation of the data.

The subject group was selected from a list of potential participants developed from engineering organizations within the Dallas-Fort Worth, Texas, metropolitan area. The Critical Incident pamphlet (see Appendix B) was designed to elicit the participants' behaviors used to make decisions about graduate education. The pamphlet asked participants to describe the positive and negative incidents that led them to pursue graduate education. The pamphlet was accompanied by a cover letter and a demographic survey.

Before being distributed, the critical incident pamphlets were assigned a computerized random number for the study participation, identification, anonymity, and follow-up. The pamphlets were distributed three ways: through potential participant's E-mail addresses supplied by an organizational study coordinator, through mailing addresses supplied by the organization, and through the individuals designated as the organizational study coordinator. Data were collected depending on the means of distribution, reviewed for any follow-up clarification, and assessed for sufficient response quantity. The data were analyzed using the Q-sort process. Data were interpreted using contingency tables.

Definition of Terms

The following terms are defined according to their study usage:

Critical incident: A behavior that has an intent that is clear for observation and the consequences of which are definite enough to determine its critical effect (Flanagan, 1954).

Critical incident pamphlet: The instrument designed to gather critical incidents from engineers and engineering technologists for their behavior's in the process of choosing a graduate course of study (Flanagan, 1954).

Engineering: A profession whose practitioner holds an earned bachelor's degree in a discipline normally referred to as engineering, such as electrical, mechanical, civil, industrial, or other appropriate engineering discipline. For this study, degrees in computer science areas are also included in engineering.

Engineering technology: A profession whose practitioner holds an earned bachelor's degree in an applied discipline normally referred to as engineering technology, such as electrical engineering technology, mechanical engineering technology, civil engineering technology, industrial engineering technology, or other appropriate engineering technology disciplines. For this study, degrees in computer information systems areas are included.

Graduate student: A person who holds a bachelor's degree in E or ET and is enrolled in post-bachelor's course of study (National Science Foundation, 1991).

Incident: Any observable human activity that is sufficiently complete in itself to permit inferences and predictions to be made about the person or group of persons performing the act (Flanagan, 1954).

Path jumper: College students at all program levels who are judged to be on one path of study and who suddenly change to a completely dissimilar path of study (Rever, p. 146, 1973).

Assumptions of the Study

The following basic assumptions were included as a part of this investigation:

1. The study group membership is representative of the Dallas-Fort Worth metropolitan area.
2. The reported incidents are unbiased and yielded data and insight appropriate for a critical incident study.
3. The study group participants responded honestly.
4. The use of the critical incident technique was an appropriate and reliable process for the completion of this specific study.

Delimitations of the Study

The following delimitations were included as part of this investigation:

1. This study was conducted within the Dallas-Fort Worth area. The resulting study research analysis is only applicable to this metropolitan area.
2. The Dallas-Fort Worth area study group is heavily populated by

aerospace industries. The specific occupations within the aerospace work force include all disciplines within E and ET. This incident study attempted to include as many participants as possible outside the aerospace work force.

3. Many persons perform work within the E and ET occupations. However, for the purposes of this study, only those persons reporting a completed E or ET bachelor's degree and currently enrolled in graduate study were considered within the study results.

Organization of the Remaining Chapters

Chapter Two reviews and analyzes related studies performed previously on engineers and technologists pursuing graduate studies. Detailed characteristics of the study group and the methods followed in collecting the data are described in Chapter Three. The presentation and analysis of the collected data are delineated in Chapter Four. Finally, Chapter Five consists of findings, conclusions, implications, and recommendations for further study. For the purpose of description and clarification, various tables, graphs, and charts are included in the body and appendices of the dissertation, as deemed appropriate.

Summary

America needs engineers and technologists to maintain its lead in the global economy. While US student population in E and ET is declining, those students who pursue degrees in E and ET often "jump" career paths (Rever, p. 146, 1973) to another discipline altogether, thereby creating additional losses to the current E and ET work force. With fewer US students predicted to pursue careers in E and ET, America's economic growth, international competitiveness, and national security stand to suffer greatly (Atkinson, 1990). This exodus of "intellectual capital" (Stewart, p. 44, 1991) needs to be stopped. If the reasons are known why students change paths of study, academia can adjust the curricula. If reasons are known why professional engineers and technologists leave the field altogether, industry can focus on attracting and retaining qualified engineering students and degreed engineers. This study focused on what decision-making processes professional engineers and technologists used to chose a particular area for graduate study. The critical incident technique developed by Flanagan (1954) was used to identify these processes.

Chapter 2

REVIEW OF THE LITERATURE

Introduction

Research has been performed over the past 26 years on engineers and technologists pursuing graduate education. The years from 1970 to 1995 are particularly pertinent to this study because modern computing systems were introduced, a technology that greatly influenced engineering (E) and engineering technology (ET) professions and methods. This period also represents a relatively flat era of student growth in E and ET programs. Further, this period represents the rapid decline of US students participating in American college and university E and ET programs. Although little specific research has focused on what influences practicing engineers and technologists to gravitate to an advanced degree, much research exists on characteristic data for graduate engineers and technologists. Research has been performed on why enrolled graduate students pursued a graduate degree. However, little research exists on why practicing engineers and technologists pursue graduate studies.

In this chapter, the literature reviewed focuses on graduate students in general. The literature selected is relevant to this study and has been organized into three areas: Characteristics of Engineers and Technologists Participating in Other Studies, Factors That Influence the Supply and Demand of Engineers and Technologists, and Status of US Engineering and Technology Education. A Summary concludes the chapter. Each of the three subject areas presents studies relevant to the subject. The studies will be presented chronologically within each of the first three subject areas.

Characteristics of Engineers and Technologists Participating in Other Studies

US universities and colleges produce the largest engineering and technology work-force in the industrialized world. Advancements made in E and ET lead directly to new and improved products that, in turn, lead to economic expansion and to a higher standard of living for all citizens (National Science Foundation, 1994). The US government projects that US employment in technical occupations will grow at a faster rate than the overall US employment for the rest of the 20th century. That means that the contribution of engineers and technologists to the health of the American economy is vastly disproportionate to the 4 percent of the labor force they represent (Manpower Commission, 1991).

Reports of impending E and ET personnel shortages are common. Recently, the focus has been on possible surpluses of engineers and technologists because of the recession and down-sizing of the defense industry. The defense industry has traditionally been the largest employer of engineers and technologists. These projections also consider the impact of the ever-increasing number of foreign students graduating from engineering and technology schools in the US. However, forecasting is perilous; many critical elements in the process are only assumptions about the future. Therefore, predictions of shortages or surpluses should be treated with caution. The free market economy eventually levels to the needs of certain work-force disciplines.

US labor demands are flexible and trigger fairly quick responses to shortages or overages. E and ET unemployment rates have been increasing over the last few years. However, the 1993 overall unemployment rate for engineers and technologists stood at 3.8 percent. Although data on graduate engineers and technologists are scarce, the data indicates that fewer than 2 percent are unemployed. However, E and ET unemployment rates are consistently lower than the national average (National Science Foundation, 1994).

In general, engineers and technologists earn considerably more than the average worker. The 1994 National Science Foundation study on Science and Engineering Work Force reported that, traditionally, only lawyers, physicians, and pharmacists make more than graduate degree engineers. From 1987 to 1992, the graduate E and ET median salary grew at a 20 percent rate. The gains in E and ET salaries were over-shadowed by healthy gains in the other comparable professional occupations. Those comparable salaries rose at 44 percent for physicians and at 33 percent for lawyers (National Science Foundation, 1994).

From 1970 to the present, the number of US college graduates has increased at 4.8 percent per year. A seemingly pervasive anomaly to this growth rate is that the US has the world's highest number of engineers and technologists in its labor force but the lowest proportion of engineers and technologists to college graduates of the free market economy countries of the world (National Science Foundation, 1991).

A continuing concern prevails over the long-term, gradual decline of US undergraduate engineering and technology majors, though enrollment and graduate degrees received in these disciplines have increased slightly since 1980. This rise in enrollment is the product of a rapid increase in graduate participation of non-US students (National Science Foundation, 1991).

Master's degrees were awarded to 21,120 engineers and technologists in 1989, or about 32 percent of the total degrees awarded that year. At the doctoral level, E and ET accounted for about 22 percent or 4,900 of the total science and engineering degrees awards that same year (National Science Foundation, 1991).

A 1993 National Survey of College Graduates conducted by the National Science Foundation reported that approximately 2.5 million people hold degrees in E and ET. This number is somewhat misleading because many E and ET undergraduate degree holders also hold a graduate degree in engineering or technology (National Science Foundation, 1995).

In 1990, women accounted for about 17 percent of the total engineering master's degree awards and about 7 percent of the doctoral degrees. Minority students earned about 7 percent of the total graduate engineering degrees. Black or African American students were granted about 1.7 percent of the total master's degree awards, while less than 1 percent earned doctoral degrees. Over the last 20 years, the rate of non-US students receiving graduate degrees in E and ET grew at a larger rate than did the rate of American students receiving these same degrees (National Science Foundation, 1991). In 1972, foreign students at US colleges and universities comprised 16 percent of master's students and 22 percent of the doctoral students in E and ET (National

Science Foundation, 1973). In 1990, foreign graduate students comprised about 35 percent of the master's degree awards and about 55 percent of the doctoral awards (National Science Foundation, 1991).

The (1973) study, "Graduate Science Education: Student Support and Postdoctoral" by the National Science Foundation, investigated US science, engineering, and technology student populations. The report gathered data from 4,600 department chairs in 302 graduate schools, describing the characteristics of 52,725 graduate students enrolled in 1972. This National Science Foundation report became a biannual report and is considered the definitive study of the US science and technology student population. The report shows a 3 percent decline across the board in US graduate student enrollment from 1971 enrollment levels. In particular, graduate engineering enrollment declined 5.1 percent. The report shows that, at the master's level, enrollment declined 2.1 percent while doctoral level enrollment declined 5.4 percent. This larger decline in engineering doctoral students over the master's students seemed to indicate a shift in focus at the graduate level. Previously, the doctoral degree had been the preferred educational degree for engineers. The National Science Foundation noted that "this upward trend in master's enrollment may signal a shift away from students' reliance on the Ph.D. for increased job opportunities in science and engineering" (National Science Foundation, p. 1, 1973). Clearly, the proportion of non-US students awarded advanced degrees increased substantially.

In 1973, full-time graduate student populations continued to shrink for the third consecutive year (National Science Foundation, 1973). The number of foreign students enrolled in graduate engineering programs declined at twice the rate of the US students between 1971 and 1972. The 1971 decline was the first decline in the non-US student enrollment in a quarter-century. The study reported on 52,725 engineering master's and doctoral students. Full-time students represented 76 percent of the total student population. The report stated that "master's departments enrolled a considerably higher proportion of part-time students than did doctoral departments" (National Science Foundation, p. 11, 1973).

The summary of the 1973 report indicates that several major shifts were beginning to be identified since the 1972 study. The number of part-time graduate students was increasing, while the number of full-time graduate students was decreasing. The master's degree was becoming the degree of choice for post-bachelor's engineering education (National Science Foundation, 1973). This report provides a reference point for the beginning of the stated study review period 1970 to 1996 on the characteristics of engineers and technologists.

The (1993) study, "Characteristics of Doctoral Scientists and Engineers in the United States," National Science Foundation biennial study, investigated the demographic and employment characteristics of doctoral scientists, engineers, and technologists. The purpose of the study was to report on demographic and employment characteristics of doctoral scientists, engineers, and technologists. The data provide a means to reference changes in E and ET characteristics as they occurred in scientists, engineers, and technologists since the 1973 study.

The study used a longitudinal methodology to provide information on the supply and utilization of doctoral personnel in the science, engineering, and technology disciplines. The survey was conducted using a 20-page questionnaire mailed to the subject group. The 1993 survey contained significant changes from the previous annual studies; readers were cautioned that study questionnaire changes made data from previous surveys not necessarily comparable. The sample represented a total of 84,160 engineers and technologists. The stratified study used 15 broad field variables. It over-sampled women, minority groups, and other special interest groups to acquire sufficient data for adequate analysis. The study data were presented in contingency table format and covered a number of broad categories, some of which apply to this study. The study does not separate technologists by specific discipline. They are only addressed as a general category (National Science Foundation, 1993).

The study data of 84,160 doctoral engineers and technologists by gender and occupation indicate that 44 percent were computer scientists, 15.1 percent were computer information scientists, 12.2 percent were electrical engineers, 7.2 percent were chemical engineers, 6.6 percent were mechanical engineers, 6.5 percent were technologists, 4.2 percent were aerospace engineers, 3.2 percent were civil engineers, and 0.5 percent were industrial engineers (National Science Foundation, 1993).

The data were additionally described by gender within each of these disciplines: computer scientists, 87.4 percent male and 12.6 percent female;

computer information scientists, 88.7 percent male and 11.3 percent female; aerospace engineering, 97.7 percent male and 2.3 percent female; chemical engineering, 94.1 percent male and 5.9 percent female; civil engineering, 96.7 percent male and 3.3 percent female; industrial engineering, 95.2 percent male and 4.8 percent female; electrical engineering, 96 percent male and 4 percent female; mechanical engineering, 97.5 percent male and 2.5 percent female; engineering technologists, 88.4 percent male and 11.6 percent female (National Science Foundation, 1993).

Of the 84,160 engineers and technologists responding, 90.7 percent were male. Despite many efforts to increase female participation in E and ET fields, gains have been very slow. The largest gains in female participation occurred within the computer science and computer information systems disciplines. All other disciplines have been relatively slow to show gains (National Science Foundation, 1993).

