DETERMINING IF INDUSTRIAL SUPERVISORS DIFFERENTIATE BETWEEN ELECTRICAL ENGINEERING TECHNOLOGISTS AND ELECTRICAL ENGINEERS

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LIST OF SYMBOLS, ACRONYMS AND DEFINITIONS

As used within the body of this study, the following terms are defined as:

ASEE	American Society for Engineering Education.
ABET	Accreditation Board for Engineering and Technology.
BET	bachelor of engineering technology.
ECPD	Engineering Council for Professional Development, predecessor of ABET.
ECT	electronics and computer technology.
Engineering	a four year ABET accredited course of study leading to a baccalaureate degree in electrical engineering.
Engineer	a graduate from an engineering curriculum.
Engineering Technology	a four year ABET accredited course of study leading to a baccalaureate degree in electrical engineering technology.
Engineering Technologist	a graduate from an engineering technology curriculum.
IEEE	Institute of Electrical and Electronic Engineers, a professional organization.
Technologist	engineering technologist.
U.S.	The United States of America
WWII	World War II.

CHAPTER I

INTRODUCTION

There have been dramatic and basic shifts in the orientation of engineering curricula since World War II. Engineering curricula have changed from programs that emphasize the application of engineering methods and techniques, to programs that are organized around the theoretical and mathematical foundations of engineering. As the core of the programs became more scientific, a segment of the educational community reacted by establishing a second baccalaureate degree in the engineering spectrum. This alternative approach was founded on the well established convention that engineering education should be an applications program. These alternative programs eventually became the current curricula in engineering technology.

The technological demands of WWII generated explosive growth in scientific advances that were mostly driven by the physicist, and not the engineer. The physicists possessed the advanced training in mathematics and scientific fundamentals that enabled them to take the initiative in creating new devices (Grayson, 1977). That fact led the Committee on Engineering Education After the War (Hammond et al., 1944) to acknowledge that the war demonstrated a need for change in engineering education. A clearly evident trend was the increased need for engineers prepared to practice at a higher scientific and more creative level (Hammond et al., 1944, p. 592). In fact, the President of the Massachusetts Institute of Technology asserted "...the professional scientist ... is a better bet than the professional engineer in an attempt to solve a distinctly new problem ..." (Compton, 1943, p. 42).

The war crystallized the awareness that the engineer often lacked the essential scientific and mathematical background possessed by his colleagues schooled in the basic sciences. This realization emerged both within and without the educational community (Grayson, 1977). Prior to WWII, engineering curriculum stressed description, method and application. The Committee on Evaluation of Engineering Education (Grinter et al., 1953) indicated that the curriculum as it existed from 1910 to 1940 was indeed inadequate to produce self directed engineers capable of extending engineering knowledge. In the words of Compton (1943, p. 43) "... our engineering education has not been as progressive in developing the research side as it has in developing the side of practical application of the more conventional arts..."

The war induced the changes in the curriculum that continued through the late 1960's. Those changes have dramatically altered the direction of engineering education. Scientific fundamentals coupled with extensive mathematical preparation have emerged as the dominate curriculum of modern engineering. To accommodate this change, the broad base of underlying theory was continually compressed to fit the existing four year undergraduate framework. To make room for the increased depth that a theoretical foundation required, it became necessary to concurrently narrow the focus of the undergraduate curriculum. This narrowing shunted the application aspect of engineering programs.

According to Kenyon (1985), between 1950 and 1970 the final evolution in engineering curriculum occurred, with its increased emphasis on theory, research and graduate study. This core solidification precipitated the eventual divergence of the engineering spectrum into two streams: the science of engineering and the application of engineering. Ultimately, the curriculum that accented an application orientation evolved into the four-year engineering technology program. Educators presumed that industry had a need for such graduates (Kenyon, 1985). By 1965, 73 institutions were identified as offering programs in engineering technology (Grinter & Defore, 1972). In 1967, Brigham Young University had the first program to be accredited by the Engineering Council for Professional Development (ECPD) (Mehrhoff, 1975).

The emergence of specific curriculum recognizable as engineering technology was an evolutionary process. Contributions to that evolutionary process were made by: (a) the vertical extension of two year associate degree programs, (b) the conversion of certain industrial arts programs, and (c) the expansion of existing baccalaureate level technology programs into new curriculum areas (Grinter & Defore, 1972).

The educational community acknowledged the difference between the practice of engineering and the science of engineering by establishing and maintaining the two distinct programs at the baccalaureate level. In fact, the Preliminary Report of the Committee on Evaluation of Engineering Education (Grinter et al., 1953) suggested such a dual stem approach. It is not as clear that industrial supervisors make the same distinctions (Moore, 1975). It is possible that those responsible for assigning engineering tasks make little or no distinction between technology and engineering orientations (Blackwell, Cahn, Dwon, Ernst, Forter & McCollum, 1980). If such a lack of differentiation exists in the industrial community, it may be that graduates of engineering technology programs are being placed into positions for which their application oriented education has not prepared them.

Problem

Educators make a clear distinction between an applications and a theoretical oriented education as witnessed by the differing curriculum content of engineering technology and engineering (Forman, 1979). It is not clear that industry recognizes the distinction, or that merit is assigned to the differentiation if recognized. It is important to ascertain the differentiation applied to technologists by industry in order to insure that educators adequately understand the nature of the environment that students will encounter in the field.

Purpose

The purpose of this research is twofold:

1. to determine if industrial supervisors differentiate between engineering technologists and engineers, and
2. to determine how such differentiation, if it exists, is manifested.

Objectives

The objectives of this research will be:

1. to identify any differentiation made by industrial supervisors between engineering technologists and engineers through a survey of the job types assigned each, and
2. to determine, through a survey, the assessments by supervisors of the capabilities of technologists to be used in various job functions, and
3. to determine, through a survey, the assessments by supervisors of the cognitive competencies of technologists compared to engineers.

Questions

To accomplish the purpose and objectives of this investigation, the following three questions will be addressed:

1. does differentiation exist between technologists and engineers as reflected by current industrial utilization patterns?
2. does differentiation exist as reflected by the supervisor's assessment of the technologist's capability for various tasks, or job assignments? and
3. does differentiation exist as reflected by the supervisor's assessment of the technologist's cognitive competencies relative to the engineer?

Scope

The scope of the research will be restricted to persons from only one engineering branch; electrical engineering and electrical engineering technology. Therefore, where the generic terms technologist and engineer are used, except in cited references within the literature which relate to a broader context, those terms are confined to those branches of technology and engineering commonly known as electrical or electronic. In addition, the study will be limited to the United States.

CHAPTER II

REVIEW OF LITERATURE

Engineering Technology as a Separate Curriculum

In 1955 the Report on the Evaluation of Engineering Education (Grinter et al., 1955), considered by some to be the single most significant study of U.S. engineering education (Beard, 1986), marked the beginning of engineering curriculum reform. In the so-called "Grinter Report", several far reaching recommendations were made which had the effect of changing the orientation of engineering curriculum in the United States. Among the most far reaching, in terms of curriculum impact, were the recommendations to strengthen work in the basic sciences and mathematics while providing for a common engineering core. To make room for these additions to the curriculum, some of the "art" of engineering, such as laboratory, methods and practice courses were eliminated. The "Grinter Report" curriculum recommendations helped establish the mathematical and theoretical orientation of contemporary engineering education. The Preliminary Report, which preceded the final product by two years, recommended a bifurcation of the curriculum; one segment to retain and stress the existing engineering application approach and the other segment, or branch, to stress a more scientific, mathematically based orientation (Grinter et al., 1953).

Because of resistance to the bifurcation recommendation by the engineering education community, it did not survive the Preliminary Report. In its place, only the narrower more scientifically oriented curriculum emerged, which emphasized theory. In practice, the approach which suggested all engineering students share a common core of mathematics, physical science and engineering science courses became the model. Only upon completion of that battery of preparatory courses would the students be funneled into their respective specialties, such as mechanical, electrical, civil, industrial or chemical engineering.

Nevertheless, bifurcation did not disappear as an issue with the disappearance of its mention from the 1955 report. Resurrected and used over the years, the bifurcation issue found support from those interested in establishing a practice of engineering track as distinct from a science of engineering track (Chesier, 1984). This support of a dual track contains some of the roots of engineering technology as a separate curriculum. The establishment of the practice or application oriented program was the end result. Both the shift in emphasis to a theory oriented engineering curriculum, and the relegation of the practice of engineering to a subordinate position within the engineering curriculum lent impetus to establishment of the technology curriculum (Kenyon, 1985).

Some educators maintained that the evolution of engineering technology as a distinct entity occurred as a response to an industrial need (Chesier, 1985). Others assert that the rise of the technology curriculum occurred as an academic construct, often using the bifurcation recommendation of the "Preliminary Report" (Grinter et al., 1953) as justification. The claim that the engineering technology curriculum arose as a response to an industrial need is not clearly supported. In fact, Irwin (1976) states that the advent of the four year technology program did not occur at the behest of industry. He goes further, maintaining that industry possessed an initial negative attitude to the development of such a curriculum. The case is made that industry needed more two-year technicians and not another four-year curriculum stream. Nevertheless, industry adjusted to the available manpower pool graduating from this four-year curriculum by simply placing the graduates in existing vacancies. Irwin's view is emphatically supported by Forman (1979) who states "engineering technology is an educational concept, not a separate professional or occupational field". Blackwell et al. (1980) are even stronger in contending that

> ...the educational community, in isolation from broad industrial input, concluded that it was no longer possible to educate one individual through an

> educational program of finite duration which would satisfy the industrial needs for all, or even a major portion, of the spectrum of these engineering related activities. As a result, a new baccalaureate educational program, known generally as engineering technology (technology) was conceived by the educational community...(p. 3).

Also, a review of the "Grinter Report", clearly indicates an industrial survey was conducted at the time, and the responses from industry distinctly disclosed that a heavier math-science foundation in engineering was desired (Grinter et al., 1955).

In the United States, the evidence for the establishment of a separate curriculum in technology as a response to stimulus from outside the academic community is nebulous. In Japan, for example, the establishment of technical colleges and their curriculum is fixed in national law (Jones, 1980); in effect implementing a national goal. No such clear foundation for a technology curriculum is found in the U.S.

On the other hand, it can be inferred that the partitioning of the U.S. engineering education spectrum into distinct curricular orientations stems from the academic community. For example, in the section of the 1972 Technology Final Report (Grinter & Defore, 1972), dealing with the history of engineering technology, it is noted that two-year associate degree programs have a history extending over half a century, while four-year programs have developed only recently. In fact, J.C. Eglin of Princeton University wrote in 1957 (cited in Grinter & Defore, 1972, p. 4):

> We should expand the numbers of people trained at the technician level. This can be done through the development of the technical institute, and by increasing the number of such two-year or even four-year technical institutes, and by stressing the recognition by industry as engineer-technicians and engineering aides of those so trained.

Here is an early reference by an educator to the establishment of four-year engineering technology programs. Even though he referred to the present day technologist as an engineering technician, the embryo of the current system can be seen. By 1965, the United States Office of Education listed more than sixty colleges offering a four-year technology curriculum, described as "industrial technology closely allied to the engineering field" (cited in Grinter & Defore, 1972, p.4).

It is not clear, exactly when, and by which institution, the current concept of engineering technology originated. It is known, for example, that the University of Houston granted a Bachelor of Applied Science degree in 1951, subsequently changed to a Bachelor of Science in Technology degree (Carr, 1983). However, the University of Houston aside, between the time that Bradley University listed a program in "Industrial Technology" in 1923 (Grinter

& Defore, 1972) and the time that the first engineering technology curriculum became accredited by the Engineering Council for Professional Development (ECPD) at Brigham Young University in 1967 (McCurdy, 1985), the present system took form.

From the Grinter & Defore final report (1972) several factors have emerged as influencing the development of baccalaureate technology programs. One such factor is the "bulging from within" of two-year technology programs as increasing amounts of subject matter were added to the program. Closely coupled with that aspect is the so-called "upward push" in the level of complexity and sophistication of subject matter. To maintain rigor and depth in the curriculum, and to stay relevant with contemporary technologic advances, greater amounts of material had to be added. Interwoven with these factors, is the societal one of the desire to obtain a baccalaureate degree, and to obtain an education known to provide upward mobility. If these factors are combined with the bifurcation issue, a more comprehensive explanation of the roots of engineering technology emerges. In addition, industry's willingness to hire technology graduates, encouraged a pool of students to choose technology over engineering. These events round out the mosaic which blends itself into the roots of engineering technology.

Educational Differentiation Between Technology and Engineering

It has been suggested (ASEE, 1971) that a skills/theory continuum can be used to locate various categories of personnel engaged in technical endeavors. If such a continuum is accepted, then engineers require more theoretical training than skills training, and craftsmen require a predominantly skills oriented program. As can be seen from such a scheme, adapted from Chesier (1985, p. 29), engineering technologists require less theory, but more skills training than engineers. When considering such a scheme, as displayed in Figure 1, it is extremely important to realize that the skills and theory mix for any classification on the figure are not rigidly fixed. In reality, there is overlap and a blurring of the boundaries.

Grinter and Defore (1972) report that approximately 70% of the content of engineering technology curriculum at the baccalaureate level involves math-science-technical. The percentage for the baccalaureate engineering program for the same discipline or branch, is approximately 80%; achieved, in part, by reducing the practice oriented courses.

However, those percentages alone are not sufficient to convey the whole picture. Differences are not only found in quantity of the math-science-technical courses taken, but also in depth and breadth. Blackwell et al. (1980, p. 3) point out that differences "in pace, emphasis, mathematical and scientific level, student capability and maturity, and

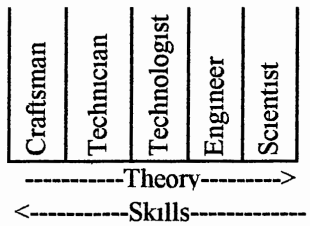

Figure 1. Theory/Skills Training Mix

fundamental philosophy have caused curricular differences ..." that distinguish engineering from technology. In engineering technology, an emphasis is placed upon laboratory experiences. In fact, the Final Report (Grinter & Defore, 1972, p. 14) states that:

> the central purpose of engineering technology education is to be support for the practical side of engineering achievement with emphasis upon the end product rather than the conceptual process.

This statement is in sharp contrast to what is identified as the central objective of engineering from that same report. Therein the controlling objective is stated to be "the design of machines, structures or processes" (Grinter & Defore, 1972, p. 13). A notice is added to define design to be based upon high levels of both mathematics and science, and involving both analysis and synthesis.

These differences are reinforced in a career guidance pamphlet published by the Institute of Electrical and Electronics Engineers (Institute of Electrical and Electronic Engineers [IEEE], undated). From that document, which is intended for the use of prospective students in determining which branch of engineering best fits their interests, Table I is extracted. As can be seen, the IEEE recognizes the difference in emphasis within the two curricula.

However, Grayson (1977) notes that it is not the professional societies, such as the IEEE, which drive the curriculum content within engineering; rather it is the educators. Because engineering education did not evolve from apprenticeship, as happened in the professions of medicine, law and dentistry, but from the institutions teaching engineering, the educators possessed a unique opportunity to define from within what the curriculum ought to be. The IEEE, as the professional society representing the profession of electrical engineering, is acknowledging in an after the fact manner, the differing emphasis between engineering and technology as driven by the existing curriculum.