The study data on characteristics of doctorate engineers and technologists were analyzed by ethnicity and occupation. Of the 84,160 total engineers and technologists surveyed, 62,940 were White, 17,910 were Asian, 1,590 were Hispanic, 940 were Black, and 160 were Native American (National Science Foundation, 1993). Further data analysis showed that White respondents represented 74.7 percent of the engineers and technologists participating in the survey. Computer science was the largest discipline represented with 29,640 participating in the study. Respondents in computer information science numbered 9,860 (National Science Foundation, 1993).

Black or African Americans comprised 1.12 percent of the respondents. Less than 1 percent of the total population were African American in computer science (National Science Foundation, 1993).

The largest discipline group for Hispanic Americans was computer science and computer information, at slightly more than 2 percent of the total population (National Science Foundation, 1993).

Asian respondents comprised 21.13 percent of the total study population. Asians in computer science represented 10 percent of the total population. Asians in computer information represented 3 percent of the population (National Science Foundation, 1993).

Most of the Native American responses came from computer science and electrical engineering disciplines with a combined response of less than 0.5 percent of the population. Less than 1 percent of the respondents reported they were Native American (National Science Foundation, 1993).

The data from the National Science Foundation study analyzed by citizenship and occupation indicated that, of the 84,160 total engineers and technologists surveyed, 84 percent were US citizens and 16 percent were non-US citizens. About 16.8 percent of the doctoral respondents indicated they were naturalized US citizens (National Science Foundation, 1993).

Non-US citizens accounted for 6 percent of the computer science doctorates, while US citizens amounted to 38 percent of the computer science doctorates. US citizens who were awarded doctorates in computer information represented 13 percent of the population while non-US citizens represented 2 percent of the population. US citizens who were awarded doctorates in aerospace engineering accounted for 4 percent of the population. Non-US citizens were awarded doctorates in aerospace engineering presented less than 0.5 percent of the population. Other significant findings showed that 10 percent of the US citizen population and 3 percent of the non-US citizen population were awarded doctorates in electrical engineering. Further, 6 percent of the US citizen population and 0.5 percent of the non-US citizen population were awarded doctorates in engineering technology (National Science Foundation, 1993).

The following data reflect the characteristics of engineers and technologists by their ages and occupations. The study data indicated that of the 84,160 total engineers and technologists surveyed, 13 percent were under the age of 30 and 0.5 percent were over the age of 65 (National Science Foundation, 1993).

Respondents to the age data were separated into nine groups. The largest group reporting was the 45 to 49 age group at 17 percent of the population. The smallest group reporting was the over-65 age group, at 0.5 percent of the population. Eight percent of the respondents were computer scientists, the largest single subgroup. A total of 3 percent reported as computer information scientists. The number of responses from industrial engineers was not sufficient enough to be conclusive (National Science Foundation, 1993).

Computer scientists in the over-65 group constituted 41 percent of the population, and the 45 to 49 age group constituted 46 percent. Chemical engineers in the over-65 age group comprised 11 percent of the population and 6 percent represented the 45 to 49 age group. All other subgroups were not significantly different (National Science Foundation, 1993).

The study on "Characteristics of Doctoral Scientists and Engineers in the United States," is a biennial longitudinal study considered the definitive project on the supply and utilization of American doctoral personnel in the science, engineering, and technology disciplines, showed major shifts in certain areas of E and ET student enrollments. Foreign student enrollment has significantly increased to represent over 35 percent of the master's degree students and 55 percent of the doctoral students. The 1973 biennial longitudinal study reported that less than 10 percent of science, engineering, and technology doctoral recipients were non-US citizens. During this same 25-year period, computer science has replaced electrical engineering as the engineering curriculum of choice. The White male student has continued to be the largest group inspite of substantial efforts to increase the number of women and minorities participating in engineering and technology.

Influencing Factors on the Supply and Demand of Engineers and Technologists

One of the purposes of this study was to identify the factors that influence engineers and technologists to pursue a graduate degree or to choose the graduate degree curriculum. The research reviewed describes influences on educational development during the educational years, characteristics of career planning, and reasons for a graduate degree choice.

This (1973) study, "Factors Influencing Development During the Educational Years," was performed by Phillip Rever for the American College Testing Program. Rever used a longitudinal analysis of existing research and other research in process. The purpose of the study was to guide future research on E and ET career development during the educational years. Rever also wanted to identify those environmental factors that can be manipulated to influence E and ET student supply and demand. The design of the study was to concentrate on those factors that influenced the educational choices of scientists and engineers (Rever, 1973).

Rever found strong evidence that the paths to engineering and physics declined in popularity during the 1960s (1973). He also found that no large-scale path of movement existed from engineering to other professional or paraprofessional paths during those collegiate years.

Rever also wanted to identify environmental and personal factors that account for changes in career paths within engineering and the sciences (1973). He identified two areas that are predictors: level of career path selection and direction of career choices. Each of the two area predictors are discussed below.

First, Rever identified six factors related to the level of career path selection: gender, general academic ability, parental expectations, social class, teachers, and peer groups. Gender was the No. 1 influence in determining direction of career choice. In the study, Rever (1973) found that 50 percent of high school aged males entered college within five years of completing high school compared to only 40 percent of the females at the same age. This finding appeared even in the traditionally female-dominated fields. General academic ability was the second most important predictor of career path. However, the differences between career path predictors within general academic abilities tended to be small, making it difficult to distinguish between the various predictors. Parental expectations were the third most powerful influence as a predictor of career path choice. The importance of parental expectations seemed to be a function of social class. Rever noted that "parental expectations in some cases are more influential in level of career path than other factors" (p. 141, 1973). Social class was found to be the fourth most important influence; teacher and peer groups ranked fifth and sixth in influence (Rever, 1973).

Second, Rever identified five factors influencing the direction of career choice: gender, interests, aptitudes, father's occupation, and the school environment. Gender was found to be the most powerful influence in career choice. Second, interest patterns were shown to be slightly better than other factors in career path choice direction. Aptitude, father's occupation, and school environment ranked third, fourth, and fifth in influence. However, these factors were found to have negligible influence on the direction of career path choice (Rever, 1973).

In his summary, Rever (1973) recommended that more emphasis should be given to the study of career choice and development in predictive studies concerning the environmental factors influencing direction and level of career path choice. He noted that "there are four sub-populations about which little is known in terms of career development in the sciences or other fields" (Rever, p. 146, 1973). The first sub-population is women; the second, paraprofessionals; the third, graduate students; and the fourth, path jumpers (Rever, 1973). Rever's conclusion was that "the career development of scientists and engineers is of considerable importance to our society..." (p. 149, 1973).

The (1983) study on "Career Planning Characteristics of Engineering Students," performed by Kevin D. Shell, William K. LeBold, Kathryn W. Linden, and Carolyn M. Jagacinski, investigated the career planning process of beginning engineering and technology students. This study was performed on 1,229 full-time engineering students at 17 engineering schools across America. The authors used a survey and comparative analysis methodology to conduct this study. The cumulative data were reduced to percentages and placed into tables. Because the study sampled a spectrum of beginning engineering students, it was not totally random. The survey did include a random selection of women and minorities (Shell, LeBold, Linden, and Jagacinski, 1983).

The subgroups within the study consisted of 1,110 freshmen and 119 sophomores: 97 African Americans (7.9 percent), 166 Hispanic (13.5 percent), 13 American Indian (1.0 percent), 918 Caucasion/White (74.7 percent), and 35 listed as Other (2.9 percent). US students represented 95 percent of the study population. Full-time students represented 89 percent of the study population (Shell, et al., 1983).

When asked about the highest education degree they expected to earn, 34 percent of the students responded that they expected to attain a graduate degree. The study reported no significant difference between the number of male and female students expecting to attain a graduate degree. About 8 percent of those respondents indicated they believed they would attain a doctoral degree (Shell, et al., 1983). The study identified significant ethnic differences concerning graduate study intentions. The study noted that a larger number of minority students expected to attain a graduate degree than did majority students. Fifty-seven percent of Black students and forty-one percent of Hispanic students reported that they intended to complete graduate studies. Forty percent of the majority students expected to pursue a graduate degree (Shell, et al., 1983).

Twenty percent of the respondents reported that they planned to pursue a career in electrical engineering. Mechanical engineering was chosen by 15 percent of the respondents, while chemical engineering was chosen by 12 percent. Other popular responses reflected 9 percent for civil engineering, 7 percent for computer engineering, and 6 percent for aeronautical engineering (Shell, et al., 1983). Gender and ethnicity had only negligible impact on the overall response to career planning. The few career planning differences between gender or ethnicity identified were marginal and thus, not considered significant. The top reason given for pursuing a graduate degree was for job opportunity. Good salary (68 percent) followed by challenging work (65 percent) were close behind (Shell, et al., 1983).

In summary, the study found that men and women showed somewhat similar career planning characteristics. The study did identify two interesting characteristics. First, most students responded that they did not believe a formal education beyond the undergraduate degree was required for a successful engineering career. A response different from the 1973 National Science Foundation study. Second, most students in the study responded that they were influenced by the characteristics of engineering work (Shell, et al., 1983).

In the study, "To Pursue or Not to Pursue a Graduate Engineering Degree" (1989), Elinor G. Barber, William P. Darby, Robert P. Morgan, and Laura J. Sallmen-Smith researched whether or not a student wanted to pursue a graduate degree. The data were gathered under the auspices of the Institute of International Education. In the spring of 1988, two surveys were conducted on both US and foreign students who indicated a desire to obtain a doctorate in engineering. The participants from one survey were full-time undergraduate seniors; full-time graduate students were the participants for the second survey (Barber, Darby, Morgan, and Sallmen-Smith, 1989). The purpose of the study was to identify the primary reason engineering students chose to pursue a graduate degree. The study methodology placed the cumulative data into contingency tables for analysis.

The study surveying the graduate students was accomplished with assistance from the chairs and faculty of engineering departments in chemical, civil, electrical, and mechanical engineering. The department chairs served as the contact between the students and the researchers. The data were gathered through the use of survey forms from 2,464 graduate students, representing 174 departments from various colleges and universities. Seventy-three percent of those surveyed said that the subject matter of their studies was "very important," while 63 percent indicated that they wanted to know more about their engineering field (Barber, et al., p. 551, 1989). Fifty-nine percent reported that graduate study was a prerequisite to doing interesting work (Barber, et al., 1989).

These responses were similar results from students who were pursuing a doctorate degree. These students frequently cited a desire to learn more about their field to improve their career opportunities, to prepare them for a research position, to gain prestige, and to improve their earning power as reasons for pursuing a graduate degree (Barber, et al., 1989).

The Barber, et al., study (1989) revealed that, of those graduate students not wishing to be professors, most believed that earning a doctorate was too time consuming, not cost effective, too theoretical, and too research-oriented for the workplace. The researchers reported that, "although economic considerations play a part, career preferences appear important" (Barber, et al., p. 551, 1989).

This study considered factors that influence graduate student's educational pursuits. Study analysis reflected that 48 percent of the student's viewed the curriculum as too demanding. Thirty seven percent of the student's found the course work too theoretical. Additional data reported that 50 percent of doctoral students received far more encouragement from faculty than from family. The researchers concluded that most graduate students had a broad educational background during undergraduate work and were more pleased by the undergraduate experience than by their graduate experience. This same population group reported that 38 percent of their fathers and 18 percent of their mothers held a graduate degree or some other professional degree (Barber, et al., 1989).

In summary, graduate students apparently believe that acquiring a degree beyond the undergraduate level will help them in their career pursuits and that it expands their career field knowledge base (Barber, et al., 1989). This study differs from both the 1973 National Science Foundation report and the 1983 Shell report. This study examined critical incidents that led engineers and technologists to pursue a graduate degree while the other two studies looked at factors and characteristics that influenced graduate degree pursuits. However, most respondents in the Barber, et al., study believe that a doctoral degree is only beneficial to those pursuing careers as a college or university professor. Survey students indicated that pursuit of a doctorate degree was too costly and too time consuming unless they planned to become college professors. Electrical engineering was the engineering degree of choice in 1989 (Barber, et al., 1989). By 1993, it was being replaced by computer science.

Status of US Engineering and Technology Education

To understand why Engineers and Technologists pursue a graduate degree requires understanding their ability to meet the curriculum requirements needed to study engineering and engineering technology (E and ET) curricula. Then, the reasons why engineers and technologists chose to pursue a graduate degree must be better understood. Finally, the manner in which colleges and universities prepare their E and ET students for the workplace must be understood.

The study, "Crisis in American Math, Science, and Engineering Education" (1989), by the US Senate hearing before the Committee on Labor and Human Resources, consisted of testimony from recognized political and educational leaders in the fields of science and engineering. Study methodology consisted of expert testimony provided by Senator Paul Simon, Senator Claiborne Pell, Senator Mark O. Hatfield, Dr. Carl Sagan, Dr. Leon Ledeerman, and a group of professors from the Massachusetts Institute of Technology on current research. The committee was chaired by Senator Edward M. Kennedy. The purpose of the committee effort was to study possible solutions to the acknowledged under investment in US science and engineering human resources that are critical to the American economic future and national security (Senate Committee Hearing, 1989).