A further, and perhaps even stronger reinforcement to the differentiation is given by the Accreditation Board for

TABLE I

COMPARISON; ENGINEERING AND ENGINEERING TECHNOLOGIES

Comparison Factor	Engineering	Engineering Technologies
Program Emphasis:	develop analytical ability and basic understanding of physical phenomena.	use current application information and practices for specific technical problems.
Lecture Emphasis:	use mathematics and sciences and stress underlying theory.	apply technical knowledge and techniques to current technical problems.
Laboratory Emphasis:	investigate experimental methods to learn techniques.	solve practical design and learn evaluation techniques for industrial problems.
Technical Design Emphasis:	develop design principles applicable to a wide variety of engineering problems.	develop current design procedures of a complex, but well established nature in a specialized technical area.

(IEEE, undated, p. 7)

Engineering and Technology (1980) in a guidance pamphlet which describes the functions of engineers and technologists. The pamphlet says:

> The engineer is primarily an innovator or creator of new products, processes, procedures, or systems whose interest is in: how to solve practical problems

(through the use of mathematics, knowledge of science and practical judgment) and how to do that economically.

The engineering technologist is typically a practical person interested in applying engineering principles and in organizing people for industrial production, construction or operation or in the improvement of devices, processes, methods or procedures.

The fact that the Accreditation Board for Engineering and Technology (ABET) can issue such a document stems from its status as the accrediting arm of the engineering profession. That stem has its root in a 1932 meeting which included representation from the major professional societies: the National Bureau of Engineering Registration, the Society for the Promotion of Engineering Education, together with the Engineering Council for Professional Development (the forerunner of ABET). That meeting established a committee to begin accreditation of engineering schools (Neathery & Schmidt, 1990). From that beginning, ABET has evolved into the accrediting agency. As the accrediting agency, ABET accepts accrediting criteria recommendations from the IEEE, (IEEE, 1982) and the IEEE, in turn, has accepted the educational community's practice of curriculum differentiation between technology and engineering. The characterization of engineers and technologists by ABET is merely a linear reflection of the judgment concerning the differences between engineers and technologists as applied by the educational community.

Additional reflections of differentiation between technology and engineering can be found in the accreditation criteria for each type of program. The IEEE has published curricular guidelines (IEEE, 1982) which are approved by the ABET Board of Directors. For baccalaureate technology programs those guidelines include the following mathematics requirements:

> A minimum sequence of college level algebra, trigonometry, ...analytic geometry, applied differential and integral calculus.
>
> Emphasis throughout the mathematics sequence should be on practical aspects and applications with less emphasis on theoretical aspects and derivations/proofs. To be appropriate...the mathematics sequence will ordinarily be more applications oriented than the sequence that is taken by engineering students.

Here is a very clear statement of not only what mathematics ought to be taken by the technologists, but also a comparison of the degree of rigor expected of the engineering student. The IEEE guidelines, with regard to the entire program, are also very clear; they state that "It is critical that the program be structured as an engineering technology program, and not as an engineering science program..." (IEEE, 1982, p. 9). Within that document the

IEEE is careful to establish that engineering science programs (synonymous with engineering herein) "emphasize innovative...rather than applied..." (IEEE, 1982, p. 9).

From the careful distinctions made within the curricular guidelines, it is intended that the technologist is to be educated at a qualitative level different from the engineer. Within technology, the emphasis is on applications; and within engineering, the emphasis is on theory.

The IEEE guidelines have a significant influence on the accreditation process, through the ABET criteria for accrediting programs (ABET, 1990). The ABET criteria says, in part, "...that a program in a curricular area covered by approved curricular guidelines must be in compliance both with ABET criteria and with the interpretive contents of the guidelines, to be satisfactory." (ABET, 1990, p.7). That statement essentially means that differentiation among technologists and engineers is officially documented in the accreditation criteria applied to technology programs. It seems reasonable to conclude that the accrediting criteria adequately reflects the current consensus within the academic community, as reflected by ABET; and within the professional society, as reflected by the IEEE guidelines.

Differentiation in the Industrial Community

Of the studies which deal directly with industrial acceptance of engineering technologists, those of Stone (1975), Smoot and King (1981), Ehrenberg (1982) and Varma (1983) researched the attitudes and opinions held by those in industry. Other studies also exist, but not of the scope contained in these four.

Stone (1975) conducted a survey among a mixed group of 453 manufacturing and construction personnel as well as some faculty. The thrust of his survey intended to ascertain the role of engineering technologists within the research-production team. Stone's survey is important in that it is a very early attempt to identify where, within the engineering hierarchy the technologist fits as seen by practitioners. His findings are extensive and detailed; however they can be briefly summarized by paraphrasing some of the data from the table dealing with emphases of the research-production team (Stone, 1975, p. 20). Stone's table uses a seven point scale, with a score of seven representing maximum. It compares the relative emphasis the engineering research-production member is expected to place on various aspects of the effort. The following matrix, Table II, is extracted from Stone (1975, p. 20). It represents a truncation of the original table because two columns, one for technicians, and another for operators, are not reproduced.

In fact in all aspects of team effort, engineers scored higher in each emphasis area than did technologists, except in physical skill.

Stone (1975) has clearly shown, that for the group surveyed, clear distinctions between engineers and technologists existed in the opinion of those persons involved in the study. Stone's work does not equate directly to the present effort because it deals only with research-production teams, and is further confined to construction and manufacturing. It does serve as an indicator that differentiation between technologists and engineers did exist in some segments of industry in 1975.

Smoot and King (1981) queried 326 supervisors of baccalaureate graduates of several branches of engineering and technology. Their survey predominantly focused on the western United States, but because almost one-third of the respondents were located outside of that region, their findings have national significance. However, because they did not restrict their investigation to the electrical field of engineering and technology, their findings only correlate to the topic under consideration herein, in a general way.

The ratio of engineers to technologists working for the supervisors of Smoot and King's study is two to one. According to their survey, about 60% of technology graduates

TABLE II

COMPARISONS OF SCIENTISTS, ENGINEERS AND TECHNOLOGISTS; STONE'S STUDY

		Position	
Emphasis	Scientist	Engineer	Technologist
Ideas	6.7	6.7	3.7
Solutions (Analytical)	6.7	7.0	3.0
Solutions (Applied)	3.7	6.3	5.7
Applications	2.7	5.3	5.0
Data Gathering	4.7	5.7	4.7
Evaluation	6.3	7.0	4.7
Sphere of Influence	6.0	6.7	4.3
Physical Skills	1.3	1.7	4.7
Educational Training	7.0	6.7	4.3

have "engineer" in their job title. Smoot and King (1981) also found that a large percentage of technologists are involved in manufacturing, computer programming and development; but the percentage of engineers who participated in design and administrative functions is larger than the percentage of technologists involved in those same functions. Also, it is not difficult to draw a tentative conclusion from Smoot and King's data that differences in assignment percentages do exist between engineers and technologists per job category, but in general, those differences are not large. Further, in line with the findings of Moore (1977), Smoot and King found the salary differences between practicing engineers and technologists to be small, on the order of 6%; engineers drawing the higher salary average.

Their study would have had more utility for the topic under consideration, had the survey been more geographically general, and the field limited to the electrical specialty.

Ehrenberg (1982) concluded, in a detailed study, that there is essentially no difference in assignments, or responsibilities relegated to engineering technologists versus engineers. Further, supervisors tended to regard the capabilities of the two groups to be virtually equal.

Though confined to the employers of California Polytechnic State University baccalaureate graduates of technology programs, Ehrenberg's 1982 survey did poll 132 employers of those graduates, 85% of which were in California. His study included employers of graduates from all the branches of engineering technology offered at the school.

Significantly he found that 75% of those employers used the title "engineer" for their BET (Bachelor of Engineering Technology) employees. Also, 73% of the employers assigned

BET employees to assignments with the same responsibilities as baccalaureate engineers. As summarized by Erhenberg (1982):

> As seen through the eyes of his immediate supervisor, the typical California Polytechnic BET graduate is employed in California and his job title is engineer or manager. His compensation is equal to the BS [Bachelor of Science] engineering graduate and higher than the two-year associate degree graduate, and his education adequately prepared him for the engineering position he holds.
>
> His assignments and responsibilities are the same as his fellow workers with BS engineering degrees, and his employer reports that he has equal qualifications. His employer often finds that his BS engineering colleague is not expected to perform job tasks requiring a higher level of proficiency, and he feels that the BET graduate's chances for promotion are not limited because of his BET degree.

Although not a direct one-for-one equivalent to the present investigation because of geographic limitations and the limited depth of his probe into differentiation between technologists and engineers, Ehrenberg's study is nevertheless a significant hallmark. His work clearly provides an early (1982) attempt to determine if, and to what extent, differentiation exists between technologists and engineers in the view of the supervisor.

Based on the results of Ehrenberg's study, a reviewer is led to the preliminary hypothesis that, as seen by the industrial supervisor, the technical continuum between engineering technologists and engineers is seamless. The author of the study went on to conclude that "there is a serious identity problem and much confusion in the industrial community over the differences between a BS engineering graduate and a BET graduate." (Ehrenberg, 1982, p.42) He concludes that the opposite is true among educators, professional societies and accreditation boards; in those cases there is no confusion; clear differentiation is implied.

The study conducted by Varma (1983) concerned itself with ascertaining the degree of correlation between the opinions of educators and industrial representatives regarding engineering technologists. Varma did not confine his study to the electrical branches, but included all disciplines in an undifferentiated mix. When discussing Varma's work "technologist" and "engineer" are generic terms, not to be confused with the specialized usage herein. This generalization, coupled with the fact that he chose personnel managers to answer for industry, in lieu of engineering supervisors, distinguish his efforts.

Varma's research serves to provide some general groundwork for determining the differentiation applied to technologists versus engineers. The chief thrust of his work compared the attitudes of educators with those of industrial representatives (personnel managers), and his results indicate some general findings of interest. For example, the majority of educators believe that technologists and engineers are given similar engineering assignments, however the majority of industrial representatives indicated they were not given similar assignments. Also the majority of educators, 92%, believed that technologists did not lack technical competence; conversely only 62% of industrial representatives held that view; a significant difference of opinion.

Varma's work is particularly useful as a source for determining the views and perceptions of the educational community. In reading the results of his probe of the opinions of educators concerning the abilities and utilization of technologists, there are no surprises. The educational community reflects the published positions of both ABET and the IEEE regarding the distinction between technologists and engineers. On the other hand, because he framed his instrument in general terms, and because engineering supervisors were not the respondents, the utility of his work is bounded by those constraints with regard to determining the actual opinions of industrial supervisors regarding technologist-engineer differentiation.

A further study, though very small in scope, dealt with 23 employers in New York state (Satre, 1977). In that study 70% of the responding employers indicated that technologists within their employ had the title of engineer. However, 37%

of the responding employers indicated that there existed perceived differences between engineering technologists and engineers. The study did not identify what specific differences were noted. Although not exhaustive, this small study agrees in a qualitative way with the later study by Ehrenberg (1982) of technologists in California.

Other studies dealt with either the opinions and attitudes of students or graduates of baccalaureate technology programs. These efforts were valuable for determining how the participant in the curriculum perceived his or her status, but they shed relatively little direct light on the perceptions of industrial supervisors. They do allow for some measure of inference about industrial acceptance, or supervisor attitude by extension, however. In Moore's (1977) study he found that 74% of the respondents considered themselves about equal in job assignment and responsibilities with engineering graduates. From that finding, an inference can be made that this group of technologists were treated about the same as engineers; a clear implication that the technologists surveyed in the study were being assigned to tasks perceived to be similar to those assigned to engineers.

In an earlier effort, Moore (1975) analyzed the results from 178 responding technologists who were alumni of Pennsylvania State University. He found that 84% of those technologists felt that their assignments and responsibilities were about the same as those assigned to baccalaureate engineers. He also found that 98% of the technologists felt that they were at least equal technically to engineers within the same firm. In addition, 95% of those technologists declared that their technical education was at least sufficient for their first industrial position. Again, these results are not direct evidence of the attitudes and perceptions of industrial supervisors. They may at least reflect the response of those supervisors to the technologists in the workplace in a very pragmatic way; the positive attitude that the technologists hold regarding their qualifications when they compare themselves to engineers may be a reaction to a perception garnered from their supervisors.

In yet another study, Moore (1979) found that the starting salaries of technology graduates to be 94% of the starting salaries of baccalaureate engineers. That relatively high percentage is not conclusive evidence of near equivalence. The near parity in compensation does imply that industry values the technologists about the same as the engineer. Nevertheless, 94% is not 100%, therefore some differentiation between the two groups existed.

Differentiation as a Function of Cognitive Competency

Because the approach utilized in this study to catalog differentiation in competencies is grounded in Bloom's

Taxonomy of Cognitive Competencies (Bloom, 1956), a short discussion of that taxonomy is included herein.

Bloom is frequently credited with the authorship of a set of well known educational objectives. However, Bloom is not the sole contributor to the effort. He served as editor for the undertaking, a project of the Committee of College and University Examiners (Bloom, 1956). This committee included thirty-four other participants who contributed to the development of that taxonomy of cognitive educational objectives.

Between 1949 and 1953, conferences were held among and between these contributors in an "...attempt to build a taxonomy of educational objectives" and to develop a scheme for "...classification of the goals of our educational system" (Bloom, 1956, p. 1). Starting from these goals, the Committee eventually formed the taxonomy of cognitive educational objectives; now commonly referred to as "Bloom's Taxonomy".

The cognitive taxonomy consists of six objectives, each of which is referenced below:

1. knowledge - the components of this educational objective involve the recall of specifics and universals; methods, processes, patterns, structures, and settings. Briefly, this objective emphasizes the psychological process of remembering (Bloom, 1956, p. 201).

2. comprehension - this term represents the lowest level of understanding. It refers to the process by which the individual knows what is being communicated and can make use of the material without relating it to other material or understanding its fullest implications (Bloom, 1956, p. 204).
3. application - this objective implies the use of principles, ideas, and theories in dealing with particular and concrete situations. The inference is that abstractions can be translated into practice (Bloom, 1956, p. 205).
4. analysis - this objective refers to the restructuring of ideas into constituent elements, forming a relative hierarchy, and identifying the relationship between those elements. This component of the taxonomy clearly refers to abstract manipulation; often requiring dealing with symbols (Bloom, 1956, p. 205).
5. synthesis - this objective involves the piecing together of a set of operations from elements and parts, in such a way as to form a pattern or structure not clearly there previously. This level of accomplishment also includes the ability to deduce propositions from data or other propositions, and to formulate hypotheses (Bloom, 1956, p. 207).

6. evaluation - this, the most complex objective, implies an ability to evaluate, or judge, the merit of a proposition, hypothesis, or method. The criteria used for judgment is generated using both internal and external evidence, i.e., the student can produce and defend qualitative and quantitative arguments to defend his/her judgment of merit (Bloom, 1956, p. 207).

The taxonomy of knowledge, comprehension, application, analysis, synthesis and evaluation proceeds from the simplest ability to merely recall theories or facts, to the most complex task of judging the merit of propositions or hypotheses. This taxonomy forms a convenient set of objectives, translatable to skills, fragmented into observable behaviors by which judgments relating to skill or competency level can be formulated. In other words, using the taxonomy as a guideline, a competency hierarchy can be formed and used as a sieve to classify levels of skill and expertise.

Because this taxonometric system is observable and well known, it has been chosen as a core for the research into differentiation between technologists and engineers as applied by industrial supervisors.

CHAPTER III

PROCEDURES

A four part questionnaire was developed as the research instrument, a facsimile is included in appendix D. The first portion of the instrument asks for the respondent's address, classifies the industry and measures relative populations of technologists and engineers within the respondent's company. It also catalogs the types of job tasks assigned to technologists and engineers at that company. This portion is designed to uncover differentiation in the physical domain, in that it deals only with numerical and classification facts as known by the respondent. The primary purpose of this section is to catalog which types of tasks are assigned technologists, and which types are assigned to engineers.