The committee was engaged to "consider the status of American math, science and engineering education" (Senate Committee Hearing, p. 1, 1989). Today, just over half of US high schools offer physics courses; many other high schools do not offer chemistry or biology courses. At the college level, the situation is equally bleak. Less than one-fourth of today's incoming freshmen, compared to 1970 incoming freshmen, chose to pursue math. Hence, the committee reported that demographic trends indicate the problem will increase in the future (Senate Committee Hearing, 1989). The committee met to try and identify potential ways to stem the decline in math and science education. The committee noted that "the problem does not stem from any lack of talent among

American youth. The fault lies in our educational system and our community support structure" (Senate Committee Hearing, p. 2,1989). The committee felt a need to address the entire spectrum of education, both formal and informal, from kindergarten through graduate school (Senate Committee Hearing, 1989).

The teaching of physics has been dropped by 7,000 of approximately 25,000 high schools. Additionally, 4,000 have abandoned teaching chemistry; and 2,000 schools no longer offer biology. Further, lab courses are offered in less than half of the schools still teaching these subjects. In a comparison of US high school seniors and seniors of 13 other industrialized countries, the US students ranked ninth in physics, eleventh in chemistry, and last in biology (Senate Committee Hearing, 1989).

At the college level in 1989, less than one percent of America's freshman level students were majoring in mathematics compared to 4 percent in 1970. In 1989, only 5 percent of American students earned undergraduate degrees in science. This figure is compared to 20 percent in Japan and 37 percent in Germany in 1989. Moreover, the committee noted that demographic trends indicated that the situation will only get worse by the turn of the century. The committee predicted that the US will face a shortage of 450,000 scientists and engineers by the year 2000. In 1989, 50 percent of US college and university doctoral conferrals in engineering were granted to non-US students. Less than one-half of these students remain in the US after graduating (Senate Committee Hearing, 1989).

The committee noted that scientific literacy should be central to the national goals of education. The committee challenged American school children to achieve their full potential; schools were challenged to provide these children with the opportunity to develop their talents in math and science. The committee stated: "Today's global atmosphere is one of competition. We must provide our citizens with the tools necessary for construction and maintenance of a strong and competitive nation" (Senate Committee Hearing, p. 3, 1989).

The US has historically depended on the Caucasian/White male for scientific and engineering resources (Senate Committee Hearing, 1989). The changing demographics now place a strain on this reliance. Sixty-three percent of the traditional college-aged students are neither Caucasian/White nor male (Senate Committee Hearing, 1989). These changing demographics will require US colleges and universities to find ways to recruit and educate larger percentages of non-Caucasian/White male engineering and science students. The committee also found that the US economy could place 138,000 engineers in the job market every year. The key question from the hearing was: "Where are we going to get the young people for the future?" (Senate Committee Hearing, p. 7, 1989).

The committee provided several solutions to this key question. First, the government must send a signal to the American public that science and engineering are important. Second, scientists and engineers must do a better job of explaining to the general public what they do . Third, society must find a way to counter the peer pressure that prevents students from excelling intellectually in science and math. Fourth, schools must provide higher quality math and science education to elementary and high school students (Senate Committee Hearing, 1989).

The committee concluded: Science and math education are important to more than our global economy and national security. They are important for resolving issues, such as of food shortages and environmental depletion. These are issues that must be decided intellectually. Lack of qualified scientists and engineers severely impacts the ability of the Department of Energy, Department of Defense, National Institute for Health, Food and Drug Administration, and many other government agencies. Education is the key (Senate Committee Hearing, 1989).

In the (1990) study, "Choosing Futures: US and Foreign Student Views of Graduate Engineering Education," Elinor G. Barber, William P. Darby, and Robert P. Morgan analyzed the factors influencing the decision of engineering seniors and enrolled graduate students to continue or not to continue their graduate studies. The purpose of the study was to identify pertinent career and educational decisions of engineering students. The methodology used consisted of a random survey that was designed around three components associated with: 1) their undergraduate education, 2) their post baccalaureate plans, and 3) their career aspirations and views about the engineering profession. The analysis was completed using contingency tables.

The survey consisted of 22,836 full-time college engineering seniors. Non-US students made up 43 percent of the study population. Graduate students were broken down by their undergraduate degrees: 11 percent civil engineering; 22 percent chemical engineering; 24 percent mechanical engineering; and 29 percent electrical engineering (Barber, Darby, and Morgan, 1990). Seventy-three percent of the study population reported that acquiring interesting work was the top reason for attaining a master's degree. Eighty-two percent of the study population reported a desire to learn more about their field as the top reason for attaining a doctoral degree (Barber, et al., 1990).

The demographic composition of the population of engineering graduate student respondents differs mainly in the number of foreign students responding to the survey. The number of non-US students represented 43 percent of the study population. The number of female students represented 11 percent of the US student population. Blacks, Hispanics, and Native Americans represented three percent of the total US student survey population (Barber, et al., 1990).

The survey administered to graduate students emphasized the decision to go to graduate school. It contained questions on student views of the engineering profession, the kinds of activities they would prefer to pursue, their career goals, and their family backgrounds (Barber, et al., 1990).

As in other studies, the top reason for attending graduate school was for idealistic reasons. Some 59 percent reported that attainment of interesting and challenging work was only available through an advanced degree, while 68 percent said they wanted to know more about their chosen field. Forty-five percent of the respondents reported that research careers were only available through completion of a graduate degree (Barber, et al., 1990).

The most frequently given reason for doctoral pursuit was a desire to learn more about the field. This response was reported by 82 percent of the respondents. Seventy-two percent reported career improvement, while 71 percent of the students reported that prestige and improved earning power were the top reasons for attaining a graduate degree. Eighty-one percent reported that a master's degree would allow them to be more involved in design and development. By contrast, 90 percent of the doctoral students were more interested in research; and 68 percent, in teaching. Thirty-one percent of the respondents reported wanting to be successful in industry as the main reason for completing graduate school (Barber, et al., 1990).

Sixty-three percent of the master's degree respondents said they did not want to be a college professor as their reason for not attending doctoral school; fifty-eight percent said the degree pursuit was too time consuming; fifty-one percent reported it was too costly; and forty-six percent reported that a master's degree was too theoretical. Only 33 percent reported funding as a contributing factor for not attempting doctoral studies (Barber, et al., 1990).

When non-US students were compared to US students, the most noticeable difference in their reasons for attending graduate school was in family encouragement. Sixty-eight percent of the foreign students reported that their families highly regarded an advanced degree while 53 percent of the US students reported that their families encouraged them to pursue graduate studies. The study reported that "there appears to be no important difference in the extent to which US and foreign students were influenced by academic and career-related reasons or by economic factors in their decision to go to graduate school" (Barber, et al., p. 40, 1990). Of the non-US students surveyed, 81 percent indicated that they would pursue doctoral studies compared to only 59 percent of US student respondents (Barber, et al., 1990).

Barber concluded "that only a complicated set of 'sticks and carrots' is likely to induce more US engineering undergraduates to continue their education. So long as there is wide acceptance of the norm that a first engineering degree should produce satisfactory results, who can expect a considerable number of engineering seniors to reason that a graduate degree is worth the effort and the income foregone?" (Barber, et al., p. 43, 1990).

Study response differences between US female and male E and ET students were generally small. Fifteen percent of the female respondents were members of minority groups; ten percent of the female respondents were majority students. Fifty-nine percent of the female E and ET students had engineers for fathers compared to 35 percent for male E and ET students (Barber, et al., 1990). Female E and ET respondents tended to see their careers taking them to greater heights than did their male counterparts. The female student in pursuit of a graduate degree did not necessarily have the same expectations as the male student. For the most part, though, "the similarities between male and female students tend to outweigh the differences" (Barber, et al., p. 46, 1990).

The study, "Reshaping the Graduate Education of: Scientists and Engineers" (1995), by the Committee on Science, Engineering, and Public Policy, studied and reported on possibly reshaping the graduate education for scientists and engineers. The committee consisted of experts representing industry and education. The purpose of the study was to examine how well graduate schools prepared students to integrate and disseminate their knowledge and apply it to the full range of present and future social needs (Committee on Science, Engineering, and Public Policy, 1995).

The committee on Science, Engineering, and Public Policy consisted of: Dr. Phillip A Griffiths, Director of the Institute for Advanced Studies at Princeton; Dr. Robert McCormick Adams, Secretary Emeritus of the Smithsonian Institute; Dr. Bruce M. Alberts, President of the National Academy of Sciences; Dr. Arden L. Bement, Distinguished Professor of Engineering at Purdue University; Dr. Elkan R. Blout, Director Emeritus of the Division of Biological Sciences at Harvard; Dr. Felix E. Browder, Professor of Mathematics at Rutgers University; Dr. David R. Challoner, Vice President for Health at the University of Florida; Dr. Ellis B. Cowling, Distinguished Professor at North Carolina State University; Dr. Bernard N. Fields, Chairman of the Department of Microbiology and Molecular Genetics at Harvard Medical School; Dr. Alexander H. Flax, Senior Fellow at the National Academy of Engineering; Dr. Ralf E. Gomory, President of the Alfred P. Sloan Foundation; Dr. Thomas D. Larson, Federal Highway Administration; Dr. Mary Jane Osborn, Head of the Microbiology Department at the University of Connecticut Health Center; Dr. Phillip A. Sharp, Professor at the Center for Cancer Research and Head at Massachusetts Institute of Technology; Dr. Kenneth Shine, President of the Institute of Medicine at the University of California at Los Angeles School of Medicine; Dr. Ralf Snyderman, Dean of the

School of Medicine at Duke University; Dr. H. Guyford Stever, Former Director of the National Science Foundation; Dr. Morrus Tanenbaum, Chief Finical Officer of AT & T; and Dr. Robert M. White, President of the National Academy of Engineering.

The committee acknowledged that graduate education of scientists and engineers is an activity of growing importance in an increasingly technological world, because graduate degreed scientists and engineers play a central role in American industrial and commercial life. They contribute directly to the national goals of technological, economic, and cultural life (Committee on Science, Engineering, and Public Policy, 1995).

The committee sought answers to five key questions during their research. What are the typical career paths for scientists and engineers and how have they changed in recent years? Given present career paths, what are the most appropriate structures and functions for graduate education? How can science and engineering graduate students be prepared for a variety of careers in teaching, industry, government, and in other employment sectors, in addition to research? Are we producing the right numbers of doctoral graduates? What are the nation's needs for graduate science and engineering education (Committee on Science, Engineering, and Public Policy, 1995).

The results of the study offered three general recommendations to colleges and universities: offer a broader range of academic options; provide better information and guidance; and devise a national human resource policy for advanced scientists and engineers (Committee on Science, Engineering, and

Public Policy, 1995).

The first recommendation was to offer a broader range of academic options that can be promoted on two levels. On the academic level, students should be discouraged from over-specializing. Those grounded in research careers should be disciplined in the broad fundamentals of their specialization and related sub-fields. On the career skills level, students should be encouraged to broaden their skill level. Off-campus internships in industry or government can lead to additional skills and exposure to authentic work situations. Implementation of these recommendations will produce more versatile scientists and engineers (Committee on Science, Engineering, and Public Policy, 1995).

The second recommendation stated that scientists and engineers should receive more up-to-date and accurate information about the workplace to help them make informed decisions about professional career choices. The burden of learning about realistic career options should not be left to the students themselves. Academic departments should provide career information to prospective and current students to allow them to make informed decisions about their future careers (Committee on Science, Engineering, and Public Policy, 1995).

The third recommendation was to devise a national human resource policy for advanced scientists and engineers. The policy would come from national discussion groups. The committee believed these groups should include representatives of government, universities, industries, and professional organizations. The members should examine the goals, policies, conditions, and unresolved issues of graduate-level human resources. The committee recommended establishing national goals and policy objectives and establishing relationship between graduate education and current employment trends (Committee on Science, Engineering, and Public Policy, 1995).

The findings of the committee stowed that an increasing number of doctoral recipients are not working in the traditional academic environment. They are doing applied research, development, and management in industry, or they are working in government or in nonprofit institutions. The committee identified a need for graduate schools to prepare students for an increasingly interdisciplinary, collaborative, and global job market. They found that graduate education should not be viewed as only a byproduct of immersion in an intensive research experience. With more than half of all new doctoral graduates in science and engineering going to work in nonacademic settings, graduate education needs to reflect a broader range of skills. The results of these changes should be a new type of doctoral degree, one that emphasizes adaptability and versatility as well as technical proficiency (Committee on Science, Engineering, and Public Policy, 1995).

Summary of the Literature

Whether or not a student decides to pursue an engineering (E) or engineering technology (ET) graduate degree is quite complex. In reviewing the data presented from other studies, several factors take preference over others. The review of the past research showed some differences in the research given. The studies reviewed were from populations of full-time graduate students and college seniors preparing for full-time graduate studies.

Previous research showed that E and ET disciplines were largely White/Caucasian males. Women and minorities made some gains since 1970. Fifty-five percent of doctorate degrees in engineering and engineering technology are conferred to non-US students. The 35 to 54 year age group contained the largest percentage of engineers and technologists (National Science Foundation, 1993). These engineers and technologists represented undergraduate students from the mid-1960s through the early 1980s when E and ET college and university enrollments peaked. These enrollments occurred before universities and industries sought to limit the number of engineers and technologists (Somers, 1991).

Previous research also showed that most full-time graduate students were motivated by idealistic reasons to pursue graduate education. Barber, et al,. (1989) revealed that 73 percent of the respondents indicated that increased knowledge of their discipline was very important in their decision to pursue graduate studies. Moreover, sixty-three percent of the respondents wanted to know more about engineering and technology. This study also reported that 59 percent of the respondents sought interesting work through a graduate degree. Most students not wishing to pursue a professorship felt that doctoral studies were too time consuming, not cost effective, and too theoretical for the work place (Barber, et al., 1989).