The next two sections, labeled I and II, of the questionnaire deal with the affective domain. The first of these addresses the attitudes of supervisors towards the technologist's technical abilities, as indicated by the supervisor's assessment of which tasks he or she feels are suitable as assignments for the technologist. The second section addresses the supervisor's assessment of cognitive competencies as cataloged by Bloom's taxonomy. In the taxonomy section, the supervisor is asked to compare the technologist to the engineer, and then rank the technologist's competencies. Each question in these two sections is arranged as a seven segment Likert scale, in which the response is scaled with the maximum weight toward the opinion or observation most favorable to the technologist.

The fourth, and last, segment of the questionnaire collects information about the respondent, and elicits the respondent's opinion concerning the difference between technologists and engineers.

Outline of Procedures

First Mail Attempt

1. A prototype instrument was developed and circulated among faculty for comment (P. R. McNeill, personal communication, June 7, 1990). Primary consideration emphasized whether or not the instrument would deliver the desired information, and whether or not overt bias existed in the questions. Changes and refinements were made based upon faculty comments.
2. The revised prototype questionnaire was then sent to a Senior Staff Engineer (Mr. David M. Barnett, personal communication, December 20, 1990) at a major aerospace company for field testing by six engineering supervisors who had agreed to do so.

Upon completing the prototype questionnaire, these supervisors made comments and suggestions which resulted in further refinements. At this point the instrument was again submitted to faculty (P. R. McNeill, personal communication, January 19, 1991). Following that second faculty review, the survey became ready for transmission to the survey population.

3. Identification of initial target population occurred concurrently with questionnaire development. The target population became the engineering managers at electronics firms known to be actively involved in recruiting both technologists and engineers. These firms were identified through a survey of Peterson's Annual Job Guide (Billy & Geoffrey, 1988). A review of the guide yielded a list of 346 such companies. It is important to realize that this review yielded only the names and addresses of companies, and not the names of specific engineering managers. The survey was confined to firms seeking electrical engineering technologists and engineers within the United States.

4. After reviewing the roster of 346 firms that seek both electrical engineering technologists and electrical engineers, the entire population was chosen for sampling.

5. A questionnaire packet included: an introductory letter addressed to the company's personnel manager, a letter addressed to the engineering manager, a short glossary of terms used in the instrument, the instrument and a self-addressed postage paid return envelope. Each of the 346 companies was mailed a packet addressed to the personnel manager. The introductory letter to the personnel manager requested that the survey be routed to the appropriate engineering supervisor. The above procedure assumed that the companies, because they were seeking both technologists and engineers, would retain a person responsible for supervising such employees.
6. Mailing occurred during the last week in April 1991.

Of the 346 questionnaires mailed, 43 or 12.4% were returned, of these 38 were usable. The unusable responses were those in which the questionnaire was not completed, or those in which the respondent had no direct knowledge of technologists. Herein, this first survey cycle is referred to as the first mail survey.

Discussion of Problems

Using Dillman (1978) as a guide, an analysis of the factors which impacted the response rate indicated several mistakes occurred. Chief among those mistakes is addressing a survey to a position title rather than to a person, making the recipient anonymous. The practice of anonymous addressing leads to a situation wherein no person is responsible for answering the survey. Dillman (1978, p. 163) suggests that addressing the questionnaire to a generic position title such as "Engineering Manager" versus using a person's name does contribute to disappointing raw count of instruments returned. Because the data base from which the company names and addresses was drawn did not contain the names of engineering managers, pursuing those unknown individuals for follow-up by mail or telephone would have been costly and time consuming. In order to have followed up, the names of supervisors would had to have been identified by company telephone operators or personnel office employees. Reliance on persons other than the intended respondents for assistance would not have guaranteed a greater success than the initial mailing to personnel managers. In short, personnel not directly involved in the survey would have to be depended upon to finish the routing to the proper respondent. The inherent weakness of the initial mailing would not be reduced by further contacts through intermediates.

Because the identity of respondents was unknown, efforts to use an address oriented data base were abandoned. In effect, this first survey attempt was treated as an extended field test of the instrument. Cosmetic changes were made in the instrument layout after this first mail survey, again in consonance with Dillman (1978). All survey questions remained unaltered.

The abandonment of the address oriented data base of companies known to employ technologists and engineers could be justified if, and only if, a substitute listing could be generated which contained the personal names and addresses of individuals who were known to be engineering supervisors or managers. Just such a listing was obtained for the second survey attempt.

Second Mail Attempt

A second, independent and fresh approach to a mail survey began with obtaining the names of 1500 people who had identified themselves as engineering managers. This list was purchased from the Institute of Electrical and Electronics Engineers. Names contained within the IEEE data base originated from biographical data supplied by the member at the time of application to the IEEE, and the information is updated annually.

In coordination with the manager of IEEE Mailing List Sales (G. L. Klapisch, personal communication, June 3, 1991, June 30, 1991), the search parameters were identified for a random generation of 1500 names. The search parameters included only those who had identified themselves as engineering or scientific managers, and who were currently employed as:

1. an engineering or scientific manager, or

2. a chief engineer or scientist, or
3. the vice president or director of engineering.

The 1500 names were drawn at random without regard to location, from within the U.S. The above factors constituted the only search sieve.

The revised procedure progressed as follows:

1. A cosmetically redesigned instrument, according to the suggestions outlined in Dillman (1978), became the new questionnaire. Those changes consisted of adding a cover page, a graphic and changing the paper stock and color. The core of the instrument remained unchanged.
2. The mail packet consisted of the revised questionnaire, a letter addressed to an individual, the glossary of terms used in the first attempt, and a self-addressed postage paid return envelope. The introductory letter to the individual explained that the packet was a survey which required their input as an engineering supervisor.
3. The mailing of the second attempt occurred during the last week in October 1991.
4. A follow-up reminder, in the form of a postal card was mailed to all addressees ten days later. The follow-up thanked them for returning the survey, if they had already done so, and reminded them

that their input was important if they had not as yet returned the survey.

Herein, this survey cycle is referred to as the second mail survey. Of the 1500 questionnaires mailed during this cycle, 21 survey packets or postal cards were returned as undeliverable. Of the remaining 1479 survey packets, 114 or 7.7%, were returned in the postage paid envelope. Eighty-five, 5.7%, of the surveys were usable as data. The 29 unusable responses consisted of those in which the questionnaire was not completed, or the respondent indicated that he or she did not possess enough knowledge to complete the survey. In all, 135 or 9.0%, of the 1500 packets were accounted for.

Because the participants in the first mail survey were not known, there was no way of knowing whether or not a participant in the first mail survey might also have participated in the second. Therefore the second mail attempt responses could not be merged with those of the first. For this reason, no inquiry was made to show that the results from each mail survey were independent. As mentioned before, the first mail survey was viewed as an extended field trial, and the second mail survey formed the core of the research.

Discussion of Problems

As with the first mail survey attempt, the return rate at 30 days was disappointing. Since a follow-up post card had already been mailed, any continuing effort to gather more responses by mail would have been marginal. Further follow-up was done by telephone. In order to preserve population integrity, telephone follow-up used the same data base as the second mailing. The data base contained both names and addresses. Those respondents who included their address on the returned survey, were purged from the data base used for telephone follow-up. In 15 cases, correlation of a returned instrument to a specific individual failed, because the address was not provided. Although some residual ambiguity remained regarding the 15 responses which failed correlation, there was a high degree of confidence that the other persons responding by mail, and those responding over the telephone comprise mutually exclusive sets. A summary of facts which supports that conclusion is included and discussed in the next segment dealing with the telephone survey.

The Third Survey - The Telephone

After depletion of the 120 mail respondents already identified, a listing of 1380 names constituted the telephone data base. During December 1991, the microfilm assets of the Edmond Low Library at Oklahoma State University were used to retrieve as many telephone numbers as possible from this data base. Only 410 telephone numbers were found and retrieved. In the remaining 970 cases, no telephone number was available.

Persons having no personal interest in the research, and possessing no special understanding of technology or engineering were retained to perform the telephone survey. In particular, two undergraduate students, one from the College of Business Administration, and one from the College of Education, along with a local high school junior were retained to make the telephone survey. One of the students, the person from the College of Business, had previous experience with telephone survey techniques, having worked for the Oklahoma State University Alumni Foundation. She provided the basic training to the others in the rudiments and protocols of telephone survey etiquette and consistency.

The following table represents the numerical results of follow-up efforts through using the telephone.

The category in the above table referring to calls which could not be completed, includes only those telephone numbers for which no connection occurred after several attempts, or for which the prospective respondent diverted his or her telephone to an answering machine. Control was maintained by deleting the name of any person from the data base who completed the questionnaire by telephone, or who declined to participate or who claimed insufficient knowledge to answer the survey.

The justification for claiming that the incidence of respondent duplication is not significant between the second base who completed the questionnaire by telephone, or who declined to participate or who claimed insufficient knowledge to answer the survey.

The justification for claiming that the incidence of respondent duplication is not significant between the second

TABLE III

TELEPHONE ACTIVITY RESULTS

Activity	Number
Number of Potential Telephone Respondents:	1380
Number of Telephone Numbers Found:	410
Number of Telephone Calls Made:	724
Number of Calls Which Could Not be Completed:	406
Number of Connections:	318
Respondents Completing Survey:	72
Respondents Declining to Participate:	101
Respondents Claiming Insufficient Knowledge:	141
Respondents Claiming Completion by Mail	4

mail survey respondents and the telephone survey respondents, is founded upon the following rationale. From the total roster of 1500 names used in the second mail survey, 135 responses arrived by return mail, which left a residue of 1365 non-respondents. Of those 135 who did respond by mail, only 120 could be identified, leaving 15 persons who had responded but could not be positively identified. That led to a roster of 1380 names, which included the unidentified 15 respondents as candidates for telephone follow up. If it can be assumed that those 15 persons were randomly distributed throughout the total of 1380 names, then contact could be expected to occur with one of those persons in every 92 telephone connections. Because 318 connections were completed, at least three persons were expected to claim that they had already completed the survey. Four persons from that group of 318 actually claimed prior completion; therefore it is reasonable to conclude that the incidence of response duplication is insignificant.

It is interesting to note that 23.8% of those contacted by telephone, did complete the survey. Of the 76.2% who did not complete the survey, 31.8% declined to do so, while another 44.4% claimed they possessed insufficient knowledge of the topic to participate.

Because of the random nature of the original base of 1500 names, it is reasonable that a percentage of managers and supervisors having no knowledge of the topic would be encountered. The same observation extends to those who would not participate in the survey. If it is presumed that the 76.2% who did not participate are representative of the entire data base of 1500, and that they are evenly distributed over the entire population, then the expected number of non-responses from the entire group equals 76.2% of 1500, or 1143. Conversely, the expected number of completed responses is 357, or 23.8% of 1500.

In spite of the fact that only 157 mail and telephone responses were gathered out of an expected 357, the decision to terminate became necessary. Budgetary and schedule constraints required ending data collection efforts even though only 44% of the expected number of responses had been attained. Therefore, follow-up telephone activity was concluded during the last week of March 1992.

CHAPTER IV

FINDINGS

Distribution of Respondents by Area and Industry

A catalog of all the states from which responses were received are contained in appendix A. A review of that roster shows that a wide dispersal of geographic locales were represented. Responses came from all geographic regions of the U.S., representing 29 states and the District of Columbia.

Within those regions, the respondents represent 56 different industries as cataloged in appendix B. A perusal of the listing shows that major and widely varied segments of industry were represented, from electric utilities to spacecraft. Also represented are non hardware industries, such as technical services and software companies. In all, a satisfactory cross section of both locale and industry type were represented.

Relationship Between Surveys

First Mail Survey

Due to the extremely low raw respondent count of the first mail survey, and the inherent difficulty in reaching the proper person for follow-up; and because independence among respondents could not be guaranteed between the first mail survey and subsequent ventures, this survey served only as a field test of the instrument.

Relationship Between Populations - Second Mail Survey and Telephone Survey

The numerical raw count of responses from both the second mail survey and the telephone survey, individually, are small. However, if a rationale can be developed, and defended, allowing the combination of the results into a single data base, then the numbers approach a respectable count. To combine the results into a single set, it must be shown that there is no significant difference in the responses of the two groups. If a case can be made that there is no significant difference, then the respondents of the second mail survey and the telephone survey can be treated as members of the same population.

The persons who did not respond to the second mail survey constituted the non-responding population which became the data base for the telephone survey. Their subsequent response to a telephone survey, albeit using the identical instrument, does not allow the assumption that their responses correspond with the responses of those who completed the survey by mail. Without establishing congruence between the two groups, they must be treated independently. In order to establish congruence, a comparison of means is an appropriate test (Book, 1977, p. 154).

In developing an appropriate comparison, each of the eight postulates from that portion of the instrument labeled Section I, and each of the nine statements from that portion of the instrument labeled Section II had the mean individually calculated for both the second mail and the telephone survey. Calculations for each survey were made independent of the other. For the sake of comparison of the means, the content of each of the questions was ignored; only the numerical scale value of the response was considered. After acquiring the mean for each question, from each of the surveys, a comparison between the means of each question from the second mail survey and from the telephone survey was made using the following algorithm (Book, 1977, p. 154):

$$z = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} \qquad (1)$$

z = test statistic

$\bar{x}_{1,2}$ = sample mean

$s_{1,2}$ = standard deviation

$n_{1,2}$ = number in sample

In developing a test based upon the statistic of equation (1), a hypothesis stating that:

$$H \ \mu = \mu_0 \tag{2}$$

μ = true mean telephone survey
μ_0 = true mean mail survey

can be used. But, an alternative hypothesis is more convenient in this case, namely (Book, 1977, p. 152):

$$A \ \mu \neq \mu_0 \tag{3}$$

μ = true mean telephone survey
μ_0 = true mean mail survey

When using the alternative hypothesis it is also convenient to modify the test statistic to the form:

$$|z| > z_{\frac{\alpha}{2}} \tag{4}$$

z = test statistic
α = significance level

To assert, using the alternative hypothesis at the α=.005 significance level, that the mean of the telephone survey does not equal the mean of the second mail survey, for any question of the sections labeled I or II of the instrument, it is necessary for $|z|$ to equal or exceed 2.81. That value signifies the distance from the mean as measured in standard deviations. At a value of 2.81 standard deviations on either side of the mean, the cumulative distribution function has a value of .0025 at each end (Standard Mathematical Tables, 1967, p. 524). The sum of the ends is .005, which is the significance level. That significance level represents the probability of committing an error by rejecting the hypothesis when it is true. An inspection of Figure 2, which tracks the mean of both the telephone and second mail survey for each question in sections I and II of the instrument, as well as plotting $|z|$ at each question, shows that the hypothesis must be rejected. In other words, the hypothesis that the true mean of the telephone survey does not equal the true mean of second mail survey is rejected. By rejecting the hypothesis, the probability of making a Type I error (Book, 1977, p. 155), which is to reject the hypothesis when it is really true, is equal to the significance level of .005, or one-half of 1%.

An inspection of loci shown in Figure 2 indicates that, indeed, no significant differences among the respondents of the telephone and second mail survey exist. Coupling that inspection with rejecting the hypothesis that $\mu \neq \mu_o$, leads to the conclusion that the responses do in fact arise from the same population.