In the past, most research was performed on E and ET students attending full-time graduate school, focusing on their demographic make-up and on their reasons for pursuing graduate studies. The factors that influence practicing E and ET professionals to pursue part-time graduate studies has not been studied. This study explored those factors.

Chapter 3

METHODOLOGY OF THE STUDY

Introduction

The purposes of this study were (1) to identify the critical incidents that motivate professional engineers and technologists to seek graduate degrees; (2) to identify the critical incidents that motivate professional engineers and technologists to choose a curriculum in engineering, technology, or in another discipline; (3) to identify other factors that foster an engineer's or technologist's choice to pursue a specific field of study.

The purpose of this chapter is to describe the methods and procedures used in the study. The organization of the chapter includes: description of the critical incident methodology, selection of the study group, development of the critical incident pamphlet, distribution of the critical incident pamphlets, collection of the data, analysis of the data, and chapter summary.

Description of the Critical Incident Methodology

The critical incident methodology developed by Flanagan (1954) was used to explore what decision processes practicing engineers and technologists used in choosing to pursue a graduate education. Flanagan defined the technique as "a set of procedures for collecting observations of human behavior in such a way as to facilitate their potential usefulness in solving practical problems and developing broad psychological principles" (p. 327, 1954). The technique outlines a set of general rules for collecting observed incidents having special significance and meeting systematically defined criteria. In other words, analysis looks to human behavior for solutions to practical problems and formation of psychological principles. Flanagan defined an incident as "any observable human activity that is sufficiently complete in itself to permit inferences and predictions to be made about the person performing the act" (p. 327, 1954).

The critical incident technique is a widely known tool in the realm of psychological studies (Flanagan, 1947). Flanagan's critical incident methodology is a direct result of studies performed during World War II by the United States Army Air Force for application in its Aviation Psychology Program (Flanagan, 1949). This form of research is well suited to problems involving incidents of successful and unsuccessful behavior (Borg and Gall, 1989). Flanagan's critical incident technique is well suited for probing critical cues in decision-making processes. The method has been used in a wide variety of fields for eliciting domain knowledge of personal experience (Klein, Calderwood, and MacGregor 1989).

To date, the procedure for data collection, analysis, and synthesis has been refined into a flexible set of principles that can be modified and adapted to meet specific situations under many applications (Lesles, 1968). The critical incident methodology is extremely sensitive to the responses of population participants. Meaningful analyses of human decision-making can be accomplished through the use of descriptive critical incident responses of human activity that occur in a situation in which the behavior or decision is fairly clear and its consequences are sufficiently defined to leave little doubt concerning its effects (Glaser and Strauss, 1967). In this particular study, analyses of what motivates engineers in their choice of graduate curricula may suggest directions for educational programs that can be used to help maintain enrollment in E and ET programs. At the same time, this study may identify organizational behaviors and working structures that could possibly stem the exodus of E and ET personnel from engineering related companies and professions.

Selection of the Subject Group

The participant group for this study was selected from 10 companies in the Dallas-Fort Worth area known to employ large populations from E and ET. Each organization was telephoned and asked if that company wished to participate in the study. They were also asked for the name of an individual who could serve as a point-of-contact. When the contact person was named, a letter was written explaining the nature of the study (see Appendix B). The contact persons were asked to identify potential study participants from their company personnel records of degreed engineers and technologists currently enrolled in graduate studies. Once the initial listing of graduate participants was identified, the list was reviewed to determine the undergraduate degree of each employee. Those employees meeting the selection criteria were then selected for study participation. Four organizational contact persons from the initial 10 companies responded and provided a list of participants willing to participate in the study. The remaining six companies chose not to participate.

A letter explaining the nature of the study was then sent to each participant listed from each participating company (see Appendix B). Some of the letters were sent by E-Mail and the others were sent through the US Postal Service. The four participating companies (Lockheed Martin Tactical Aircraft System, Bell Helicopter - Textron, Texas Instruments, and E-Systems - Greenville) reported a combined total of 75 engineers and technologists enrolled in graduate studies during the spring and summer of 1996 who were willing to participate.

Development of the Critical Incident Pamphlet

The Critical Incident pamphlet (see Appendix B) was created based on the critical incident technique developed by Flanagan and the American Institute for Research (Flanagan, 1954). The incident pamphlet was defined to allow for reporting and separating specific critical incidents that were positive and critical incidents that were negative in the participant's graduate degree selection process. The individual responses to the pamphlet were the vehicle for data accumulation. The response pamphlet (see Appendix B) consisted of:

1. A cover letter.
2. A demographic survey.
3. Positive incident sheets.
4. Negative incident sheets.

The cover letter was used to explain the nature of the study. The content of the letter explained why the study was being conducted, how the pamphlet was to be completed, and how to return the completed pamphlet.

The demographic survey requested information, such as age of the respondent, gender, ethnicity, and place of employment; the type of undergraduate E or ET degree earned; and the course of graduate study currently being pursued.

The positive incident sheet requested the participants to describe two positive incidents that influenced the decision-making process leading to the selection of graduate curriculum study area. The negative incident sheets requested the participants to describe two negative incidents that influenced the decision-making process leading to the selection of the graduate curriculum study area. Even though this method of recalling specific events cannot be assumed to be totally reliable, it has been found to be highly successful in eliciting critical cues and details of judgment (Klein, et al., 1989). Klein (1989) believed that these cues and details cannot generally be captured by traditional reporting methods.

Distribution of the Critical Incident Pamphlets

Before being distributed, all critical incident pamphlets were assigned a random number for study incident pamphlet identification. Additionally, the pamphlet numbering procedure provided the means for necessary follow-up activities.

Distribution of the critical incident pamphlets was accomplished through the point-of-contact at each of the participating companies. Each company was asked to select one of three methods to distribute the pamphlets. These methods were used to protect employee information.

The first method of distributing the pamphlets was to have the organization's point-of-contact provide an E-Mail address of each employee who met the population selection criteria (see Appendix B). The participants of Texas Instruments chose the E-Mail contact method. The use of an E-Mail address provided the researcher the means for direct contact and follow-up activities with each participant. The E-Mail address ensured the anonymity of the individual participant by not revealing the participant's proper name or telephone number. This process also provided for strong control of the data collection process and placed the least amount of burden on the company point-of-contact.

The second method of pamphlet distribution was to have the participating company's point-of-contact provide the researcher a company internal mail address for each employee participating in the study. The participants at Lockheed Martin Tactical Aircraft Systems chose this method. This process allowed the researcher direct communication for follow-up activities with each participant. It did not provide the same individual anonymity as the E-Mail process. However, it did provide a good measure of data collection control and did not place a large burden on the company point-of- contact.

The third method of distributing the pamphlets was through the participating company's point-of-contact who distributed and collected the critical incident pamphlets. The participants at Bell helicopter - Textron and E-Systems - Greenville chose this method. During follow-up activities, the point-of-contact also distributed the request for completion letters. The request letters were then returned to the researcher by the participant to the point-of-contact. This process ensured a good measure of participant anonymity. It did not provide a good measure of data collection control and unduly burdened the company point of contact.

The first distribution process was preferred by the researcher because it provided the greatest measure of control, ensured a good measure for participant anonymity, and placed the least burden on the company point-of-contact. However, all three methods were selected by at least one of the participating companies.

Collection of the Data

Data collection steps included:

1. Return of the completed pamphlets.
2. Follow-up of participant's response.
3. Determination of sufficient response quantity.

Pamphlet completion and response return was targeted for 15 days from the initial distribution to each company. When the proper number of returns was not received within 15 days from the initial distribution, a reminder notice was sent to the participants who had not returned their completed pamphlet (see Appendix B). Thereafter, reminder letters were sent every 15 days. The initial returns were received on 5 May 1996. The final pamphlets were received on 10 July 1996.

Flanagan does not set a minimum number of study participants. Because of the request for four statements in each critical incident pamphlet, the total number of statements amounted to nearly four times the number of completed pamphlets. Therefore, the minimum quantity of critical incident participants was set at 50 by the researcher's guidance committee. A total of 75 participants were identified by the four participating companies requiring a return of 63 pamphlets to be a valid sample size (Krejcie, 1970). A total of 66 critical incident pamphlets were returned from the four companies.

Analysis of the Data

After receiving all the completed pamphlets, the study resumed with the analysis of the data using the Q-sort process. Sheldon (1960) viewed the Q-sort method as very effective for the purpose of the critical incident study. The Q-sort method, developed by Stephenson (1953) was used after at least 50 critical incident pamphlets had been received. The Q-sort method consisted of the following steps:

1. Selecting the Q-sort panel.
2. Identifying the broad precept categories.
2. Conducting the Q-sort test.
3. Conducting the panel Q-sort test.
4. Completing the panel Q-sort.

The Q-sort panel membership consisted of three doctoral students from the Department of Secondary and Higher Education (SHED), at Texas A & M University - Commerce. One panel member has a master's degree in counseling, one panel member has a master's of business administration, while the third panel member has a master's degree in industry and technology (see Appendix A). All three panel members are doctoral candidates in the Department of Secondary and Higher Education at Texas A & M University-Commerce. A date, location, and time were agreed to by all panel members.

The Q-sort was scheduled for Wetherford College in Wetherford, Texas, on Thursday, 8 August 1996 at 5 PM.

The Q-sort panel met at Wetherford College at the agreed time and date. Q-sort process training was provided by the researcher. Training consisted of explaining what a precept category was and how it should be defined. Reliability of the study data was addressed using a sample Q-sort test. The sample test was used to measure the reliability of the preliminary critical incident precept categories (Sheldon and Sorenson, 1960). To provide the reliability measure, 12 incident responses were chosen at random as a sample test from the total population of 226. Each member of the Q-sort committee was asked to score the 12 incidents into one of the four preliminary precept categories (see Appendix B). After the panel scoring was completed, a discussion of the scoring technique was held by the three members. The panel then discussed any differences in scoring methods. Any differences in the category association were discussed and adjustments to the broad categories or response associations were made until complete consensus was achieved by the panel. At this time, the panel suggested that a fifth category be added. The new category was discussed by the panel members and a definition was assigned.

A second round of Q-sort reliability was then performed on an additional 12 incidents. The same scoring and discussion procedure was followed until agreement was reached on the second set of 12 incidents.

After completion of the second Q-sort, a discussion was held on the need for these five precept categories.

1. Educational development.

2. Theoretical progression.

3. Career development.

4. Career retention.

5. Company support.

The panel agreed that the five precept categories were valid for the completed samples. This agreement completed the sample testing. The accomplishment of the sample test provided the reliability of the precept categories (Sheldon and Sorenson, 1960). Once the five broad precept categories were agreed upon and defined, process sheets containing a numbered column relating to the incident response statement and a row representing the pamphlet number were used to document the incident data (see Appendix B). These process sheets provided the means to sort and document each incident response into a precept category.

During the panel Q-sort process, each member of the panel sorted each of the incident responses into one of the five broad precept categories established during the sample tests. After the sorting was completed, the panel reviewed each incident for precept category scoring agreement. Any discrepancies in scoring were discussed and agreement was eventually reached. This review process provided panel consensus for the entire study population. Use of the Q-sort process provided precept category identification of the population critical incident data.

After the precept category assignments, the Q-sort was completed; the data were assigned to contingency tables and analyzed. Each critical incident was assigned to one of the three research questions by placing the research question number in the data table next to the critical incident. The data were validated when each member had agreed upon the research question assignment in the same manner that had been used for the precept category assignment.

The training and precept category assignment of the 226 incident statements took slightly more than five hours. The training and the initial Q-sort alone consumed more than one hour.

Chapter Summary

The methodology used in this study was Flanagan's Critical Incident technique (1954). The purpose of the study was to determine what influences practicing engineers and technologists to pursue a graduate degree. Because of its flexible set of principles, the critical incident method is extremely sensitive to the responses of population participants. When critical incidents are applied to the participating group, it produces clear responses to human behavior. The study participants were selected from four companies in the Dallas - Fort Worth area known to employ engineers and technologists. The study participants were identified by a point-of-contact at each of the four participating companies. To qualify for the study, the participants had to be currently enrolled in graduate studies and have an undergraduate degree in a specified engineering or technology discipline.

A critical incident pamphlet was prepared and given a random number.

The pamphlets were then distributed to the study participants through the method chosen by each company. The three distribution methods were: through E-Mail, through a company internal mail address, or through the company point-of-contact. The data from the pamphlets were collected in the same method used for the distribution.

The data were treated by a panel employing Sheldon's and Sorenson's Q-Sort process (1960). The panel convened at a specified location at a specified time on a specified date and were given Q-Sort process training. After the panel members practiced the Q-Sort method process, they sorted the actual data, separating them into five precept categories. Sorting the 226 incident statements into one of the five precept categories for the three research questions consumed slightly more than five hours.

Chapter 4

PRESENTATION AND ANALYSIS OF THE DATA

Introduction

One of the purposes of this study was to identify the reasons why professional engineers and technologists choose to obtain a graduate education. A second stated purpose of this study was to identify why professional engineers and technologists choose to pursue a specific curriculum for their graduate studies. The reason for this study was presented in Chapters 1 and 2. Chapter 3 presented a descriptive procedure for the collection and analysis of the data relative to the purpose of the study. Chapter 4 presents the analysis of the data related to the study purposes and research questions detailed in Chapter 3.

A critical incident pamphlet was completed by 66 practicing professional engineers and technologists in the Dallas-Fort Worth, Texas, metropolitan area. These engineers and technologists represented four large engineering and manufacturing firms: Bell-Helicopter-Textron, E-Systems, Lockheed Martin Tactical Aircraft Systems, and Texas Instruments. Bell Helicopter and Lockheed Martin represent the aerospace industry in the Fort Worth area. E-Systems and Texas Instruments represent the electronics and computer industries in the Dallas area. The study population consisted of personnel holding undergraduate degrees in one of the specified engineering or engineering technology (E or ET) curricula who were also enrolled in a formal graduate program, regardless of the curriculum. Respondents provided demographic data and incident data that revealed positive and negative influences on their decisions to pursue graduate education.

The study data were classified according to qualitative variables using contingency tables. According to Sincich (1993), a contingency table is a practical method for studying the proportions of qualitative variables of collected data. According to Borg, "The most common method for summarizing critical incident methodology data is through the use of absolute frequencies, such as number of specific incidents found in the data, and relative frequencies, such as the proportion of particular events to the total" (p. 528, 1989). The Critical Incident Pamphlet responses were interpreted using the Q-sort methodology and categorized by the Q-sort panel. The responses were then placed into contingency table format. The tables present data that addresses the research questions and contains the precept categories with the frequencies of negative and positive incident responses. The contingency tables were also used on the demographic data to display the data for each of the six characteristic questions. The contingency tables are presented through sub-sets of the total demographic data gathered. All table percentages were rounded using standard practices.

The findings presented are organized into two major sections: Characteristics of the Respondents and the Research Questions. The chapter is completed with a Summary of the presented research data.

Characteristics of the Respondents

The characteristic data were gathered from the six demographic questions contained on the first page of the critical incident pamphlet (see appendix B). The characteristic data for this study were categorized by age group, ethnicity, gender, undergraduate degree completion year, undergraduate degree held, and graduate studies discipline being pursued. The study population characteristic data are presented in Tables 1 through 6.

Age Group

The first demographic question asked: What is your age group? The largest percentages of the respondents were in the 31 to 35 year age group, while the smallest percentages of responses were in the over-65 year age group. The data related to this question are presented in Table 1.

Table 1.

Summary of the Number and Percentages of Respondents by Age Group

AGE GROUP	NUMBER	PERCENTAGE
21 - 25	4	6%
26 - 30	12	18%
31 - 35	21	32%
36 - 40	12	18%
41 - 45	9	14%
46 - 50	5	8%
OVR 50	3	5%
TOTAL	66	100%

Thirty-two percent of the respondents of this study were in the 31 to 35 year age group. Eighteen percent of the respondents were in the 26 to 30 year age group and the 36 to 40 year age group. Fourteen percent of the responses were in the 41 to 45 year age group, while eight percent were in the 46 to 50 year age group. Six percent of the responses were in the 21 to 25 year age group, and five percent were in the over-65 year age group.

Ethnicity Category

The second demographic question asked: What ethnicity are you? The largest percentages of the respondents were Caucasian/White. The data related to this question are presented in Table 2.

Table 2.

Summary of the Number and Percentage of Respondents by Ethnicity Category

ETHNICITY CATEGORY	NUMBER	PERCENTAGE
CAUCASIAN/WHITE	52	80%
MIDDLE EASTERN	0	0%
NATIVE AMERICAN	4	6%
ASIAN/PACIFIC RIM	3	5%
AFRICAN AMERICAN/BLACK	2	3%
HISPANIC/LATINO	0	0%
OTHER	4	6%
TOTAL	65	100%

Eighty percent of the respondents were Caucasian/White. Twenty percent of the respondents of this study were in minority groups. Six percent of the respondents reported they were Native American. Six percent of the respondents reported the Other category. Five percent of the respondents reported they were Asian/Pacific Rim. Three percent of the respondents reported they were African American/Black. One respondent did not select an ethnicity category. This respondent stated that he did not choose an ethnicity category because he did not believe in separating people by ethnicity.

Gender Category

The third demographic question asked: What is your gender? The largest percentages of respondents were male. The data related to this question are presented in Table 3.

Table 3.

Summary of the Number and Percentage of Respondents by Gender Category

GENDER CATEGORY	NUMBER	PERCENTAGE
MALE	59	89%
FEMALE	7	11%
TOTAL	66	100%

Eighty-nine percent of the respondents were male. Eleven percent of the respondents of this study were female.

Undergraduate Degree Year of Graduation

The fourth demographic question asked: What year did you complete your undergraduate studies? The largest percentages of responses were in the 1980s year group. The data related to this question are presented in Table 4.

Fifty-six percent of the respondents completed their undergraduate degrees in the 1980s. Twenty-four percent of the responses completed their

Table 4.

Summary of the Number and Percentage of Respondents by Undergraduate Degree Year of Graduation

GRADUATION YEAR	NUMBER	PERCENTAGE
1950s	0	0%
1960s	3	5%
1970s	10	16%
1980s	35	56%
1990s	15	24%
TOTAL	63	100%

undergraduate degrees in the 1990s. Sixteen percent of the responses were in the 1970s category. Five percent of the responses were in the 1960s category, and none of the respondents completed undergraduate studies in the 1950s.

Undergraduate Degree Discipline

The fifth demographic question asked: What is your undergraduate degree in? The largest percentages of the responses were in the electrical engineering discipline. The data related to this demographic question are presented in Table 5.

Thirty-nine percent of the respondents completed their undergraduate degrees in electrical engineering. Eighteen percent of the responses were for computer science. Fourteen percent of the respondents obtained their undergraduate degree in mechanical engineering and 14 percent in engineering technology. Eleven percent of the respondents indicated Other as their undergraduate degree discipline. Three percent of the responses were in industrial engineering. Two percent of the respondents were degreed in computer information. None of the respondents reported degrees in

Table 5.

Summary of the Number and Percentage of Undergraduate Degrees Held by Discipline

UNDERGRADUATE DEGREE	NUMBER	PERCENTAGE
ELECTRICAL ENGINEERING	26	39%
MECHANICAL ENGINEERING	9	14%
INDUSTRIAL ENGINEERING	2	3%
MANUFACTURING ENGINEERING	0	0%
CIVIL ENGINEERING	0	0%
COMPUTER SCIENCE	12	18%
COMPUTER INFORMATION	1	2%
SCIENCE (PHYSICS & CHEMISTRY)	0	0%
ENGINEERING TECHNOLOGY	9	14%
OTHER	7	11%
TOTAL	66	100%

manufacturing engineering, civil engineering, or science.

Graduate Studies Discipline

The sixth demographic question asked: What is your current graduate studies in? The largest percentage of respondents were pursuing graduate studies in computer science. The data related to this question are presented in Table 6.

Thirty-three percent of the respondents reported they were enrolled in

Table 6.

Summary of the Number and Percentage of Graduate Degrees Being Pursued

GRADUATE DEGREE	NUMBER	PERCENTAGE
ELECTRICAL ENGINEERING	12	18%
MECHANICAL ENGINEERING	2	3%
INDUSTRIAL ENGINEERING	1	2%
MANUFACTURING ENGINEERING	1	2%
CIVIL ENGINEERING	0	0%
COMPUTER SCIENCE	22	33%
COMPUTER INFORMATION	3	5%
BUSINESS	15	23%
EDUCATION	1	2%
SCIENCE (PHYSICS & CHEMISTRY)	1	2%
ENGINEERING TECHNOLOGY	2	3%
OTHER	6	9%
TOTAL	66	100%

graduate computer science. Twenty-three percent named business as the subject of graduate studies. Eighteen percent of the respondents named electrical engineering. Five percent of the respondents named computer information. Nine percent of the respondents were pursuing graduate studies in

Other areas. Three percent of the respondents were pursuing graduate studies in mechanical engineering and 3 percent in engineering technology. Two percent of the respondents were pursuing graduate degrees in either industrial engineering, manufacturing engineering, education, or science as their graduate pursuit. No respondents reported civil engineering as their graduate degree being pursued.

Research Questions

The Q-sort panel met and developed five precept categories: educational development, theoretical progression, career development, career retention, and company support. Data related to the three research questions are presented in Tables 7 through 9.

The first precept category was educational development, which represented knowledge for knowledge's sake. This precept category represented the student's desire to pursue graduate studies with the goal of attaining more knowledge. The second precept category was theoretical progression, which represented the quest for knowledge attainment within a discipline. This precept category reflected the effort to attain a greater understanding within a chosen curriculum or, more specifically, to be the expert in the chosen area. The third precept category was career development, which represented attaining greater knowledge to support career enhancement. The fourth precept category was career retention, which represented attaining knowledge simply for keeping a career position. The fifth precept category was company support, which represented company funding, other company support, or the company providing access to graduate study.

Research Question No. 1

Research question No. 1 asked: What are the critical incidents that motivate some professional engineers and technologists to seek graduate studies? Fifty incidents were in response to this question, representing approximately 22 percent of the total data set. Fifty-six percent of the respondents reported that they were positively influenced in their decision to seek a graduate degree. The data related to this research question are presented in Table 7.

Sixty percent of the respondents identified career development as the primary reason for pursuing a graduate degree. Career development represents attaining greater knowledge to support career enhancement. Twenty-eight percent of the respondents cited positive career development incidents as the primary reason for pursuing graduate studies. One respondent pursuing a graduate degree in electrical engineering (MSEE) [Master's of Science in Electrical Engineering] wrote: "An advanced degree certainly enhances the ability to be promoted, but I don't think anyone would be willing to endure an MSEE or another MS [Master's of Science] program on this idea alone. Performance on the job leads to promotion and, in my case the MSEE degree has given me a much broader and deeper perspective in problem-solving." Thirty-two percent of the respondents cited negative career development incidents as the primary reason for pursuing graduate studies. One respondent pursuing a graduate degree in business (MBA) [Master's of Business Administration] wrote;

Table 7.

Summary of Positive and Negative Critical Incidents by Precept Category That Motivate Professional Engineers and Technologists to Seek Graduate Studies

PRECEPT CATEGORIES	POSITIVE INCIDENTS		NEGATIVE INCIDENTS		INCIDENT TOTALS	
	NUMBER	PERCENT	NUMBER	PERCENT	NUMBER	PERCENT
EDUCATIONAL DEVELOPMENT	7	14%	3	6%	10	20%
THEORETICAL PROGRESSION	4	8%	2	4%	6	12%
CAREER DEVELOPMENT	14	28%	16	32%	30	60%
CAREER RETENTION	1	2%	1	2%	2	4%
COMPANY SUPPORT	2	4%	0	0%	2	4%
TOTALS	28	56%	22	44%	50	100%

"Engineering is fine, but one needs to continue to grow in one's career. An MBA seemed like the answer."

Twenty percent of the respondents identified educational development as the primary reason for pursuing a graduate degree. Educational development represents knowledge for knowledge sake. Fourteen percent of the respondents cited educational development as a positive factor in their decision to pursue graduate studies. One respondent pursuing a doctoral degree in electrical engineering (PhDEE) [Doctorate of Electrical Engineering] wrote: "I would like the option of teaching later in my career and felt that a PhDEE would enhance my options." Six percent of the respondents cited negative educational development incidents that influenced their decision to pursue graduate studies. One respondent pursuing a graduate degree in computer science wrote: "I like engineering most of the time. When I'm not happy, it usually has to do with difficult people, which would probably happen more often in other professions [when] compared to engineering. If I won the lottery tomorrow, I would leave the company. But I would continue taking classes in something, and I would always be interested in technology."

Twelve percent of the respondents identified theoretical progression as the primary reason for pursuing a graduate degree. Theoretical progression represents the quest for knowledge attainment within in a discipline. Eight percent of the respondents cited positive theoretical progression incidents as the primary reason for pursuing graduate studies. One respondent pursuing a graduate degree in electrical engineering wrote: "I want to gain a deeper understanding of the principles of electrical engineering. Specifically communication systems and microwaves." Four percent of the respondents cited negative theoretical progression incidents as the primary reason for pursuing graduate studies. One respondent pursuing a graduate degree in computer science wrote: "I saw too many people without direct education in my discipline trying to do the work of a software design engineer with marginal or below marginal success. Some of these people held lead or manager positions that overall, lowered the respect of the discipline."

Four percent of the respondents identified company support as the primary reason for pursuing a graduate degree. Company support represents company funding, other company support, or the company providing access to graduate studies. Four percent of the respondents cited positive company support incidents as the primary reason for pursuing graduate studies. One respondent pursuing a graduate degree in electrical engineering wrote: "Learning is one of my strengths, so I took advantage of the tuition assistance opportunity provided by the company." None of the respondents cited negative company support incidents as the primary reason for pursuing graduate studies.

Four percent of the respondents identified career retention as the primary reason for pursuing a graduate degree. Career retention represents attaining knowledge for knowledge sake. Two percent of the respondents cited positive career retention incidents as the primary reason for pursuing graduate studies. One respondent pursuing a graduate degree in electrical engineering wrote: "Changes in the kinds of products the market needs and the kinds of skills needed made it obvious that there was career value in seeking enhanced skills. My idea is to use graduate education to develop strengths in fundamentals." Two percent of the respondents cited negative career retention incidents as the primary reason for pursuing graduate studies One respondent pursuing a graduate degree in electrical engineering (MSEE) wrote: "Companies have restructured, eliminating jobs. I felt it would be best to emphasize technical skills and that an MSEE would imply greater skill than internal course work, making it easier for the company to get a good deal by continuing to employ me."

Overall, the results show that sixty percent of the respondents believed that career development desires motivated them to pursue a graduate degree.

Four percent of the respondents cited company support and career retention as incidents which influenced their decision to pursue graduate education.

Research Question No. 2

Research question No. 2 asked: What are the critical incidents that influence professional engineers or technologists to choose a curriculum in engineering, technology, or in another discipline? A total of 134 incidents were in response to this question, representing approximately 59 percent of the total data set. Sixty-four percent of the respondents reported positive incidents related to their decision to pursue a specific graduate degree. The data related to this research question are presented in Table 8.