After establishing congruence between the respective populations, the two sets of responses were combined to yield a single data base. This combination formed the basis for all subsequent analysis and findings. The gross

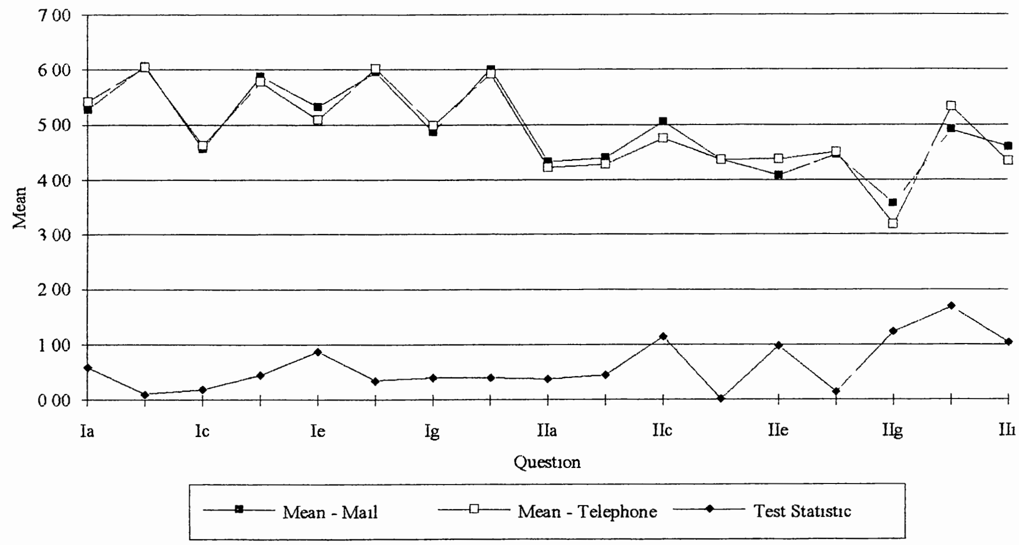

Figure 2. Comparison of Means Telephone versus Second Mail survey

response count becomes 157, which equals the sum of 72 telephone responses and 85 mail responses. If, as discussed above in the section dealing with the telephone survey, the number of responses is expected to be 357, then the combined base count of 157 represents approximately 44% of those who either could or would participate.

Again, without regard for question content, but only considering the scale value, a graph of the mean of the single data base responses for each of the postulates and statements of sections I and II from the instrument is represented in Figure 3.

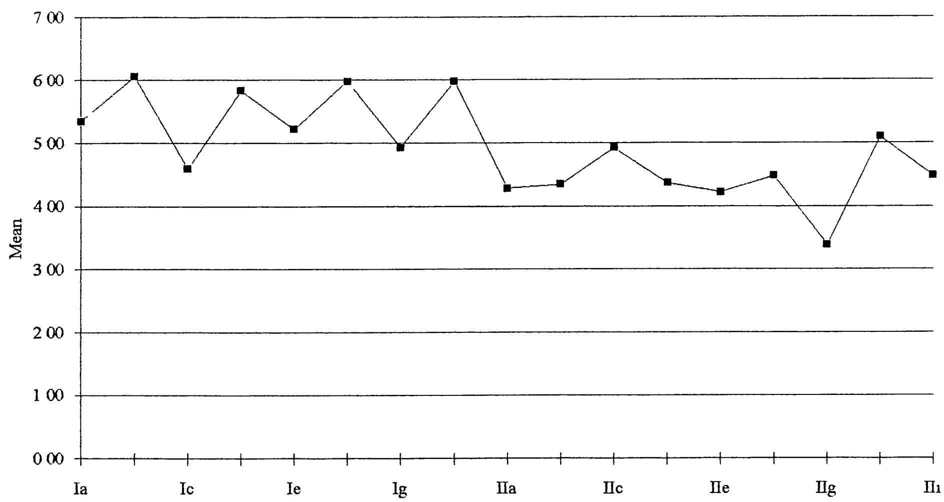

Figure 3. Combined Means, Second Mail and Telephone Survey

Initial Quantifiable Data - The Empirical Situation

Populations of Technologists and Engineers

The initial, non-numbered portion of the instrument gathered empirical data. The first segment of this portion asked the respondent to estimate the population size of both technologists and engineers at the facility. Figure 4 shows the results.

A review of Figure 4 indicates that there are more companies with populations of technologists less than 50 than companies with populations of engineers less than 50.

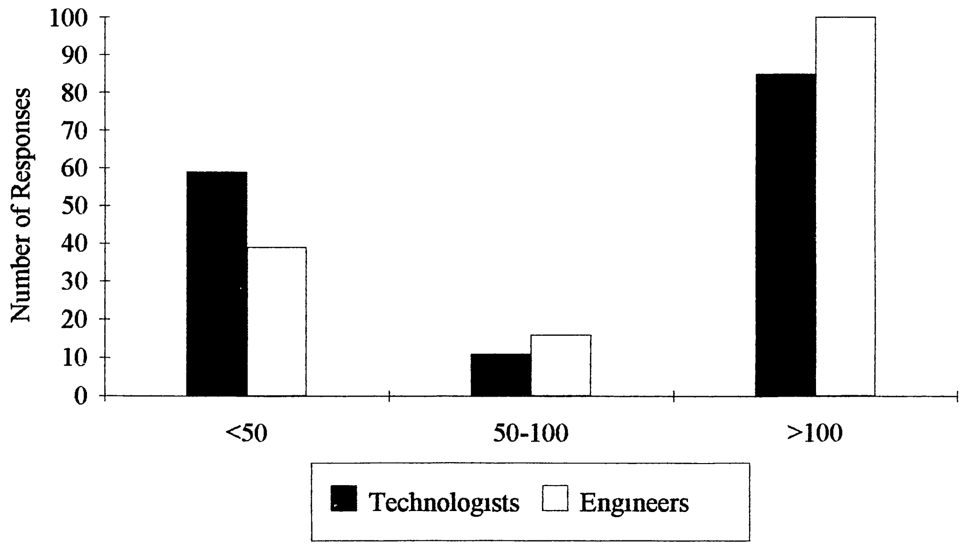

Figure 4. Relative Populations by Facility Size

Conversely, there are more companies with populations of engineers greater than 100 than companies with populations of technologists greater than 100. Curiously, the response data indicates that there are more companies at each end of the spectrum than there are in the middle. A synopsis of the population breakdown follows in Table IV.

A review of Table IV population breakdown shows that 51%, 79 of 155 who provided data, are associated with the largest company or facility size, that is, organizations employing greater than 100 technologists and greater than 100 engineers. The next largest reporting group, 21%, are associated with the smallest companies, less than 50 technologists and less than 50 engineers. The third largest reporting group, 12%, are associated with organizations employing less than 50 technologists and more than 100 engineers.

TABLE IV

COMPANIES AND THEIR POPULATION MIX

Number of Technologists	Number of Engineers	Number of Occurrences
<50	<50	33
<50	50-100	8
<50	>100	18
50-100	<50	3
50-100	50-100	5
50-100	>100	3
>100	<50	3
>100	50-100	3
>100	>100	79

Job Assignments - Technologists and Engineers

The second segment of the initial portion of the instrument asked the respondent to indicate which tasks the company or facility assigned to technologists and which to engineers as their principle job function. Eight function categories were listed, each of which had been defined for the respondent in a separate glossary included in the survey packet. A copy of that glossary is included in appendix C. The eight functions are listed in Table V.

TABLE V

PRINCIPLE FUNCTIONS

Customer Service/Support	Marketing/Sales
Field Service	Research & Development
Line Engineering	Supervision/Management
Manufacturing/Production	Support Engineering

Survey results from that portion of the questionnaire are shown in Table VI. This segment of the survey reflects the actual conditions extant at the companies or facilities with which the respondents are associated.

Inspection of Table VI reveals that at least 50% of all respondents indicated that the company or facility that they were associated with assigned technologists to any job function within the survey categories. This figure is arrived at by excluding those percentages indicating that only engineers were assigned to the job function. In some

TABLE VI

TECHNOLOGISTS AND ENGINEERS BY ASSIGNED JOB FUNCTION

	Percentage of Respondents Indicating		
Job Function	Technologists & Engineers	Engineers only	Technologists only
Customer Service /Support	52%	22%	26%
Marketing /Sales	35%	49%	16%
Field Service	45%	21%	34%
Research & Development	48%	50%	2%
Line Engineering	44%	47%	9%
Supervision/ Management	45%	50%	5%
Manufacturing/ Production	47%	34%	19%
Support Engineering	60%	25%	15%

cases technologists are either assigned independently or in combination with engineers.

From Table VI, it is clear that industry makes significant use of technologists across the job function spectrum. Figure 5 charts these job function assignments, in descending order.

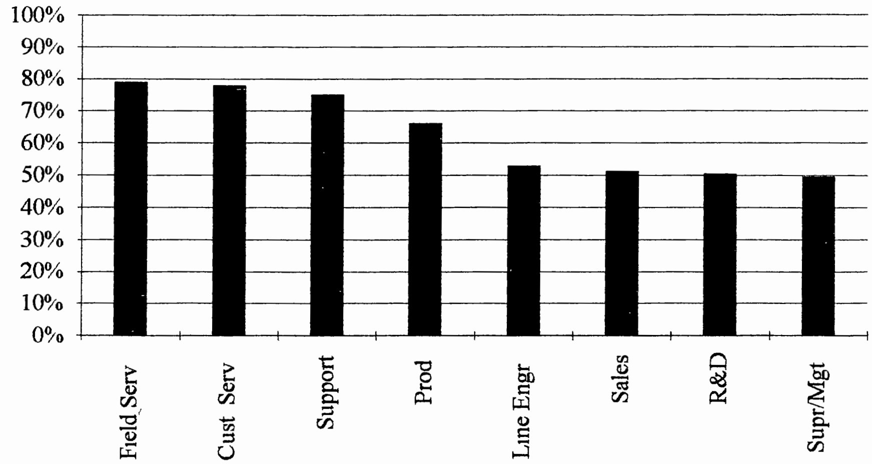

Figure 5. Technologist Utilization as Reported by Survey Respondents

This distribution reflects the reported actual situation; therefore it is fair to claim that technologists are assigned to the same functions as engineers by at least 50% of respondents.

Section I of the Instrument - Uses of the Technologist

That portion of the instrument labeled Section I gleaned personal opinion about which job functions were suitable for technologists, as defined by the glossary and exactly matching those titles in the initial portion of the instrument. The purpose of this section is to develop a mechanism for measuring the congruence between actual job or task assignment and the opinion of the supervisor regarding the suitability of technologists for that assignment. For each of the eight job function postulates, the respondent was asked to indicate the degree of his or her disagreement on a seven segment summated scale.

The scale for each of the statements is arranged horizontally on the instrument, with the response boxes arranged from strongly agree on the left to strongly disagree on the right. A facsimile of the scale is shown in Figure 6.

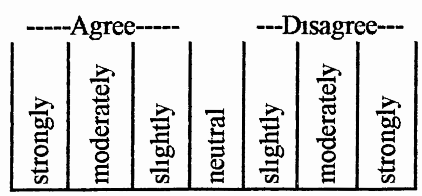

Figure 6. Evaluating Scale Used In the Survey Instrument

The scale is weighted such that the response most favorable for technologists would receive a value of seven, and the least favorable would receive a value of one. This scheme is used throughout sections labeled I and II of the instrument to allow for statistical compilation and analysis.

The eight postulates associated with Section I for which the respondent was asked to indicate a degree of agreement or disagreement are:

Technologists can be used in:

a. Line Engineering

b. Support Engineering

c. Research & Development

d. Manufacturing/Production

e. Marketing/Sales

f. Customer Service/Support

g. Supervision/Management

h. Field Service

The definition of each of the above categories can be found in the glossary provided in appendix C. Each of the above statements is phrased using the verb "can", which implies "being capable of". Presumably, the responses to these eight statements would differ if "should" or "ought to" had been used instead. The use of either of those latter two terms could have supported an interpretation of "properly used in" or "preferably used in". Because the attribute of "capable" was more central to the nature of the research, "can" was chosen as the verb.

Postulate Ia - Technologists Can Be Used in Line Engineering

The respondent was asked to rank his or her level of agreement or disagreement with the above statement. The results of the survey for the first postulate are shown in Figure 7.

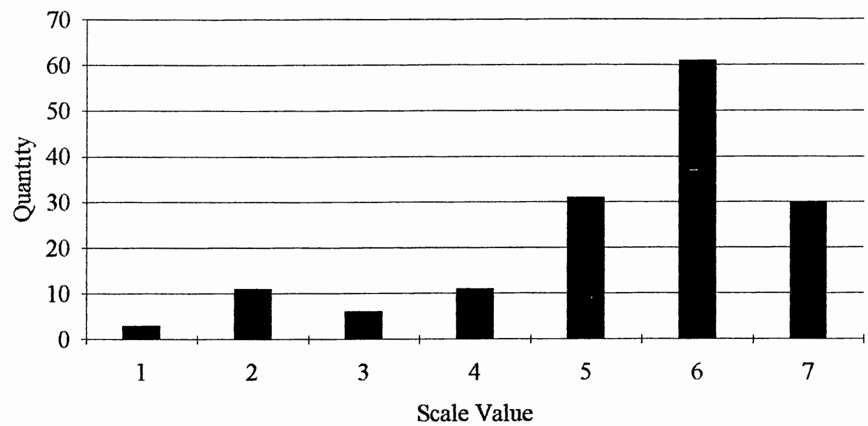

Figure 7. Distribution of Response Values Section I Postulate a - Technologists Can Be Used in Line Engineering

The distribution has a mean value of 5.35, from a count, n, of 153. That count, as with any count from sections I and II will not, in general, equal the raw count of 157 total usable surveys, because not all respondents chose to answer all questions within the survey.

A mean as well as a level of confidence can be established for the distribution. Knowing that sample means tend toward the true mean of any population, whether or not the population is normally distributed (Sanders, Murph &

Eng, 1976, p. 13), and using equation (5) (Book, 1977, p. 113), it is found that for a 95% degree of confidence, the true mean lies between 5.11 and 5.59.

$$\overline{x} - z_{\frac{\alpha}{2}}\left(\frac{s}{\sqrt{n}}\right) < \mu < \overline{x} + z_{\frac{\alpha}{2}}\left(\frac{s}{\sqrt{n}}\right) \quad (5)$$

s = Standard Deviation

$\overline{x}$ = Mean

z_{α} = Test Statistic

μ = True Mean

n = Sample Count

Summaries of these data are contained in Table VII.

TABLE VII

STATISTICS RELATING TO SECTION I POSTULATE a; TECHNOLOGISTS CAN BE USED IN LINE ENGINEERING

Sample Size	True Mean: Lower Limit	Sample Mean	True Mean: Upper Limit
153	5.11	5.35	5.59

A score of seven is viewed as indicating unqualified acceptance of technologists for the job function under consideration, and a score of one is viewed as unqualified rejection of technologists for that job function. That evaluation system arises from the descriptors used: a score of seven correlates to "strongly agree" while a score of one correlates to "strongly disagree". Using that interpretation, and understanding that a score of four represents the mid point, then it follows that any mean value equal to, or in excess of five represents some degree of clear acceptance of technologists for the function. Conversely, any score below four must be viewed as indicating that supervisors would not accept technologists for that job function. The remaining isolated value, four, is ambivalent, but nevertheless is interpreted to be minimally acceptable. Because clear rejection is not indicated, it is presumed that any supervisor registering a response of four would tentatively accept technologists for that job function.

With regard to the use of technologists for a line engineering job function as requested in Postulate Ia, the consensus of engineering supervisors and managers is positive, with 79.7% of the respondents assigning a value of five or greater. When acceptance is extended to four or greater, then 86.9% of the respondents would accept technologists in this job function. This result varies from the reported actual utilization. Only 53% of the responding supervisors reported that their company or facility utilized technologists in that job function. The high acceptance value indicates that, in the opinion of supervisors, line engineering is an appropriate function for technologists. Considering that a variance exists between actual utilization and supervisory acceptance, it is credible to suppose that the present industrial practice underutilizes technologists in this function. This situation could plausibly arise from a condition where actual utilization rates lag the general view by some period of time. The amount of disparity between actual utilization and reported acceptance by supervisors of technologists, for this job function, should decrease as the prevailing opinion diffuses throughout the industrial community. Therefore, it should be expected that the percentage of companies or facilities utilizing technologists in line engineering functions will increase in time.

Postulate Ib - Technologists Can Be Used in Support Engineering

The respondent was asked to rank his or her level of agreement or disagreement with the above statement. The results of the survey for the second postulate are shown in Figure 8.

The distribution has a mean value of 6.05, from a count, n, of 155, with a 95% degree of confidence that the true mean lies between 5.88 and 6.22. Summaries of these data are contained in Table VIII.

With regard to the use of technologists in the support engineering job function, the consensus of engineering supervisors and managers is very positive, with 91.6% of the

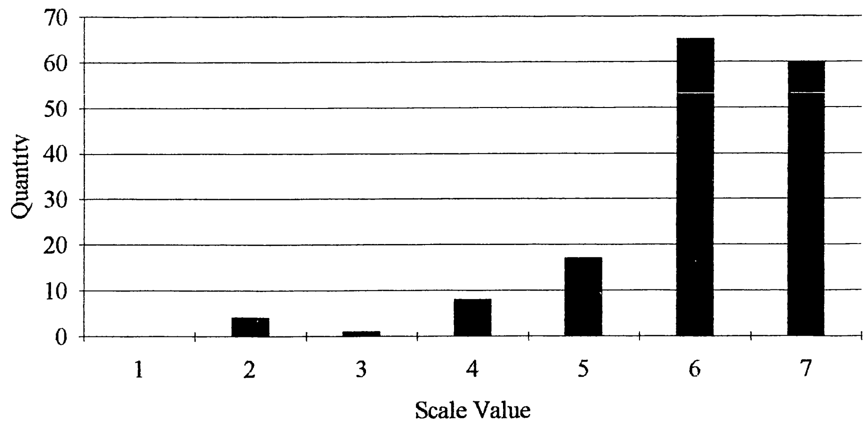

Figure 8. Distribution of Response Values Section I Postulate b - Technologists Can Be Used in Support Engineering.

TABLE VIII

STATISTICS RELATING TO SECTION I POSTULATE b; TECHNOLOGISTS CAN BE USED IN SUPPORT ENGINEERING

Sample Size	True Mean: Lower Limit	Sample Mean	True Mean: Upper Limit
155	5.88	6.05	6.22

respondents assigning a value of five or greater. Extending the acceptance level to a score of four or greater, then 96.8% of supervisors would accept technologists in this job function. This result varies from the reported actual utilization. Only 75% of the responding supervisors reported that their company or facility utilized technologists in that job function. The result also indicates that, in the opinion of supervisors, support engineering is an appropriate function for technologists. For the reasons already stated above, this condition indicates that the present industrial practice underutilizes technologists in this job function. It should be expected that the percentage of companies or facilities utilizing technologists in support engineering functions will increase with time.

Postulate Ic - Technologists Can Be Used in Research & Development

The respondent was asked to rank his or her level of agreement or disagreement with the above statement. The results are shown in Figure 9.

The distribution has a mean value of 4.59 from a count, n, of 156, with a 95% degree of confidence that the true mean lies between 4.27 and 4.91. Summaries of these data are contained in Table IX.

With regard to the use of technologists in the support engineering job function, the consensus of engineering supervisors and managers is favorable, with 60.3% of the respondents assigning a value of five or greater. Extending the acceptance envelope to four or greater, then the acceptance percentage rises to 67.3%. This result varies from the reported actual utilization. Only 50% of the

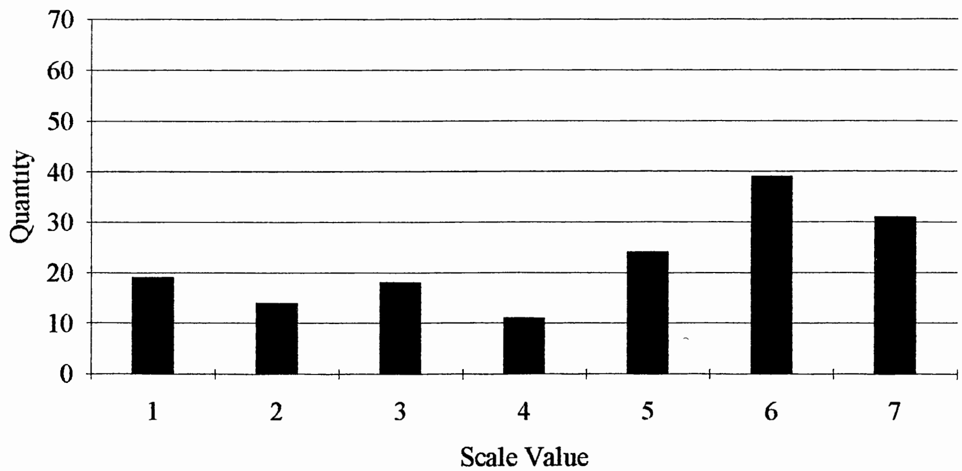

Figure 9. Distribution of Response Values Section I Postulate c - Technologists Can Be Used in Research and Development

TABLE IX

STATISTICS RELATING TO SECTION I POSTULATE C; TECHNOLOGISTS CAN BE USED IN RESEARCH AND DEVELOPMENT

Sample Size	True Mean: Lower Limit	Sample Mean	True Mean: Upper Limit
156	4.27	4.59	4.91

responding supervisors reported that their company or facility utilized technologists in this job function. The result also indicates that, in the opinion of supervisors, research and development is an appropriate function for technologists. This fact indicates that the present industrial practice underutilizes technologists. Again, for the reasons cited above, it should be expected that the percentage of companies or facilities utilizing technologists in research and development functions will increase with time.

Postulate Id - Technologists Can Be Used in Manufacturing or Production

The respondent was asked to rank his or her level of agreement or disagreement with the above statement. The results of the survey are shown in Figure 10.

The distribution has a mean value of 5.83, from a count, n, of 147, with a 95% degree of confidence that the true mean lies between 5.62 and 6.04. Summaries of these data are contained in Table X.

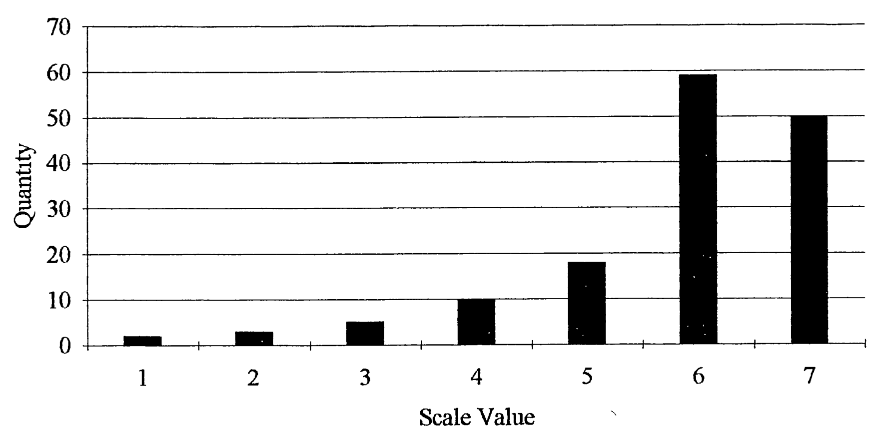

Figure 10. Distribution of Response Values Section I Postulate d - Technologists Can Be Used in Manufacturing or Production.

TABLE X

STATISTICS RELATING TO SECTION I POSTULATE d;
TECHNOLOGISTS CAN BE USED IN
MANUFACTURING OR
PRODUCTION

Sample Size	True Mean: Lower Limit	Sample Mean	True Mean: Upper Limit
147	5.62	5.83	6.04

With regard to the use of technologists in the manufacturing or production job function, the consensus of engineering supervisors and managers is very positive, with 86.4% of the respondents assigning a value of five or greater. With the acceptance envelope at four or greater, then the level of acceptance rises to 93.2%. This result varies from the reported actual utilization. Only 66% of the responding supervisors reported that their company or facility utilized technologists in this job function. The result also indicates that, in the opinion of supervisors, manufacturing or production is an appropriate function for technologists. It further indicates that the present industrial practice underutilizes technologists in this job function. As with the above three job functions, it is expected that the percentage of companies or facilities utilizing technologists in manufacturing or production functions will increase over time.

Postulate Ie - Technologists Can Be Used in Marketing or Sales

The respondent was asked to rank his or her level of agreement or disagreement with the above statement. The results of the survey for the postulate are shown in Figure 11.

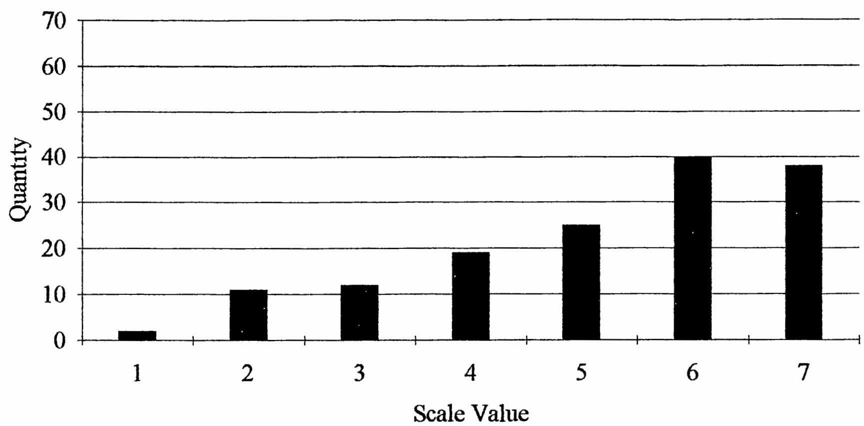

Figure 11. Distribution of Response Values Section I Postulate e - Technologists Can Be Used in Marketing or Sales.

The distribution has a mean value of 5.22, from a count, n, of 147, with a 95% degree of confidence that the true mean lies between 4.96 and 5.48. Summaries of these data are contained in Table XI.

TABLE XI

STATISTICS RELATING TO SECTION I POSTULATE e; TECHNOLOGISTS CAN BE USED IN MARKETING OR SALES

Sample Size	True Mean: Lower Limit	Sample Mean	True Mean: Upper Limit
147	4.96	5.22	5.48

With regard to the use of technologists in the marketing or sales job function, the consensus of engineering supervisors and managers is positive, with 70.1% of the respondents assigning a value of five or greater. When the acceptance level is extended to four or greater, then the level of acceptance rises to 83%. This result varies from the reported actual utilization. Only 51% of the responding supervisors reported that their company or facility utilized technologists in this job function. The result also indicates that, in the opinion of supervisors, marketing or sales is an appropriate function for technologists. This condition reflects that current industrial practice underutilizes technologists in this job function. As with the previous job functions, it should be expected that the percentage of companies or facilities utilizing technologists in marketing or sales functions will increase with time.

Postulate If - Technologists Can Be Used in Customer Service or Support

The respondent was asked to rank his or her level of agreement or disagreement with the above statement. The results of the survey are shown in Figure 12.

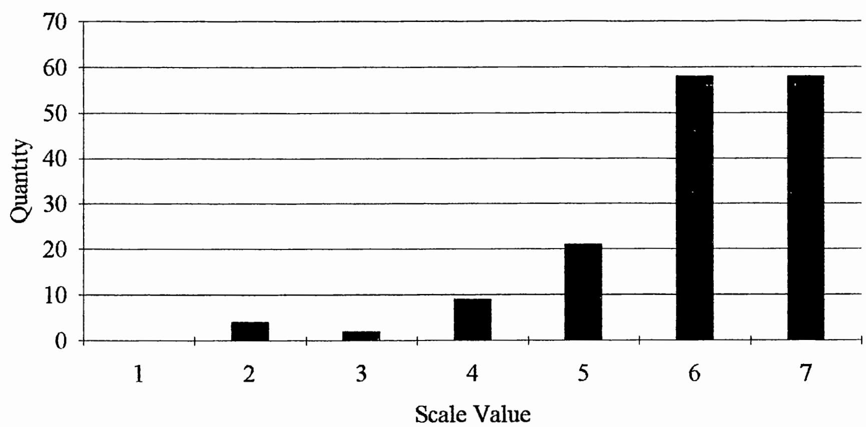

Figure 12. Distribution of Response Values Section I Postulate f - Technologists Can Be Used in Customer Service or Support.

The distribution has a mean value of 5.98, from a count, n, of 152, with a 95% degree of confidence that the true mean lies between 5.80 and 6.16. Summaries of these data are contained in Table XII.

TABLE XII

STATISTICS RELATING TO SECTION I POSTULATE f; TECHNOLOGISTS CAN BE USED IN CUSTOMER SERVICE OR SUPPORT

Sample Size	True Mean: Lower Limit	Sample Mean	True Mean: Upper Limit
152	5.80	5.98	6.16

With regard to the use of technologists in the customer service or support job function, the consensus of engineering supervisors and managers is extremely favorable, with 93.2% of the respondents assigning a value of five or greater. Extending that acceptance level to four or greater, the acceptance level rises to 96.1%. This result varies from the reported actual utilization. Only 78% of the responding supervisors reported that their company or facility utilized technologists in this job function. The result also indicates that, in the opinion of supervisors, customer service or support is an appropriate function for technologists, further indicating that the current industrial practice underutilizes technologists in this job function. As with the previous job functions, it should be expected that the percentage of companies or facilities utilizing technologists in customer service or support functions will increase in time.

<u>Postulate Ig - Technologists Can Be Used in Supervision or Management</u>

The respondent was asked to rank his or her level of agreement or disagreement with the above statement. The results of the survey for the postulate are shown in Figure 13.

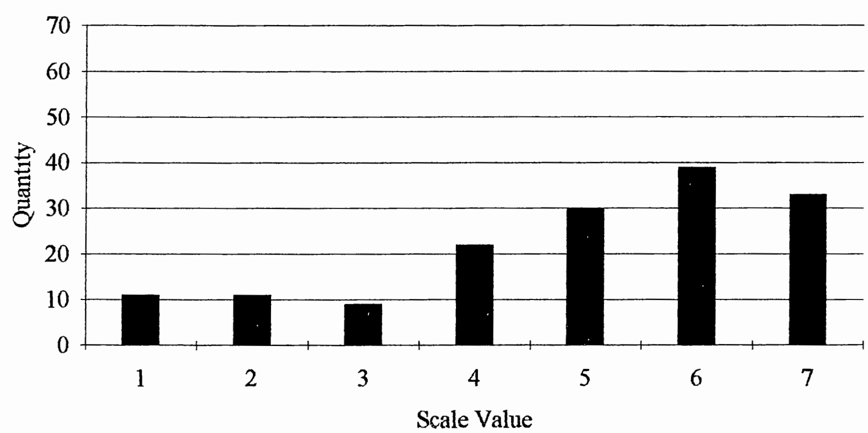

Figure 13. Distribution of Response Values Section I Postulate g - Technologists Can Be Used in Supervision or Management.

The distribution has a mean value of 4.92, from a count, n, of 155, with a 95% degree of confidence that the true mean lies between 4.64 and 5.21. Summaries of these data are contained in Table XIII.