Forty-nine percent of the respondents reported theoretical progression as their primary reason for pursuing a graduate degree. Theoretical progression represents the quest for knowledge attainment within a discipline. Thirty-one percent of the respondents cited positive theoretical progression incidents as the primary reason for pursuing graduate studies. One respondent pursuing a graduate degree in systems engineering wrote: "I felt I needed to learn more about operating systems and computer architecture because I felt I was obsolete after ten years." Seventeen percent of the respondents were negatively influenced by theoretical progression. One respondent pursuing a graduate degree in computer science wrote: "I have had little opportunity to perform circuit design in my job assignment and see less in the future. I believe my choice of circuit design for my undergraduate training was not well targeted toward the future, although the training does support a graduate degree in software very well since I have an understanding of the task from both the hardware and

Table 8.

Summary of Positive and Negative Critical Incidents by Precept Category That Influence Engineers and Technologists to Chose a Graduate Curriculum

	POSITIVE INCIDENTS		NEGATIVE INCIDENTS		INCIDENTS TOTALS	
PRECEPT CATEGORIES	NUMBER	PERCENT	NUMBER	PERCENT	NUMBER	PERCENT
EDUCATIONAL DEVELOPMENT	7	5%	2	1%	9	7%
THEORETICAL PROGRESSION	42	31%	23	17%	65	49%
CAREER DEVELOPMENT	36	27%	22	16%	58	43%
CAREER RETENTION	0	0%	1	1%	1	1%
COMPANY SUPPORT	1	1%	0	0%	1	1%
TOTAL	86	64%	48	36%	134	100%

software view."

Forty-three percent of the respondents reported career development incidents as the primary reason for pursuing a graduate degree. Career development represents attaining greater knowledge simply for keeping a career position. Twenty-seven percent of the respondents cited positive career development incidents as the primary reason for pursuing graduate studies. One respondent pursuing a graduate degree in computer science wrote: "Being a service organization, software engineers are one of my main customers. I thought a degree in software would expand my horizons and opportunities and assist me in the support of my customers." Sixteen percent of the respondents were negatively influenced by career development. One respondent pursuing a graduate degree in Computer Science wrote: "As a result of a degree that is over 10 years old, some of the areas I have been exposed to are dated. Another graduate degree in software design would expand my horizons, expose me to some of the more recent technology areas, and assist me in learning those technologies. This effort would make me more valuable to my current employer and more marketable to another employer."

Seven percent of the respondents reported educational development incidents as the primary reason for pursuing a graduate degree. Educational development represents knowledge for knowledge sake. Five percent of the respondents cited positive educational development incidents as the primary reason for pursuing graduate studies. One respondent pursuing a graduate degree in computer science wrote: "My current degree in computer science is more than 10 years old. I felt the need to bring my education current and at the same time expand it." Two percent of the respondents cited educational development incidents as the primary reason for pursuing graduate studies. One respondent pursuing a graduate degree in business wrote: "I see my future in the field of engineering. I chose to pursue an MBA [Master's of Business Administration] to give myself a better knowledge of handling money and a fresh look at things. I don't think I would ever enjoy anything as much as I do engineering."

One percent of the respondents reported company support as their primary reason for pursuing a graduate degree. One percent of the respondents cited positive company support incidents as the primary reasons for pursuing graduate studies. Company support represents company funding, other company support, or the company providing access to graduate study. One respondent pursuing a graduate degree in computer science wrote: "The company declared software engineering to be critical, and a strategic need in the company and in conjunction with SMU has provided on-site classes and paid tuition. There have also been some raises and bonuses linked to software engineering along with better job security." None of the respondents cited company support incidents as the primary reason for pursuing graduate studies.

One percent of the respondents reported career retention as their primary reason for pursuing a graduate degree. Career retention represents attaining knowledge simply for keeping a career position. None of the respondents cited positive career retention incidents as the primary reason for pursuing graduate studies. One percent of the respondents cited negative career retention incidents as the primary reason for pursuing graduate studies. One respondent pursuing a graduate degree in business wrote: "During the reorganization into functional groups, I was given a choice to move into a management or engineering cost center. I had been following a management track up until that time and had completed my MS [Master's of Science] in engineering management. The change gave me an unclear picture of the 'new' responsibility of management in the development process. I optioned for the apparent safety of the systems engineering functional group as a holding place while continuing my education in the management field and waiting for the organizational change to settle out."

Overall, the results show that forty-nine percent of the respondents were motivated by theoretical progression incidents, and forty-three percent were motivated by career development incidents when choosing to pursue a specific graduate degree.

Research Question No. 3

Research question No. 3 asked: What other factors exist that influence professional engineers and technologists to pursue a chosen graduate field of study? Forty-two of the incidents were in response to this question, representing 19 percent of the total data set. Sixty-nine percent of the respondents reported that they were negatively influenced by other factors in their decision to pursue a graduate degree. The data related to this research question are presented in Table 9.

Twenty-six percent of the respondents reported career retention as their primary reason for pursuing a graduate degree. Career retention represents attaining knowledge for keeping a career position. Seven percent of the respondents cited positive career retention incidents as the primary reason for pursuing graduate studies. One respondent pursuing a graduate degree in education wrote: "I chose an educational degree so I could remain gainfully employed." Nineteen percent of the respondents cited negative career retention incidents as the primary reason for pursuing graduate studies. One respondent pursuing a graduate degree in industrial engineering wrote: "I was working in

Table 9.

Summary of Other Positive and Negative Critical Incidents by Precept Category That Influence Professional Engineers and Technologists to Pursue a Chosen Graduate Field of Study.

	POSITIVE INCIDENTS		NEGATIVE INCIDENTS		INCIDENTS TOTALS	
PRECEPT CATEGORIES	NUMBER	PERCENT	NUMBER	PERCENT	NUMBER	PERCENT
EDUCATIONAL DEVELOPMENT	1	2%	2	5%	3	7%
THEORETICAL PROGRESSION	3	7%	5	12%	8	19%
CAREER DEVELOPMENT	2	5%	9	21%	11	26%
CAREER RETENTION	3	7%	8	19%	11	26%
COMPANY SUPPORT	4	10%	5	12%	9	21%
TOTAL	13	31%	29	69%	42	100%

the Ergonomics Department during the fall of 1994 when downsizing struck. In a group of four engineers working on a specific project, only one survived. It was then I realized that, to continue working in what was now my chosen profession, I needed better credentials, (i.e., a graduate degree)."

Twenty-six percent of the respondents reported career development as their primary reason for pursuing a graduate degree. Career development represents attaining greater knowledge to support career enhancement. Five percent of the respondents cited positive career development incidents as the primary reason for pursuing graduate studies. One respondent pursuing a graduate degree in electrical engineering wrote: "Last year, I attended a kickoff meeting for the new systems engineering program at SMU [Southern Methodist University]. It seamed to be the degree I was looking for a mixture of technical courses and engineering management/product development courses that complement my career path." Twenty-one percent of the respondents cited negative career development incidents as the primary reason for pursuing graduate studies. One respondent pursuing a graduate degree in business wrote: "The chance of my being promoted to chief or director of an engineering discipline is relatively small. I have a better chance in management."

Twenty-one percent of the respondents reported company support as their primary reason for pursuing a graduate degree. Company support represents company funding, other company support, or the company providing access to graduate study. Ten percent of the respondents cited positive company support incidents as the primary reason for pursuing graduate studies. One respondent pursuing a graduate degree in computer science wrote: "At the time I decided to pursue a graduate degree, ETSU [East Texas State University] was offering courses here at work that made it so convenient to choose a computer science degree." Twelve percent of the respondents cited company support incidents as the primary reason for pursuing graduate studies. One respondent pursuing a graduate degree in computer science wrote: "Other universities were offering courses via TAGER (electronic teleconference and communication educational consortium located in North Texas), but most required commuting to the campus for testing and were more expensive like courses at SMU [Southern Methodist University]."

Nineteen percent of the respondents reported theoretical progression as their primary reason for pursuing a graduate degree. Theoretical progression represents the quest for knowledge attainment within a discipline. Seven percent of the respondents cited positive theoretical progression incidents as the primary reason for pursuing graduate studies. One respondent pursuing a graduate degree in physics wrote: "I chose to pursue studies in physics because I found that I was more interested in 'why and how' things worked (i.e., the physical processes) than I was in how to apply them (i.e., engineering applications of the physical processes). This revelation occurred to me while I was trying to understand wave behavior in a radar jammer device I had invented and built at home. I found I enjoyed the actual research process *much* more than I enjoyed the final mechanics of designing and building it." Twelve percent of the respondents cited negative theoretical progression incidents as the primary reason for pursuing graduate studies. One respondent pursuing a graduate degree in mechanical engineering wrote: "I am pursuing a graduate degree in engineering to make up for the lack of professional development opportunities provided at work. I am interested in becoming a better engineer and the company does not encourage technical conferences or the preparation and presentation of technical papers."

Seven percent of the respondents reported educational development as their primary reason for pursuing a graduate degree. Educational development represents knowledge for knowledge sake. Two percent of the respondents cited positive educational development incidents as the primary reason for pursuing graduate studies. One respondent pursuing a graduate degree in business wrote: "I am more interested in management than in engineering. I enjoy motivating and inspiring people to action. I enjoy managing people rather than processes and procedures." Five percent of the respondents cited negative educational development incidents as the primary reason for pursuing graduate studies. One respondent pursuing a graduate degree in mechanical engineering wrote: "At some point several years ago, I realized that I was not going to reach my career goals (salary/responsibility) in the aerospace industry. This [realignment] along with the current employment uncertainties in aerospace convinced me to take measures to prepare for any future calamities. I have always been interested in teaching and research. Therefore, one of the main reasons I am pursuing an advanced degree is to be able to *jump* to a career in academics if the need should arise."

Overall the results show that twenty-six percent of the respondents named career development and twenty-six percent of the respondents cited career retention as factors influencing the pursuit of graduate studies. Twenty-one percent cited company support incidents as the primary influence in their decision to pursue graduate studies.

Summary

The population of this study consisted of 66 practicing professional engineers and technologists from the Dallas-Fort Worth, Texas, metropolitan area. The engineers and technologists responding to this study represented four large engineering and manufacturing firms within the metropolitan area. A total of 226 incident responses were received from the study population. Fifty of the 226 incident responses were in answer to research question No. 1. This represented 22 percent of the responses. One hundred and thirty-four of the 226 incident responses were in answer to research question No. 2. This represented 56 percent of the responses. Forty-two of the 226 incident responses were in answer to research question No. 3. This represented 19 percent of the responses.

Three significant characteristic data sets emerged from the responses. The first and most significant data set showed that 89 percent of the respondents were male. The second significant data set showed that 80 percent of the respondents were Caucasian/White. The third most significant data set showed that computer science usurped undergraduate electrical engineering study as the preferred graduate study. Thirty-nine percent of respondents held an undergraduate degree in electrical engineering while 33 percent of the respondents cited computer science as the preferred field of graduate study.

Overall, the results of the 226 incident responses cited career development as the primary reason for pursuing a graduate degree. Career development was cited by 44 percent of the responses; theoretical progression was cited by 35 percent of the responses; educational development was cited by 10 percent of the responses; career retention was cited by 6 percent of the responses; and company support was cited by 5 percent of the responses.

Chapter 5

SUMMARY, FINDINGS, CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS

Summary

The engineering (E) and engineering technology (ET) professions are a vital part of the US economy. Many reports during the last two decades have documented the growing need to change the way E and ET education is conducted. Interestingly, these studies have coincided with significant technological and management changes in the engineering and engineering technology work place. Most of these studies have concentrated on the traditional full-time bachelor's, master's, and doctoral students. Many of these studies have concluded that students choose to pursue graduate E and ET studies for idealistic reasons; that is, they wanted to learn more about their field and to be more involved in product design and development.

In recent years, one of the most controversial issues with university faculty and business leaders has been finding the means to encourage more American students to pursue a curriculum in E or ET. The 1989 US Senate Committee Hearing on the "Crisis in American Math, Science and Engineering Education" (p. 2) found: "We need to do more to encourage US students to enter the science and engineering fields. Encouraging education in those fields is essential to maintaining US competitiveness in the global economy of the 21st century."

The overall goal of engineering education is to produce quality engineers and technologists who contribute to the production of technical goods and services desired by US and foreign consumers of the global economy. Without these highly qualified engineers and technologists, the ability of the US to compete in the global market place may be jeopardized. The contributions of engineering and engineering technology professionals are vastly disproportionate to their small workforce representation. The steady decline of American students pursuing E and ET degrees places concern on the ability of the US economy to keep pace with global competition. This concern intensifies with the increase of non-US students earning almost 35 percent of master's degrees and 55 percent of E and ET doctoral degree conferrals from US colleges and universities (National Science Foundation, 1991). Non-US students enrolled in engineering and engineering technology have continually increased in numbers since 1970. During this time, the overall graduation rates remained relatively flat. The results of this student transition show that fewer American students are pursuing degrees in E and ET. Efforts should be pursued to find ways to increase US student enrollment without reducing current foreign student enrollment in E and ET programs.

The purpose of this study was to identify some of the critical reasons professional engineers and technologists choose to obtain a graduate education through part-time enrollment. By analyzing the educational pursuits and motivating factors of these students, directions may emerge for educational programs that encourage US students to enroll in engineering and engineering technology. A second goal was to find ways to improve part-time graduate student programs. This study is significant because it benefits both college and university faculty in their efforts to develop E and ET curriculum for professional engineers and technologists. Further, it benefits engineering business management in its efforts to retaining engineers and technologists in the workforce.