TABLE XIII

STATISTICS RELATING TO SECTION I POSTULATE g; TECHNOLOGISTS CAN BE USED IN SUPERVISION OR MANAGEMENT

Sample Size	True Mean: Lower Limit	Sample Mean	True Mean: Upper Limit
155	4.64	4.92	5.21

With regard to the use of technologists in the supervision or management job function, the consensus of engineering supervisors and managers is positive, with 65.8% of the respondents assigning a value of five or greater. However, extending the acceptance range to four or greater, raises the level of acceptance to 80.0%. This result varies from the reported utilization. Just 50% of the responding supervisors reported that their company or facility utilized technologists in this job function. However, this result does indicate, that in the opinion of supervisors, supervision or management is an appropriate function for technologists. It further implies that current industrial practice underutilizes technologists in this job function. As with the previous job functions, it should be expected that the percentage of companies or facilities utilizing technologists in supervision or management functions will increase with time.

Postulate Ih - Technologists Can Be Used in Field Service

The respondent was asked to rank his or her level of agreement or disagreement with the above statement. The results of the survey for the postulate are shown in Figure 14.

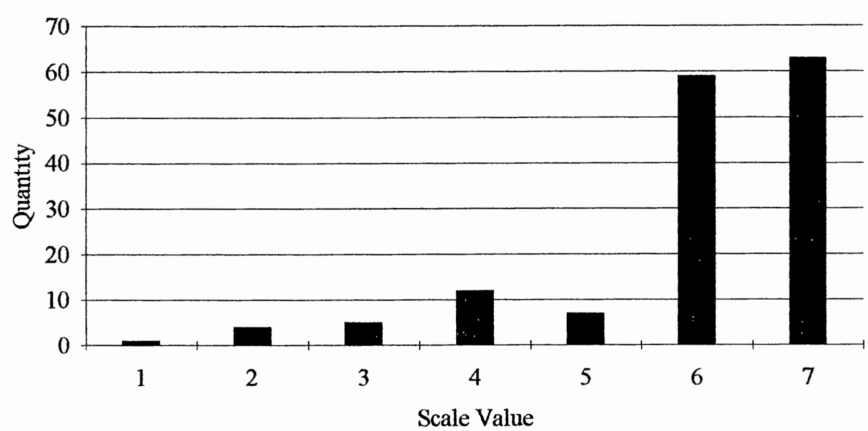

Figure 14. Distribution of Response Values Section I Postulate h - Technologists Can Be Used in Field Service.

The distribution has a mean value of 5.97, from a count, n, of 151, with a 95% degree of confidence that the true mean lies between 5.77 and 6.18. Summaries of these data are contained in Table XIV.

TABLE XIV

STATISTICS RELATING TO SECTION I POSTULATE h; TECHNOLOGISTS CAN BE USED IN FIELD SERVICE

Sample Size	True Mean: Lower Limit	Sample Mean	True Mean: Upper Limit
151	5.77	5.97	6.18

With regard to the use of technologists in the field service job function, the consensus of engineering supervisors and managers is very positive, with 85.4% of the respondents assigning a value of five or greater. As with the other job functions, extending the acceptance criteria to a score of four or greater raises the acceptance to 93.4% of responding supervisors. This result, unlike the previous results, is comparable with the reported actual utilization, for 84% of the responding supervisors reported that their company or facility utilized technologists in this job function. These factors strongly indicate that both in the opinion of supervisors, and as presently utilized by industry, field service is an appropriate function for technologists.

For Section I, Postulates a through h, a pictorial representation of the acceptance percentages by supervisors for each job function, at both the four or greater, and five or greater values is shown in Figure 15.

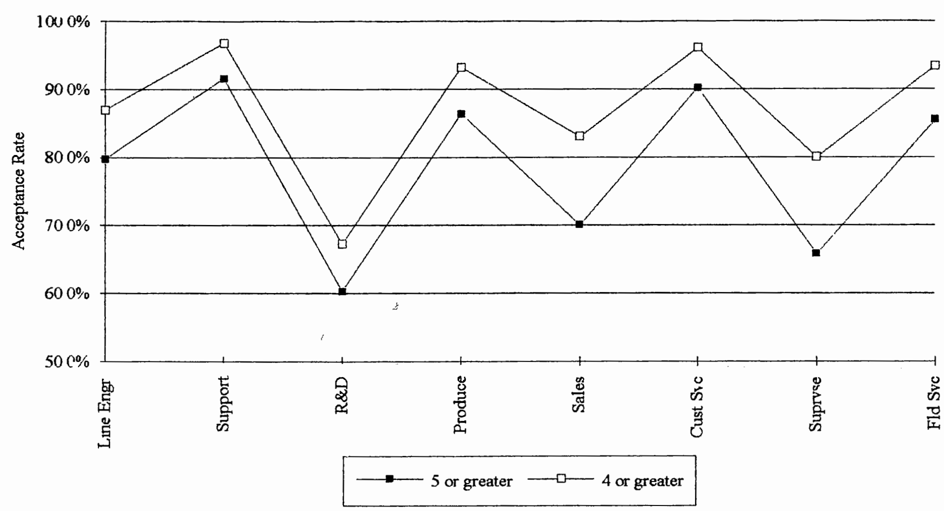

Figure 15. Acceptance Percentage as a Function of Response Value

The mean and the 95% confidence interval for each of the Postulates of Section I are shown in Figure 16.

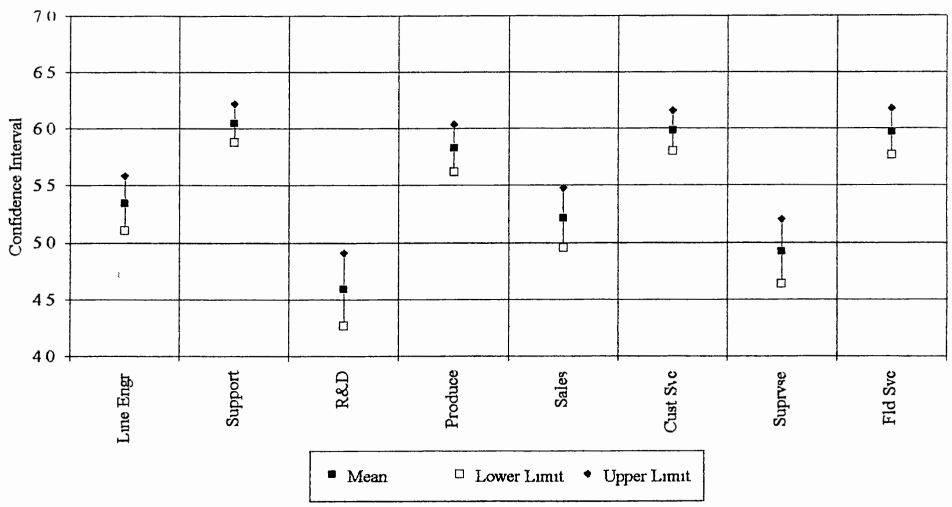

Figure 16. Confidence Interval on the Mean of the Responses in Section I.

Section II of the Instrument - Attributes of the Technologist

Section II of the instrument presented the respondent with nine opportunities to register his or her views and impressions regarding the attributes of technologists. The first six of these address the supervisor's subjective evaluation of the technologist's cognitive competencies. In each of these six assessment opportunities, the respondent was asked to compare the technologist with the electrical engineer with regard to an identified competency. The cognitive competencies chosen for this survey were those identified and classified by Bloom (1956).

The remaining three evaluation opportunities in Section II relate to growth opportunity, orientation and the intended utilization of the technologist. For convenience, the nine statements are reproduced below.

a. Technologists possess adequate knowledge of engineering and mathematical principles (compared to that attribute in engineers).

b. Technologists possess adequate comprehension of engineering and mathematical knowledge (compared to that attribute in engineers).

c. Technologists possess adequate ability to apply engineering principles in crafting a design, process, or service (compared to that attribute in engineers).

d. Technologists possess adequate ability to analyze a design, process, or service using quantitative methods, for functionality and suitability (compared to that attribute in engineers).

e. Technologists possess adequate ability to synthesize a design, process, or service by integrating techniques, methods, or procedures (compared to that attribute in engineers).

f. Technologists possess adequate ability to develop the criteria by which to technically evaluate, or judge, the merit of a design, process, or service (compared to that attribute in engineers).

g. Technologists are limited in growth opportunities.

h. Technologists are oriented more towards applications than engineers.

i. Technologists are primarily hired to perform engineering functions.

As with Section I, the respondent was offered a seven-segment scale, again arranged from strong agreement to strong disagreement. As before, values from one to seven were assigned to each response position, with seven assigned to the response most favorable for the technologist. For all evaluations, a numeric value of seven is assigned to the extreme left, strongly agree, and a value of one is assigned to the extreme right, strongly disagree. Statement IIg, "Technologists are limited in growth opportunites" differs only in that a response which agrees with the statement is not favorable for the technologist. While a score of seven

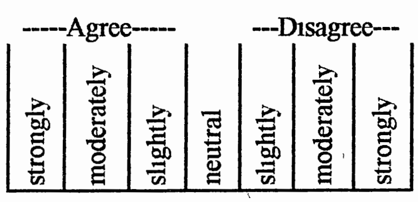

Figure 17. Rating Scale Used In the Survey Instrument

is still assigned to strongly agree, that response is the least favorable for the technologist. That covention was chosen for clarity; scores higher than four agree with the statement, and scores below four disagree with statement. A facsimile of the scale is reproduced in Figure 17.

Statement IIa - Technologists Possess Adequate Knowledge of Engineering and Mathematical Principles (Compared to That Attribute in Engineers)

The respondent was asked to indicate a degree of agreement or disagreement with the statement that, when compared with engineers, technologists possess adequate knowledge of engineering and mathematical principles. Figure 18 shows the distribution of responses to that statement.

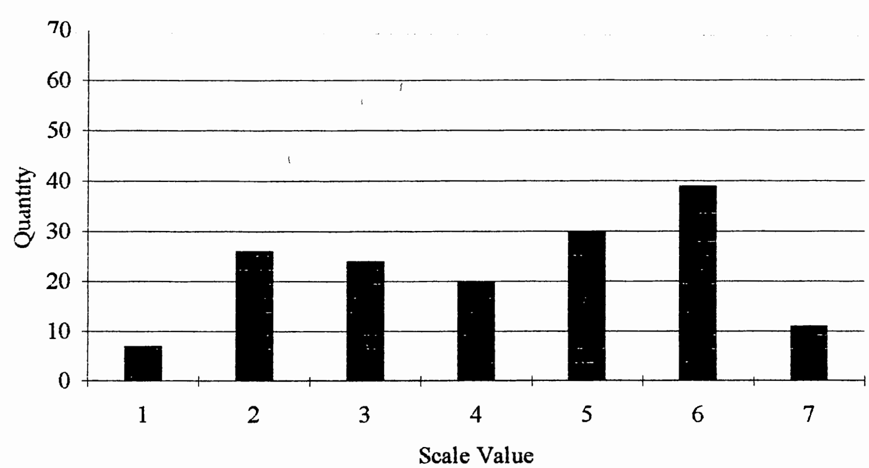

Figure 18. Distribution of Response Values Section II Statement a - Technologists Possess Adequate Knowledge.

The distribution has a mean value of 4.28, from a count, n, of 157, with a 95% degree of confidence that the true mean lies between 4.01 and 4.55. Summaries of these data are contained in Table XV.

TABLE XV

STATISTICS RELATING TO SECTION II STATEMENT a; TECHNOLOGISTS POSSESS ADEQUATE KNOWLEDGE

Sample Size	True Mean: Lower Limit	Sample Mean	True Mean: Upper Limit
157	4.01	4.28	4.55

With regard to the cognitive competency of possessing adequate knowledge of principles, 50.1% of the respondents scored technologists as five or higher. If the adequacy threshold is extended to four or greater, then 63.7% of respondents considered technologists as possessing adequate knowledge.

For statements IIa through IIf, a score of seven correlates to strong agreement with the statement. From that aspect, a score of seven can be viewed as being as adequate as engineers. That view is justified by examining the parenthetical portion of the statement. For example, statement IIa says, "Technologists possess adequate knowledge of engineering and mathematical principles (compared to that attribute in engineers)". A response of strongly agree is logically consistent with the view that technologists are as adequate as engineers. Conversely, using that scheme a score of one, strongly disagree, is interpreted as being completely inadequate when comparded with engineers. On this value scale, any score below four is below minimum adequacy because four is value neutral. A score below four cannot be viewed as adequate. On the other hand, scores of five or higher indicated that the respondent felt technologists possessed a distinctly positive degree of adequacy, when comparded with that of engineers. As with Section I, a score of four reflects ambivalence, but because it is not a rejection, value neutral is interpreted as the floor value for adequacy. Therefore, for this particular competency, the respondents viewed the technologists as marginally adequate, which is inferred from the mean score of 4.28.

It is important to frame the relative degree of adequacy with reference to engineers, because as noted in Chapter I, a prime motive for the establishment of a technology curriculum was to preserve the practice, or art of engineering (Kenyon, 1985). In addition, from those earlier chapters, it has been established that the technologists is viewed by the educational community as an engineering team member, capable of applying engineering principles, practices and procedures to the solution of problems (IEEE, undated, p. 7). Although he or she is not an engineer by definition, the IEEE views the technologist as having an education which prepares him or her to perform at a high technical level.

Statement IIb - Technologists Possess Adequate Comprehension of Engineering and Mathematical Knowledge (Compared to That Attribute in Engineers)

The respondent was asked to indicate his or her degree of agreement or disagreement with the statement that, when compared with engineers, technologists possess adequate comprehension of engineering and mathematical principles. Figure 19 shows the distribution of responses to that statement.

The distribution has a mean value of 4.34, from a count, n, of 157, with a 95% degree of confidence that the true mean lies between 4.08 and 4.61. Summaries of these data are contained in Table XVI.

With regard to the cognitive competency of possessing adequate comprehension of principles, 56% of the respondents scored technologists as five or higher. When the competency envelope included a score of four, then 67.5% rated technologists as adequate.

The responses to the statement that technologists possess adequate comprehension are essentially

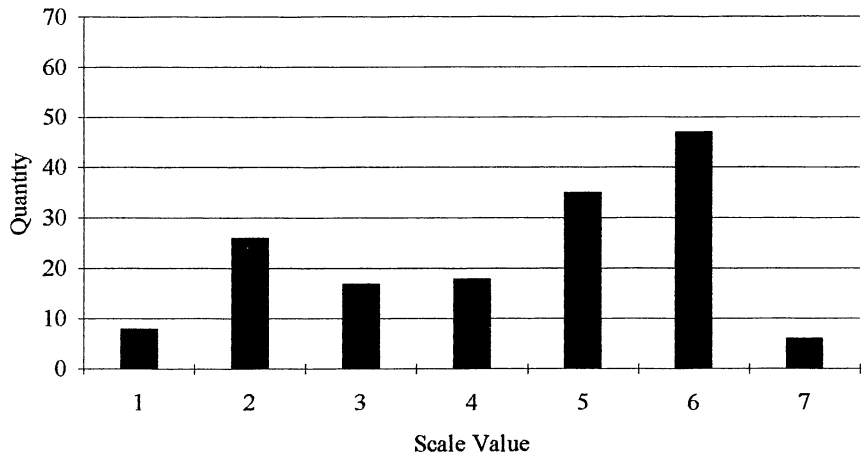

Figure 19. Distribution of Response Values Section II Statement b - Technologists Possess Adequate Comprehension.

TABLE XVI

STATISTICS RELATING TO SECTION II VIEW b; TECHNOLOGISTS POSSESS ADEQUATE COMPREHENSION

Sample Size	True Mean: Lower Limit	Sample Mean	True Mean: Upper Limit
157	4.08	4.34	4.61

indistinguishable from the responses to the previous statement dealing with knowledge. In both cases the responding supervisors rated technologists as marginally adequate. A significant proportion of the responding supervisors rated technologists as below marginally adequate with respect to engineers.

Statement IIc - Technologists Possess Adequate Ability to Apply Engineering Principles in Crafting a Design, Process, or Service (Compared to That Attribute in Engineers)

The respondent was asked to indicate his or her degree of agreement or disagreement with the statement that, when compared with engineers, technologists possess adequate ability to apply engineering principles. Figure 20 shows the distribution of responses to that statement.

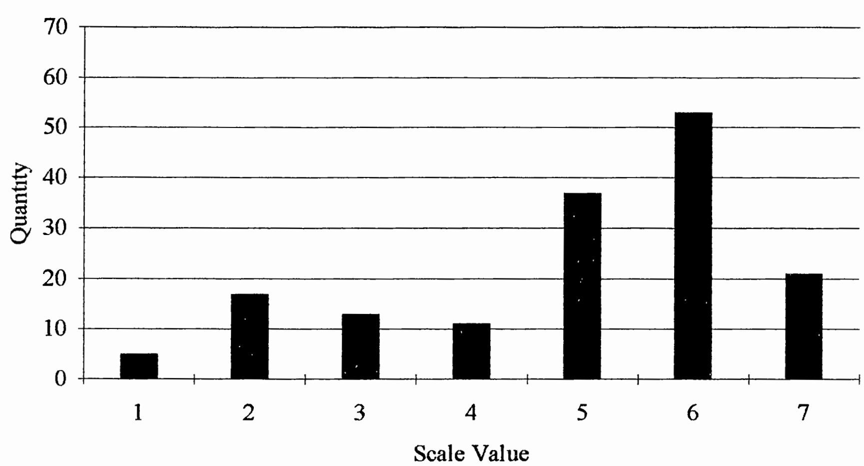

Figure 20. Distribution of Response Values Section II Statement c - Technologists Possess Adequate Ability to Apply Engineering Principles.

The distribution has a mean value of 4.92, from a count, n, of 157, with a 95% degree of confidence that the true mean lies between 4.66 and 5.18. Summaries of these data are contained in Table XVII.

TABLE XVII

STATISTICS RELATING TO SECTION II VIEW c; TECHNOLOGISTS POSSESS ADEQUATE ABILITY TO APPLY ENGINEERING PRINCIPLES

Sample Size	True Mean: Lower Limit	Sample Mean	True Mean: Upper Limit
157	4.66	4.92	5.19

With regard to the cognitive competency of possessing adequate ability to apply principles, 71% of the respondents scored technologists as five or higher. Including the minimal level of four, 77.7% respondents rated technologists as adequate.

The statement that technologists possess adequate ability was essentially viewed by the responding supervisors and managers as positive. This level of adequacy varies slightly from the aggregate responses to the previous two statements dealing with knowledge and comprehension. In this case the responding supervisors rated technologists as higher than minimally adequate.

Statement IId - Technologists Possess Adequate Ability to Analyze a Design, Product, Process, or Service, Using Quantitative Methods, for Functionality and Suitability (Compared to That Attribute in Engineers)

The respondent was asked to indicate his or her degree of agreement or disagreement with the statement that, when compared with engineers, technologists possess adequate ability to analyze for functionality and suitability, by the use of quantitative methods. Figure 21 shows the distribution of responses to that statement.

The distribution has a mean value of 4.36, from a count, n, of 157, with a 95% degree of confidence that the true mean lies between 4.10 and 4.63. Summaries of these data are contained in Table XVIII.

With regard to the cognitive competency of possessing adequate ability to quantitatively analyze, 55% of the respondents scored technologists as five or higher. However, when considered from a score or four or greater, 66.9% of responding supervisors rated technologists as adequate.

The statement that technologists possess adequate ability to quantitatively analyze a product, process or

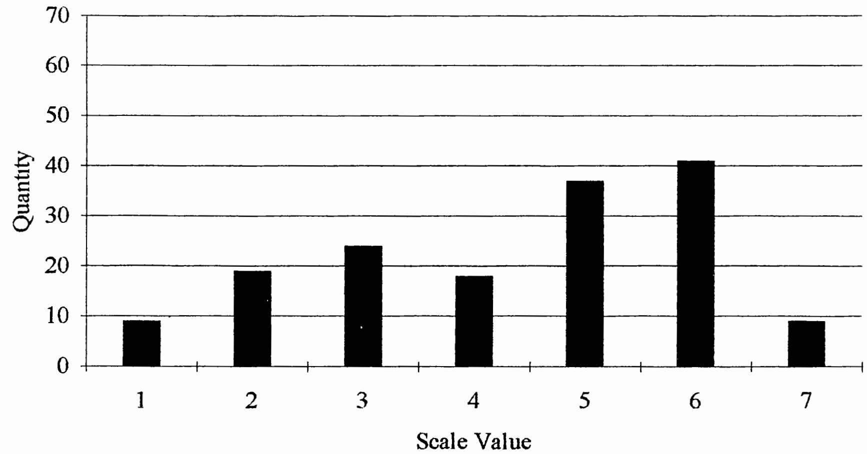

Figure 21. Distribution of Response Values Section II Statement d - Technologists Possess Adequate Ability to Quantitatively Analyze.

TABLE XVIII

STATISTICS RELATING TO SECTION II VIEW d; TECHNOLOGISTS POSSESS ADEQUATE ABILITY TO ANALYZE

Sample Size	True Mean: Lower Limit	Sample Mean	True Mean: Upper Limit
157	4.10	4.36	4.63

service was essentially viewed by the responding supervisors and managers with minimal acceptance. In this case the responding supervisors rated technologists as marginally adequate. Also, as in the responses relating to knowledge and comprehension, there is a significant proportion of the responding supervisors who rated technologists as below minimally adequate with respect to engineers.

Statement IIe - Technologists Possess Adequate Ability to Synthesize a Design, Product, Process, or Service, by Interpreting Techniques, Methods, or Procedures (Compared to That Attribute in Engineers)

The respondent was asked to indicate his or her degree of agreement or disagreement with the statement that, when compared with engineers, technologists possess adequate ability to synthesize result. Figure 22 shows the distribution of responses to that statement.

The distribution has a mean value of 4.22, from a count, n, of 156, with a 95% degree of confidence that the true mean lies between 3.93 and 4.51. Summaries of these data are contained in Table XIX.

With regard to the cognitive competency of possessing adequate ability to synthesize a result, 51.9% of the respondents scored technologists as five or higher. Assuming a level of minimal adequacy, which includes a score of four, 62.8% of the respondents rated technologists as adequate.

The statement that technologists possess adequate ability to synthesize a result, was essentially viewed by

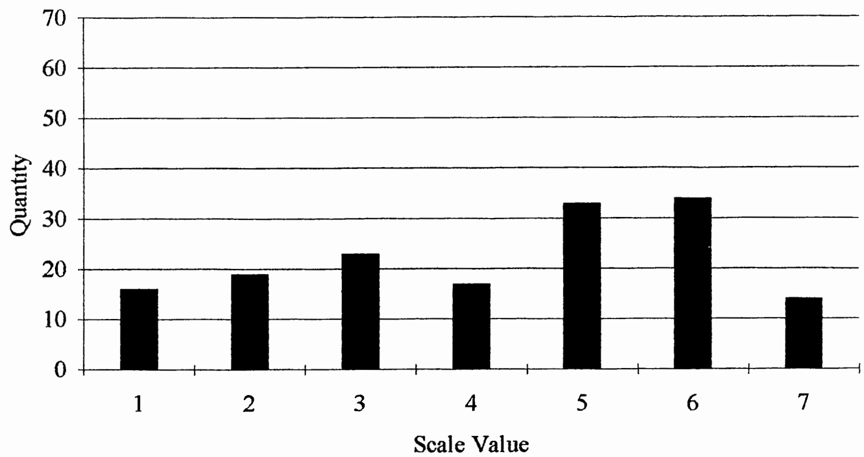

Figure 22. Distribution of Response Values Section II Statement e - Technologists Possess Adequate Ability to Synthesize.

TABLE XIX

STATISTICS RELATING TO SECTION II VIEW e; TECHNOLOGISTS POSSESS ADEQUATE ABILITY TO SYNTHESIZE

Sample Size	True Mean: Lower Limit	Sample Mean	True Mean: Upper Limit
156	3.93	4.22	4.51

the responding supervisors and managers with minimal acceptance. In this case the responding supervisors rated technologists as marginally adequate. This assessment is levied because there is a significant proportion of the responding supervisors who rated technologists at below minimally adequate with respect to engineers.

Statement IIf - Technologists Possess Adequate Ability to Develop the Criteria by Which to Technically Evaluate, or Judge, the Merit of a Design, Product, Process, or Service (Compared to That Attribute in Engineers)

The respondent was asked to indicate his or her degree of agreement or disagreement with the statement that, when compared with engineers, technologists possess adequate ability to evaluate the technical merits of results. Figure 23 shows the distribution of responses to that statement.

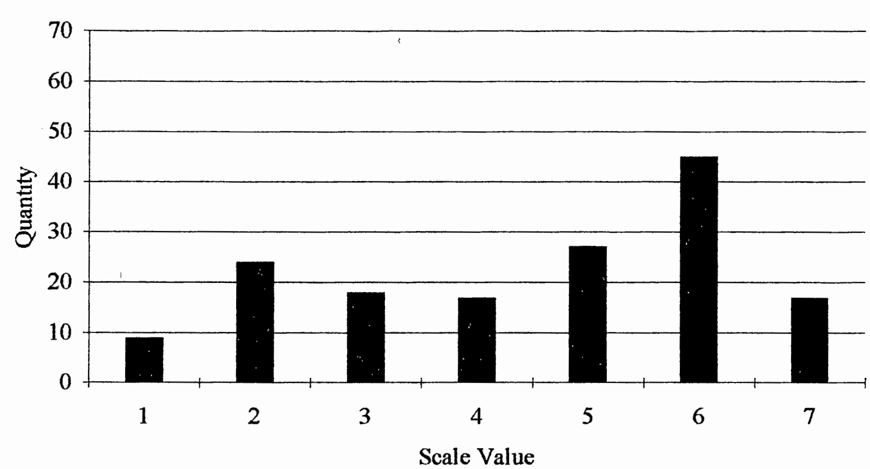

Figure 23. Distribution of Response Values Section II Statement f - Technologists Possess Adequate Ability to Evaluate.

The distribution has a mean value of 4.48, from a count, n, of 157, with a 95% degree of confidence that the true mean lies between 4.19 and 4.76. Summaries of these data are contained in Table XX.

TABLE XX

STATISTICS RELATING TO SECTION II VIEW f; TECHNOLOGISTS POSSESS ADEQUATE ABILITY TO EVALUATE

Sample Size	True Mean: Lower Limit	Sample Mean	True Mean: Upper Limit
157	4.19	4.48	4.76

With regard to the cognitive competency of possessing adequate ability to technically evaluate a result, 56.7% of the respondents scored technologists as five or higher. When considering rates at minimal adequacy and above, 67.5% of the respondents rated technologists as adequate.

The statement that technologists possess adequate ability to evaluate a result was essentially viewed by the responding supervisors and managers with marginal acceptance. In this case the responding supervisors rated technologists as slightly higher than minimally adequate. Still a significant proportion of the responding supervisors who rated technologists as below minimally adequate with respect to engineers.

Statement IIg - Technologists Are Limited in Growth Opportunities

The respondent was asked to indicate his or her degree of agreement or disagreement with the statement that technologists are limited in growth opportunities. Figure 24 shows the distribution of responses to that statement.

The distribution has a mean value of 4.61, from a count, n, of 157, with a 95% degree of confidence that the true mean lies between 4.31 and 4.91. Summaries of these data are contained in Table XXI.

For this statement, the most favorable response for technologists was the extreme right, or strongly disagree. Nevertheless, in order to remain consistent with the scoring convention, and to minimize confusion when interpreting the results, a score of seven was retained at the extreme left; strongly agree. Because a score of four represents ambivalence and not clear disagreement with the statement, it can be interpreted as the baseline.

With regard to the statement that technologists are limited with respect to growth, 59.9% of the respondents scored technologists as five or higher. At scores of four or higher, 71.3% of the respondents indicated that technologists are limited.

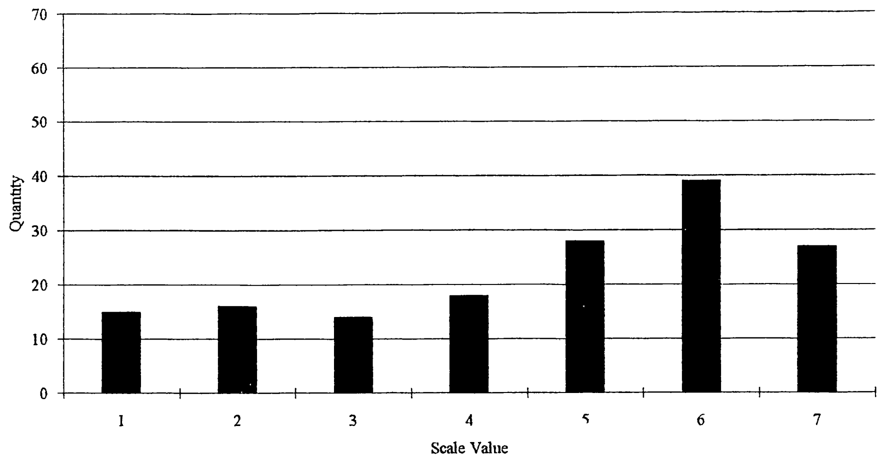

Figure 24. Distribution of Response Values Section II Statement g - Technologists Are Limited in Growth Opportunities.

TABLE XXI

STATISTICS RELATING TO SECTION II VIEW g; TECHNOLOGISTS ARE LIMITED IN GROWTH OPPORTUNITIES

Sample Size	True Mean: Lower Limit	Sample Mean	True Mean: Upper Limit
157	4.31	4.61	4.91

The statement that technologists are limited in growth was viewed by the responding supervisors and managers with acceptance. A clear majority of the responding supervisors rated technologists above a score of four, meaning they concurred with the statement.

Statement IIh - Technologists Are Oriented More Towards Applications Than Engineers

The respondent was asked to indicate his or her degree of agreement or disagreement with the statement that technologists are more applications oriented than engineers. Figure 25 shows the distribution of responses to that statement.

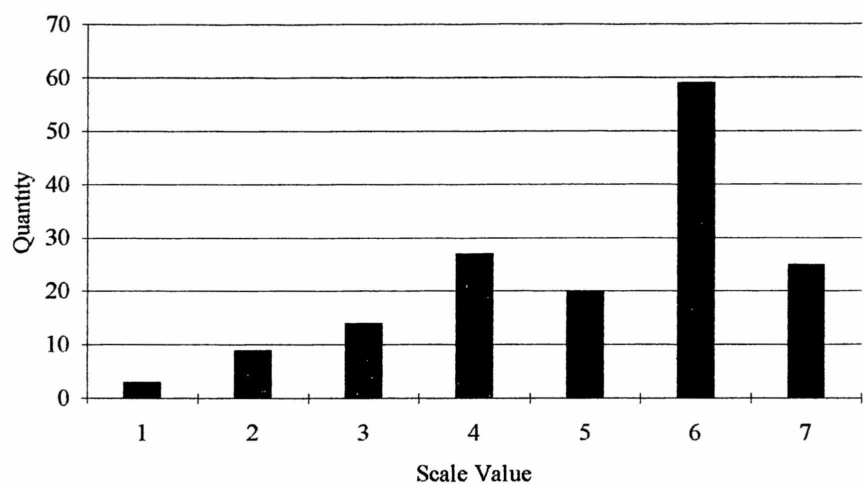

Figure 25. Distribution of Response Values Section II Statement h - Technologists Are More Applications Oriented than Engineers.