This study was accomplished using Flanagan's Critical Incident methodology (1954). A group of 66 E and ET professionals from the Dallas-Fort Worth, Texas, metropolitan area provided critical incidents that gave insight in to their decisions to pursue a graduate degree. The respondents completed a critical incident pamphlet containing questions on demographic characteristics and on positive and negative critical incidents. The quantity of returned pamphlets was validate by using Krejcie's Population Measurement Table (1970). The returned pamphlets were analyzed using Sheldon's Q-sort process (1960). The data were sorted and placed into five precept categories. The characteristics and precept category data were placed into contingency tables to present the qualitative variables (Sinch, 1993).

The responses of the 66 practicing professional engineers and technologists currently enrolled in graduate programs provided insight into what motivated them to select a particular graduate program. As representatives of the four major engineering and manufacturing firms in the area, the engineers and technologists addressed their motivations through qualitative precepts based on Flanagan's critical incident methodology (1954). These professionals are engaged in the pursuit of graduate education on a part-time basis. The results of this study differ from other similar studies because the study population consisted of practicing professional engineers and technologists, not full-time, traditional students of previous studies. The findings, conclusions, implications, and recommendations were developed from the responses of 66 participants.

Findings

The findings were based on the critical incident data generated by this study. The findings are presented for the characteristic data and for the three research questions.

Characteristic Data

The study characteristic data were analyzed and used as means to benchmark this study population in relationship to national E and ET characteristic data.

1. Thirty-two percent of the study respondents were in the 31-35 year age group. This represented the largest age group in this study. National averages presented in the 1993 National Science Foundation study, "Characteristics of Doctoral Scientists and Engineers," reported seventeen percent of the population were in the 45-49 year age group. This represented the largest age group within the National Science Foundation study.
2. The twenty percent of the study respondents were minorities. National averages presented in the 1993 National Science Foundation study, "Characteristics of Doctoral Scientists and Engineers," reported seven percent were minorities.
3. Eleven percent of the study respondents were in the female group.

National averages presented in the 1993 National Science Foundation study, "Characteristics of Doctoral Scientists and Engineers," reported 10 percent of the study population to be female.

4. Thirty-three percent of the study respondents cited computer science as the degree being pursued; 18 percent cited electrical engineering. National averages presented in the 1993 National Science Foundation study, "Characteristics of Doctoral Scientists and Engineers," reported 12 percent of the study population in computer science and 44 in electrical engineering.

5. Twenty-three percent of the study respondents were pursuing business degrees. These respondents were changing career paths or seeking to enhance their career advancement and retention . In his 1973 study, Rever identified a sub-population within E and ET that he classified as 'path jumpers.' Rever reported that little is known about the phenomenon of 'path jumpers' (1973).

Research Question No. 1

Research question No. 1 asked : What are the critical incidents that motivate some professional engineers and technologists to seek graduate studies? The critical incidents that motivate some professional engineers and technologists to seek graduate studies are career development, educational development, and theoretical progression.

1. Twenty-two percent of the responses cited critical incidents related to question No. 1 that influenced the decision to pursue graduate studies.

2. Fifty-six percent of the responses to this question cited positive incidents for pursuing graduate studies.
3. Sixty percent of the responses to this question cited career development as the primary reason for pursuing graduate studies.
4. Twenty percent of the responses to this question cited educational development as the primary reason for pursuing graduate studies.
5. Twelve percent of the responses to this question cited theoretical progression as the primary reason for pursuing graduate studies.
6. Eight percent (4 percent for career retention, 4 percent for company support) of the respondent engineers and technologists were influenced by career retention and company support when considering graduate studies.

Research Question No. 2

Research question No. 2 asked: What are the critical incidents that influence some professional engineers or technologists to choose a curriculum in engineering, technology, or in another discipline? The critical incidents that influence some professional engineers and technologists to choose a curriculum in engineering, technology, or in another discipline are theoretical progression and career development.

1. Fifty-nine percent of the responses cited critical incidents related to question No. 2 that influenced the decision to pursue a specific field of graduate studies.
2. Forty-three percent of the responses reported theoretical progression as

the primary reason for seeking specific graduate studies.

3. Forty-nine percent of the study responses cited career development as the primary reason for considering specific graduate studies.
4. Eighty-six percent of the responses to this question cited positive incidents for pursuing graduate studies.
5. Two percent (1 percent for career retention, 1 percent for company support) of the respondent engineers and technologists were influenced by career retention and company support when considering specific graduate studies.

Research Question No. 3

Research question No. 3 asked: What other factors exist that influence professional engineers and technologists to pursue a chosen graduate field of study? The other critical incidents that exist and influence professional engineers or technologists to pursue a chosen graduate field of study are career retention, career development, and company support.

1. Nineteen percent of the responses cited other factors influencing the decision to pursue graduate studies.
2. Sixty-nine percent of the responses cited negative incidents for pursuing graduate studies.
3. Twenty-six percent of the responses to this question cited career retention as the primary reason for seeking a graduate degree.
4. Twenty-six percent of the responses to this question cited career development as the primary reason for seeking a graduate degree.

5. Twenty-one percent of the responses reported company support as the primary reason for seeking graduate studies.

Conclusions

Within the limits of this study, the following conclusions were formulated,

1. Career development is the single most important critical incident that motivates most professional engineers and technologists to seek graduate studies. Career development received 44 percent of the incident responses, the highest percentage for all three research questions. This indicates that most engineers and technologists believe that they must upgrade their technical and managerial skills and strengths to stay competitive in today's highly technological market place. These engineers and technologists feel a strong need to increase their technical knowledge and managerial processes. Several stated that this higher level of learning provides them with a broader career prospective and the advanced problem-solving skills needed in today's global market. The conclusion is that most engineers and technologists are intrinsically motivated to pursue graduate studies.

2. Theoretical progression received the second highest number of responses cited that motivate professional engineers and technologists to pursue graduate studies. Theoretical progression received 35 percent of the incident responses. This indicates that engineers and technologists overwhelmingly believe that they must upgrade their discipline theory, techniques, and process skills in today's highly competitive marketplace.

These engineers and technologists indicated a strong desire to enhance their technical and theoretical skills. Most engineers and technologists want to gain a better understanding of their profession sometimes through change from one E and ET discipline at the undergraduate level to another discipline at the graduate level. The migration of undergraduate degreed electrical engineers to computer science graduate studies indicates a significant shift in study discipline. This shift emphasizes the need to stay competitive in the global market. Twenty-three percent of the respondents chose to pursue the management part of engineering by attending graduate business degree classes, further emphasizing the competitiveness in the E and ET professions. Several respondents stated that an upgrade of old outdated skills was needed to stay competitive. Several others stated they needed to learn more about their chosen field. Others reported the desire to learn more about the management side of the discipline. The conclusion is engineers and technologists overwhelmingly believe that they must upgrade their discipline to stay competitive in today's highly competitive marketplace.

3. Career retention and company support received only eleven percent (6 percent for career retention, 5 percent for company support) of the incident responses that influence engineers and technologists to seek graduate studies. However when responding to the question, What other factors exist that influence professional engineers and technologists to pursue a chosen field of graduate studies?, twenty-six percent of the

respondents cited career retention and 21 percent cited company support. The responses to this question cited negative incidents 69 percent of the time. This indicates that most engineers and technologists believe that negative factors force them to seek a graduate degree to retain their position in the market place. These engineers and technologists feel a need to enhance their skills just to retain their current positions. Several stated that downsizing was the primary reason for pursuing graduate studies. Others stated that their chances of success was significantly diminished without a graduate degree. Still other respondents reported that they were only pursuing their graduate degree because the company was paying for their class work. The findings indicate that the process of life-long learning may be a negative influence to a small number of professional engineers and technologists. These engineers and technologists must be externally motivated by other events before choosing to seek graduate studies.

Implications

Defining the curriculum change for engineering (E) and engineering technologists (ET) is impossible for broad national application. Each school and region appropriately serves its own diverse E and ET educational needs. Continuing assessment and evaluation of these educational needs are critical. Traditional assessment methods, such as student surveys of course quality and market demand for graduate students, need to be addressed constantly. Today, one out of every three graduate students is a working professional represented by this study population (National Science Foundation, 1994). He or she is a professional, practicing engineer or technologist attending graduate studies on a part-time basis. This survey showed significant differences in the reasons why practicing professional engineers and technologists pursue graduate programs compared to the full-time traditional E and ET student. Some broad implications of this difference can be made from factors identified by this study.

1. The 1989 US Senate Hearing noted that engineering colleges and universities must do a better job of promoting technical literacy to American students. Technical literacy must include more than the acquisition of technical skills; it must include life-long learning skills. This study has shown that life-long learning has become an integral part of the E and ET professional's career. The process of life-long learning is important to practicing E and ET professionals to maintain technical literacy in a rapidly changing technological environment. The thrust of undergraduate E and ET programs can no longer ignore that they do not provide all the necessary knowledge and skills for life-long E and ET employment. These skills and knowledge bases must be constantly updated for a life-long professional career. To attain this goal, US colleges and universities must develop new processes to assess curricula and then develop graduate curricula that support life-long learning in a rapidly changing technological world.
2. Emphasis must be placed on increasing the diversity in the E and ET professions. New thrusts must be made to recruit and retain minority and

women students. As the US changes from a majority Caucasian/White population to one of diverse ethnicity, minorities and women must be recruited to the E and ET professions. The very small participation of minorities and women E and ET professionals is disproportionate to their representation in the US society. This is one potential area in which rapid success can be made in recruiting and training American students in the E and ET professions.

3. Partnerships between colleges and universities and industry must become the norm in order to better prepare graduates for the multiple work skills they must have to succeed in engineering and engineering technology professions. College graduates are increasingly called upon to use not only technical knowledge but also communication, computer, and managerial skills. These skills are crucial for college graduates to become industry leaders and managers. The large E and ET discipline shift between undergraduate and graduate E and ET electrical engineering, computer science, and business education is an example of how professional engineers and technologists view the need for additional skills. US colleges and universities must recognize these trends and make graduate curricula adjustments that support these trends.

4. American colleges and universities need to make career-oriented graduate programs available to practicing professional E and ET personnel in response to the vast majority indicating career development as the overriding factor in their decisions to pursue graduate studies.

Whether that development was in a semi-related area or in a non-related area of E and ET, the common thread was career growth. In many cases, studies selected for graduate studies shifted to the business area of E and ET; in other cases, the studies shifted to pursuit of advanced knowledge in a specific specialization. Still the message was that graduate studies lead to advancement, greater knowledge and skills, and a successful engineering or technology career.

5. Most professional engineers and technologists are intrinsically motivated to enroll in graduate school to enhance their careers. Practicing engineers and technologists are more likely to be motivated by career development than by wanting to become theoretical experts in their field. They see change in the work environment, and they are adapting to that change. Consequently, they pursue graduate education in computer science and business, but not in the traditional electrical and mechanical engineering and engineering technology disciplines. These career changes may be the result of many factors, including technological change in the work environment, the lack of quality career counseling at the undergraduate degree level, identified shortages in software engineering, or work-place corporate management pressure. The specific reason is difficult to determine.

6. Life-long learning has become an important concept to professional engineers and technologists. The National Science Foundation (1973) noted that, in 1970, the preferred E and ET graduate degree was the

doctorate. Today, this preference has been replaced by the master's degree (National Science Foundation, 1991). This shift from the doctorate to the master's degree is commensurate with the increase in part-time practicing professionals attending graduate studies: over one-third of all graduate students in E and ET are part-time professional engineers and technologists (National Science Foundation, 1994).

Recommendations

The following recommendations are offered as an extension of the findings and conclusions of this study,

1. The findings of this study should be used by college and university curriculum designers, college and university department heads, and industrial training administrators to design graduate programs to help practicing engineers and technologists fulfill their perceived need for career development. These curricula changes should address the precepts of this study showing the majority of engineers and technologists pursue graduate studies to promote career development for greater knowledge and theoretical progression to enhance knowledge within a discipline.
2. Further studies similar in nature to this study should be conducted in other geographical areas. The general characteristics of the study population are similar to national characteristics presented in several National Science Foundation studies. Since this study is geographically limited to the Dallas-Fort Worth, Texas, metropolitan area, additional

studies are recommended for other geographical regions to see if the same results are noted. Additionally, a large national study similar to the National Science Foundation's Bi-Annual "Characteristics of Graduate Engineers and Scientists" should be conducted to identify national needs of professional engineers and technologists attending graduate studies on a part-time basis.

3. Recruiting emphasis must be placed on increasing diversity in the engineering and engineering technology professions. Renewed efforts must be made to recruit and retain minority and women students. The very small participation of minority and women E and ET professionals is disproportionate to their presence in the US population. Minorities and women are potential areas in which rapid gains can be made in recruiting and training American students into the E and ET professions. The percentage of US students has declined while the percentage of foreign students has increased (National Science Foundation, 1991). The overall graduates in E and ET have remained relatively constant at all levels since 1970. The trend of diminishing US student enrollment must be curtailed. Greater recruiting of minorities and women in E and ET professions represents one potential way to stave off the declining trend.

4. Engineering and engineering technology program designs need to be re-evaluated. This study identified reasons why professional part-time engineers and technologist pursue graduate studies. Review of other studies revealed reasons why full-time traditional E and ET students

pursue graduate studies. This study identified a major difference between the graduate educational needs of part-time and full-time students. In previous studies, the most reported reason traditional full-time students pursued graduate studies was for interesting and challenging work (idealistic) reasons. In this study, the most reported reason for professional part-time student's pursuit of graduate studies was for career development. This development included technical learning as well managerial skill development.

5. Employers need to consider the educational goals of the E and ET employee as well as the corporate educational goals. The study responses identified that many respondents would have chosen a different curriculum if the employer would willing to pay for it. Many respondents stated that they chose their specific graduate studies because the employer would not pay for the employees first curriculum choice, or supervisors told them they recommended a curriculum that met with the educational goals of the employer and not the employee. Possibly, employers may need to consider ways to finance educational pursuits not consistent with their educational goals. Employers and employees need to identify ways to meet the educational goals of both. When employees complete advanced education, both the employer and the employee benefit.

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Appendix A

Q-SORT COMMITTEE MEMBERS

The following were the members of the Q-Sort committee who graciously gave their time on 8 August 1996, at Weatherford College, in Weatherford, Texas:

Arleen Atkins
182 Deer Creek Drive.
Aledo, Texas 76008
817-441-9311

Arleen is currently the Dean of Student Services at Weatherford College in Weatherford, Texas. Arleen received her BS from Tarelton State University in Home Economics and her M.Ed.. from Tarelton State University in Counseling. She is a Licensed Professional Councilor (LPC). Arleen is currently a Doctoral candidate in the College of Education at Texas A&M University - Commerce.

Edwin R. Bellman
Rt. 3, Box 334B
Springtown, Texas 76082
817-220-6866

Ed is a Parts Planner for Lockheed Martin Tactical Aircraft System located in Fort Worth, Texas. He received his BS and MS from East Texas State University in Industrial Technology. Ed is currently a Doctoral candidate in the College of Education at Texas A&M University - Commerce.

Gary Lacefiled
1706 Wild Horse Road
Decatur, Texas 76234
817-627-2231

Gary is the Supervisor of Investigations for the South West Region of the Housing and Urban Development (HUD). Gary received his BA from Dallas Baptist University in Business Administration. He received his MBA from Dallas Baptist University in Corporate Finance. Gary is currently a Doctoral candidate in the College of Education at Texas A&M University - Commerce.

Appendix B

LIST OF COMPANY POINTS OF CONTACT

The following are the corporate points of contact who graciously gave their time during the critical incident pamphlet distribution and data gathering from each of the participating companies:

Dr. Leon Abbott
Chief, Management and Business Competencies
  Training and Development
Lockheed Martin Tactical Aircraft System
Fort Worth, Texas 76101
Telephone: 817-732-2042

Ted Moody
Director In-House Training
Texas Instruments
Richardson, Texas
Telephone: 214-917-7508

Dr. Mildred Golden Pryor
Director, Center for Excellence in
  Industry (E-Systems Greenville)/TAMU-C Partnership
Commerce, Texas 75429
Telephone: 903-886-5115

Robert Swanson
Training Department Administrator
Bell Helicopter-Textron
Fort Worth, Texas
Telephone: 817-280-4791

LOCKHEED MARTIN
Tactical Aircraft Systems

Dr. Leon Abbott
Chief, Management and Business Competencies
Training and Development

5 June 1996

Fellow Engineer,

I would like to ask for your support with Ed Richards' doctoral studies. Participation in his study has been approved by LMTAS.

Ed has provided instructions and a short information pamphlet for your completion. The effort should take approximately 20 minutes. Your participation is voluntary and should not be completed on company time.

Ed has requested that the completed pamphlets be returned by 20 June 1996. Completed pamphlets should be returned to Betty Barnes, MZ 1886.

Your support will be greatly appreciated by Ed.

Thanks,

Leon Abbott

Subj: Engineering Survey
Date: 96-05-16 12:05:50 EDT
From: TEDM%mimi@magic.itg.ti.com
To: ehr5005@aol.com
From: Ted Moody TEDM
Subj: Engineering Survey
-------------------- Headers --------------------------
From TEDM%mimi@magic.itg.ti.com Thur, May 16 12:05:25 1996
Return-Path: TEDM%mimi@magic.itg.ti.com
Received: from dragon.ti.com (dragon.ti.com [192.94.94.61]) by emin18.mail.aol.com (8.6.12/8.6.12) with ESMTP id RAA18242 for <ehr5005@aol.com>; Thur, 16 May 1996 12:05:24 -0400
From: TEDM%mimi@magic.itg.ti.com
Received: from robin.itg.ti.com ([128.247.31.238]) by dragon.ti.com (8.6.13/ac3i.dseg.ti.com) with ESMTP id KAA17352 for <ehr5005@aol.com>; Thur, 16 May 1996 10:59:53 -0500
Received: from itg.ti.com (magic.itg.ti.com [128.247.93.50]) by robin.itg.ti.com (8.7.3/8.6.11) with SMTP id KAA13864 for <ehr5005@aol.com>; Thur, 16 May 1996 10:55:33 -0500 (CDT)
Received: by itg.ti.com (4.1/ITG-1.1)
id AA24676; Thur, 16 May 96 10:58:14 CDT
Date: Thur, 16 May 96 10:58:14 CDT
Message-Id: <9605161558.AA24676@itg.ti.com>
To: ehr5005@aol.com
Subject: Engineering Survey

Copy of TI Cover Letter for Engineering Survey

This E-Mail letter is to solicit your support with Ed Richards' Doctoral study. He is requesting that you complete the attached survey and return it. Please provide E-Mail copy to Ed and to my self when you have completed the survey. The survey is approved by the company and may be completed at work.

I know Ed will appreciate your support in his efforts to attain his Doctorate.

Ted

Mr. Harold Don Smith
Vice President of Engineering
E-Systems Greenville Division
P.O. Box 6056 CBN 113
Greenville, Tx 75403-6056

Dear Mr. Smith:

The purpose of this correspondence is to simultaneously inform you, Denise, and Kurt that we have had a request via the Center for Excellence for E-Systems engineers to participate in a survey. This survey is for Mr. Ed Richards' who is will use the results of the survey for his dissertation he is writing in completion of his doctoral degree. I believe that we should support this effort because he is an ETSU student and because his survey results could be important to us and ETSU.

I am sending all of you copies of Mr. Richards' letter and questionnaire. If you and others in Engineering Management concur that this is a worthwhile research endeavor, copies of Mr. Richards' letter and questionnaire should be distributed to Engineers for their response.

If E-Systems does not wish to participate, please notify me via E-Mail: Mildred_Pryor@ETSU.EDU, phone 886-5115 or Fax 886-5114. Thanks very much.

Sincerely,

Mildred Golden Pryor, Ph.D.

CC: Denise Ayers
Kurt Gabitzsch

Bell Helicopter TEXTRON
A Subsidiary of Textron Inc.

INTER-OFFICE MEMO

18 June 1996
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MEMO TO: Current Engineers in Graduate Programs

COPY TO:

SUBJECT: Doctoral Study

My name is Robert Swanson. I am a Human Resource Administrator in the Training Department at Plant 7. I have been asked to send out the attached doctoral questionaire to engineers who are currently taking gradute courses, regardless of the degree. I have checked this out with the Human Resources Department and the Engineering Department and they have given me permission to send it out with one request. THat one request is that the questionaire be completed on the employees own time.

I hope you will complete the questionaire and return it to me through the company mail: Rober Swanson, Dept. ET, Plant 7. I would appreciate you responding as sonn as possible, the questionaire is very short.

Mr. Metzger has ask for the executive summry of the report, so it does have some importance to Bell Helicopter.

Thank You

Robert Swanson

INTRODUCTION LETTER

Dear Study Participant,

My name is Ed Richards. I am currently a Hydro-mechanical Engineer employed at Lockheed Martin Tactical Aircraft Systems (LMTAS) in Fort Worth. I am in the process of completing my Doctoral Studies in Curriculum Development at Texas A&M University - Commerce.

My doctoral study area of interest is: why practicing engineers and technologist choose to pursue a specific graduate degree. The population for this study must have an Engineering or Engineering Technology (E & ET) related bachelors degree, be a practicing engineer or technologist, and currently enrolled in any graduate degree program. The National Science Foundation predicts a severe shortage of qualified engineers and technologists by the turn of the century. The study is needed to help identify why we are losing so many practicing engineers and technologists. The National Science Foundation reports that only about five percent of degreed engineers attempt to pursue a graduate degree in E & ET. Many change from E & ET to pursue other graduate areas. Whether your graduate pursuits are in E & ET or a non- E & ET discipline I very interested in your responses. Your responses will help to define what is good and what is not about engineering education and the engineering profession in general.

I am asking you to complete a short Demographic Survey and the critical incidence response description sheets as part of my research. Your responses are anonymous to me. Therefore, if you would like a copy of the final study please provide a written request. If you wish to contact me for any information concerning the study, my home E-Mail is: <ehr5005@aol.com>. Please feel free to contact me. The study should be completed by May 1997.

Again thanks for participating in this study. Your input data are most valuable in my efforts.

Sincerely,

Edward H. Richards

DEMOGRAPHIC QUESTIONNAIRE

1. Personal Information:
   a. What is your age group?
   ( ) 21-25 ( ) 26-30 ( ) 31-35 ( ) 36-40
   ( ) 41-45 ( ) 46-50 ( ) Over 50
   b. What ethnicity are you?
   ( ) Cacasian/White ( ) Asian/Pacific Rim
   ( ) Middle Eastern ( ) African American/Black
   ( ) Native American ( ) Hispanic/Latino
   ( ) Other: (write in) ____________________
   c. What is your gender?
   ( ) Female ( ) Male
   d. Where is your place of employment?
   ( ) Bell Helicopter-Textron ( ) E-Systems
   ( ) Lockheed Martin ( ) Texas Instruments

2. Educational Information:
   a. What year did you complete your undergraduate degree?
   ( ) 1950s ( ) 1960s ( ) 1970s ( ) 1980s ( ) 1990s
   b. What discipline is your under graduate degree in?

Electrical:	( ) Engineering	( ) Technology
Mechanical	( ) Engineering	( ) Technology
Industrial:	( ) Engineering	( ) Technology
Manufacturing:	( ) Engineering	( ) Technology
Civil:	( ) Engineering	( ) Technology
Computer:	( ) Design	( ) Application
Information Systems	( ) Design	( ) Application
Science:	( ) Physics	( ) Chemistry
Other: (write in)	____________________	

3. In what discipline are your current graduate studies?

Electrical:	( ) Engineering	( ) Technology
Mechanical	( ) Engineering	( ) Technology
Industrial:	( ) Engineering	( ) Technology
Manufacturing:	( ) Engineering	( ) Technology
Civil:	( ) Engineering	( ) Technology
Computer:	( ) Design	( ) Application
Information Systems	( ) Design	( ) Application
Business	( ) MBA	( ) Administrative
Education:	( ) Administrative	( ) Teaching
Science:	( ) Physics	( ) Chemistry
Other: (write in)	____________________	

CRITICAL INCIDENT DESCRIPTION No. 1

(POSITIVE INFLUENCE)

Please describe vividly an incident that led to your choosing your current field of graduate study. (examples: I am interested in attaining more understanding thermodynamic analysis [OR] I am more interested in management than engineering practices) I prefer that your response is more detailed however, it can be that short, I leave that to you. I only request that the incident is sufficiently described.

CRITICAL INCIDENT DESCRIPTION No. 2

(POSITIVE INFLUENCE)

Please describe vividly an incident that led to your choosing your current field of graduate study. (examples: I am interested in job advancement and a graduate E or ET degree will led to promotion [OR] I am interested in pursuing another career discipline) Again I prefer that your response is more detailed however, it can be that short, I leave that to you. I only request that the incident is sufficiently described.

CRITICAL INCIDENT DESCRIPTION No. 3

(NEGATIVE INFLUENCE)

Please describe vividly an incident that led to your choosing your current field of graduate study. (examples: an engineering career is not what I expected it to be [OR] I have had a really bad experience in engineering) Again I prefer that your response is more detailed however, it can be that short, I leave that to you. I only request that the incident is sufficiently described.

CRITICAL INCIDENT DESCRIPTION No. 4

(NEGATIVE INFLUENCE)

Please describe vividly an incident that led to your choosing your current field of graduate study. (examples: I just do not like what I am doing and need a change [OR] I do not see any future in engineering because ....) Again I prefer that your response is more detailed however, it can be that short, I leave that to you. I only request that the incident is sufficiently described.

VITA

Edward Harold Richards was born in Portland, Oregon, on January 1, 1948, to Jessie Belle (Hoag) and Harvey Conrad Richards. After graduating from Yamhill-Carlton Union High School, 1966, he enrolled in Glendale Community College in Phoenix, Arizona. After three years of college, he enlisted in the US Air Force in 1969. Ed received his Associate of Applied Science from the Community College of the Air Force in 1981. He graduated from the US Air Force Senior Non Commissioned Officers Academy in 1984. He retired from the US Air Force in 1989 after attaining the highest enlisted rank of Chief Master Sergeant.

Ed later received his Bachelor of Applied Science degree from Troy State University in 1985 and his Master's of Science degree from East Texas State University in 1991. Ed received his Doctorate of Education from Texas A&M University - Commerce in 1997. He is currently a Senior Engineering Specialist with Lockheed Martin Tactical Aircraft Systems in Fort Worth, Texas.

Ed and his wife Linda (the former Linda Alice Stowell) have been married for 28 years. They have three sons: Kenneth Conrad, 27; Bryan Phillip, 24; and Michael Steven, 21 years old. The entire family resides in Fort Worth, Texas.

Permanent Address: 324 Balcones Drive
Fort Worth, Texas 76108