The distribution has a mean value of 5.10, from a count, n, of 157, with a 95% degree of confidence that the true mean lies between 4.85 and 5.34. Summaries of these data are contained in Table XXII.

TABLE XXII

STATISTICS RELATING TO SECTION II VIEW h;
TECHNOLOGISTS ARE MORE APPLICATIONS
ORIENTED THAN ENGINEERS

Sample Size	True Mean: Lower Limit	Sample Mean	True Mean: Upper Limit
157	4.85	5.10	5.34

For this and the following statement, the most favorable response for technologists was the extreme left. A value of seven is assigned to strongly agree, and a value of one is assigned to strongly disagree. As before, a score of four represents ambivalence, and it is not interpreted to imply disagreement with this statement. Consequently, a score of four assumes the position as the baseline of favorable reaction.

With regard to the statement that technologists are more oriented towards applications than engineers, 66.2% of the respondents scored technologists as five or higher. At scores of four or higher, 83.4% of the respondents indicated that technologists possessed that quality.

The statement that technologists are application oriented was essentially viewed by the responding supervisors and managers with a high degree of acceptance. In this case the responding supervisors rated technologists high enough to be considered more application oriented than engineers.

Statement III - Technologists Are Primarily Hired to Perform Engineering Functions

The respondent was asked to indicate his or her degree of agreement or disagreement with the statement that technologists are primarily hired to perform engineering functions. Figure 26 shows the distribution of responses to that statement.

The distribution has a mean value of 4.48, from a count, n, of 157, with a 95% degree of confidence that the true mean lies between 4.23 and 4.72. Summaries of these data are contained in Table XXIII.

With regard to the statement that technologists were primarily hired to perform engineering functions, 54.1% of the respondents scored technologists as five or higher. At scores of four or higher, 73.9% of the respondents indicated that technologists were hired to perform engineering functions.

The statement that technologists are hired to perform engineering functions was essentially viewed by the responding supervisors and managers with acceptance. In this case the responding supervisors rated technologists high enough to be considered as performing engineering function.

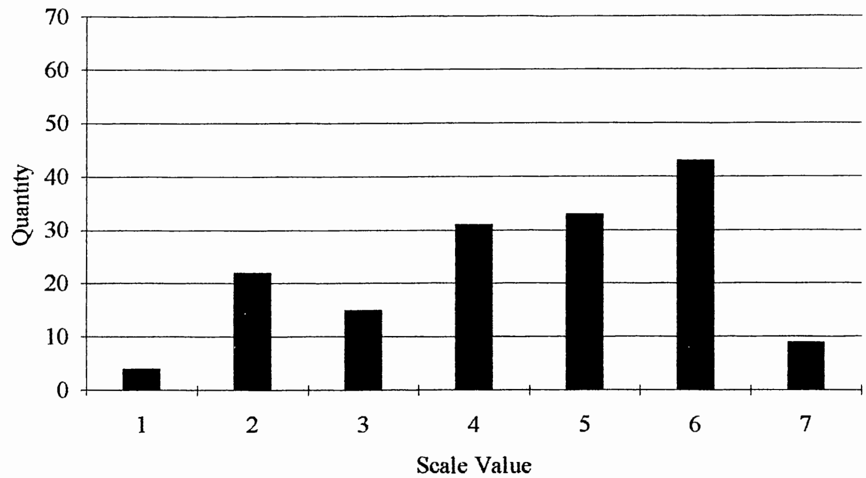

Figure 26. Distribution of Response Values Section II Statement 1 - Technologists Are Primarily Hired to Perform Engineering Functions.

TABLE XXIII

STATISTICS RELATING TO SECTION II VIEW 1; TECHNOLOGISTS ARE PRIMARILY HIRED TO PERFORM ENGINEERING FUNCTIONS

Sample Size	True Mean: Lower Limit	Sample Mean	True Mean: Upper Limit
157	4.23	4.48	4.72

Figure 27 summarizes the percentages of respondents who awarded a score of five or greater, and the percentage of those who awarded a score of four or greater for each of the nine statements in Section II.

Figure 28 collects and summarizes the mean value of the responses to each of the statements in Section II, as well as the 95% confidence interval.

A salient feature apparent from a review of Figures 27 and 28 is that supervisors rated technologists higher in the competency of application than in the two preceding competencies of knowledge and comprehension. This is in congruence with the central purpose of technology education as stated in the Final Report (Grinter & Defore, 1972, p. 14).

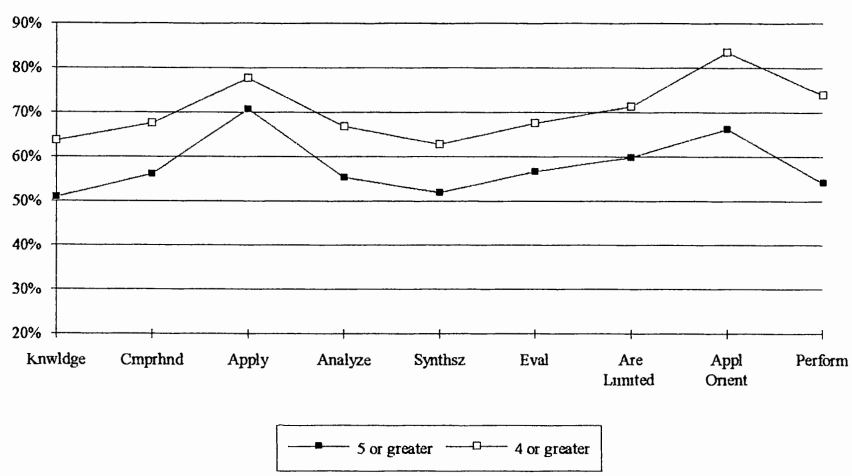

Figure 27. Percentages of Responses at Both Four or Greater, and Five or Greater.

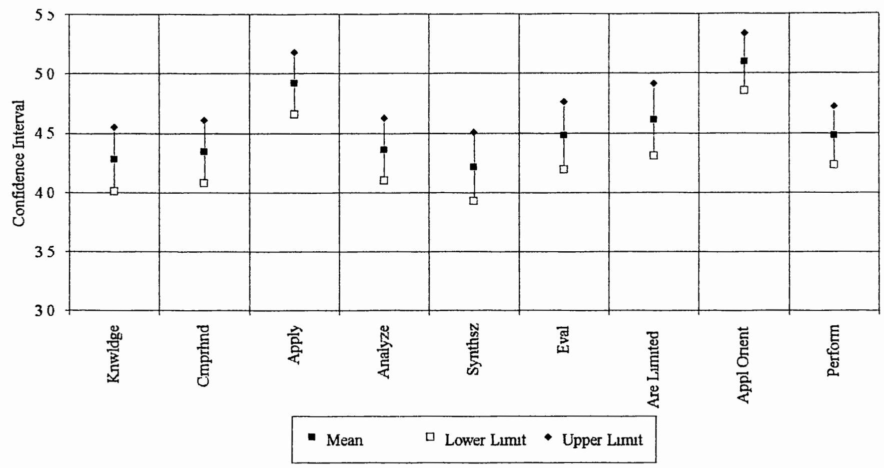

Figure 28. Confidence Intervals on the Means of the Responses in Section II

Other Data

Section III, the last section of the instrument, gathered information about the respondent. It also requested the respondent to give a personal opinion regarding the differences between a technologist and an engineer. A synopsis of those remarks is included in appendix E.

Questions a., b., c. and d. of Section III addressed the background of the respondent. For convenience those questions are reproduced below:

a. Check if your have as degree in technology ___ engineering ___

b. If you possess a degree in a field other than technology or engineering, please indicate:______________________

c. If you possess no degree, please indicate your field of expertise:________________________

d. Check if you directly supervise technologists and/or engineers:______

Of the 157 total respondents, 125 indicated that they supervised engineers and technologists directly. The remaining respondents either did not indicate, or they indicated that they were one or more working levels removed from such personnel. Nevertheless, 80% of the respondents indicated that they were in a direct supervisory role.

With regard to the background of the respondents, 94 indicated they possessed a degree in engineering, four answered that they possessed a degree in technology. The remainder of those who responded to this segment possessed degrees from other disciplines: mathematics, computer science, physics, chemistry and business. However, engineering was the largest single discipline represented among the responding supervisors.

The average number of personnel reporting to those respondents who directly supervised was 14 engineers and four technologists. For those who indicated that they did not directly supervise technologists or engineers, ten indicated they were one working level removed. Eight indicated they were two working levels removed, and two indicated three working levels removed.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The Instrument

In order to determine whether industrial supervisors differentiate between technologists and engineers, an instrument was designed, reviewed by faculty and field tested. The instrument contained four segments. The first segment gathered information concerning (a) the geographic location of the respondent, (b) the type of industry the respondent was associated with, (c) an estimate of the relative populations of technologists and engineers at the respondent's facility and, (d) the types of job functions assigned to technologists and engineers at that facility.

The second part of the instrument asked for the opinions of industrial supervisors about the capabilities of technologists. Specifically, this segment contained eight postulates, each beginning "Technologists can be used in":

1. Line Engineering
2. Support Engineering
3. Research and Development
4. Manufacturing and Production

5. Marketing and Sales

6. Customer Service and Support

7. Supervision and Management

8. Field Service

A definition of each of the above terms was included with the survey and is contained in appendix C.

The third segment of the instrument was designed to gather supervisor's assessments of technologist's cognitive competencies comparded with engineers. The competencies addressed were those defined by Bloom (1976): (a) knowledge, (b) comprehension, (c) application, (d) analysis, (e) synthesis and (f) evaluation. This segment also asked for the respondent's opinion concerning growth opportunity for technologists, the job orientation of technologists and the reason for hiring technologists. Both the second and third segments of the survey required the respondent to render a judgment that was scored on a seven-division Likert scale.

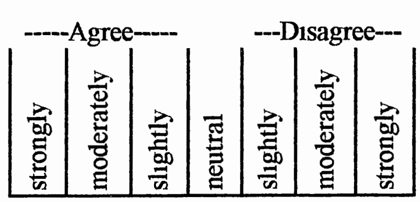

Figure 29. Rating Scale Used in the Instrument

The last segment of the instrument collected personal information about the respondent. It asked for (a) the type of degree the respondent held, (b) the respondent's field of expertise, (c) the number of technologists and engineers supervised and (d) comments about the differences between technologists and engineers.

The Procedure

The survey was conducted by randomly selecting the names and addresses of 1500 persons from an IEEE data base. These persons had identified themselves as engineering or scientific supervisors who were currently employed as such. The selection was made without regard to geographic location.

Each of the 1500 supervisors was mailed a survey. From the original mailing, 85 usable surveys were harvested. First follow-up was a post card sent to each addressee ten days after the initial mailing. Approximately thirty days later, follow-up by telephone began. Seventy-two additional surveys were gathered, yielding an aggregate total of 157 usable responses. Collection efforts were then terminated due to schedule and budgetary limitations.

The Responses

The responses revealed that 125, or 80% of the supervisors, directly supervised engineers and technologists. The remaining 20% either did not indicate, or they indicated that they were one or more "working levels" removed from such personnel. Ninety-four of the 157 respondents indicated they possessed a degree in engineering, four others answered that they possessed a degree in technology. The remainder possessed degrees from other disciplines: mathematics, computer science, physics, chemistry and business. The average number of personnel reporting to those who "directly supervised" was 14 engineers and four technologists.

Responses were completed from 29 states and from the District of Columbia. A complete listing of those states is contained in appendix A. Fifty-six different types of industries were represented by the respondents, ranging from electric utility companies to companies involved with spacecraft. A roster of the represented industries is contained in appendix B. Fifty-one percent of those industries employed greater than 100 technologists and greater than 100 engineers. Many respondents also included personal comments and opinions. Those are included in appendix E.

Respondents reported that the companies or facilities they were associated with utilized technologists and engineers at differing rates. Figure 30 graphs the current percentage of companies utilizing technologists and engineers per function.

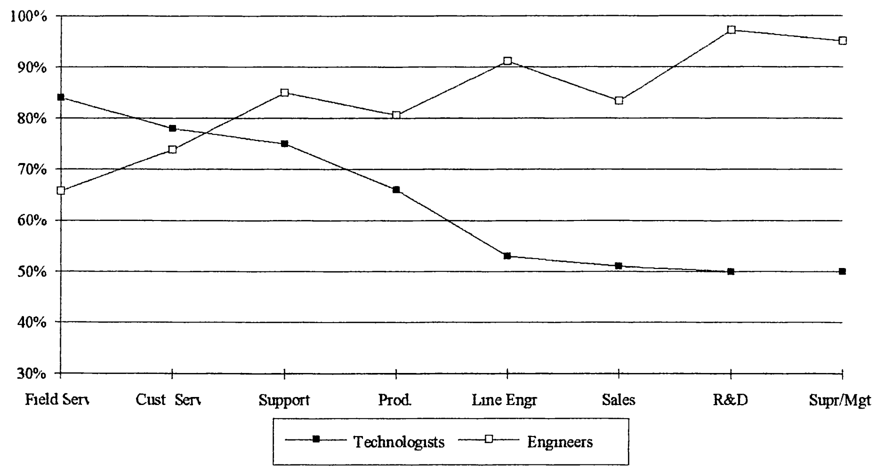

Figure 30. Technologists and Engineers by Assigned Job Function

Respondent's assessments of which job functions technologists can be used in, is shown in Figure 31. The

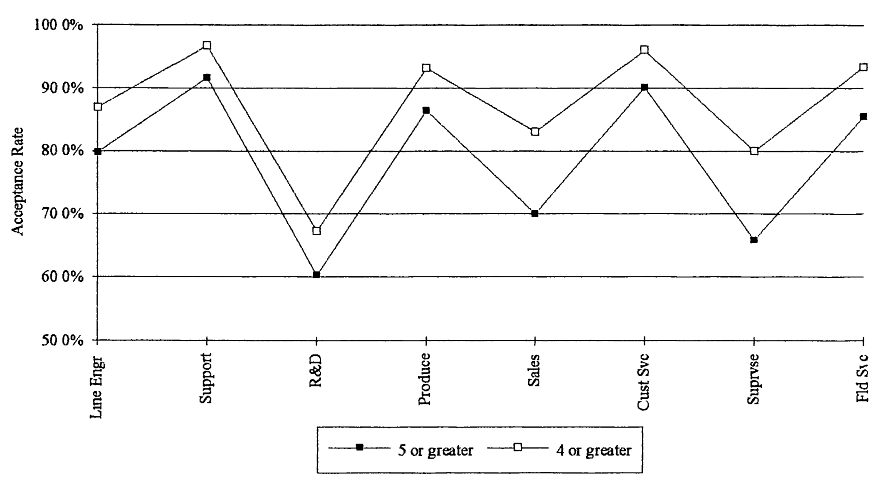

Figure 31. Acceptance Percentage as a Function of Response Value - Job Function

graph indicates only those percentages of responses ≥4 and ≥5. A score of four was value-neutral while five and above registered agreement.

As compared with engineers, respondents assessed the adequacy of technologists for each of the six cognitive competencies. As before, respondents recorded the degree of agreement or disagreement with each statement. Figure 32 records the percentage of the responses at both ≥4 and ≥5.

After completing the assessment of competencies, the participant was asked to (a) appraise growth opportunities for technologists, (b) judge the applications orientation of technologists comparded with engineers and (c) evaluate the

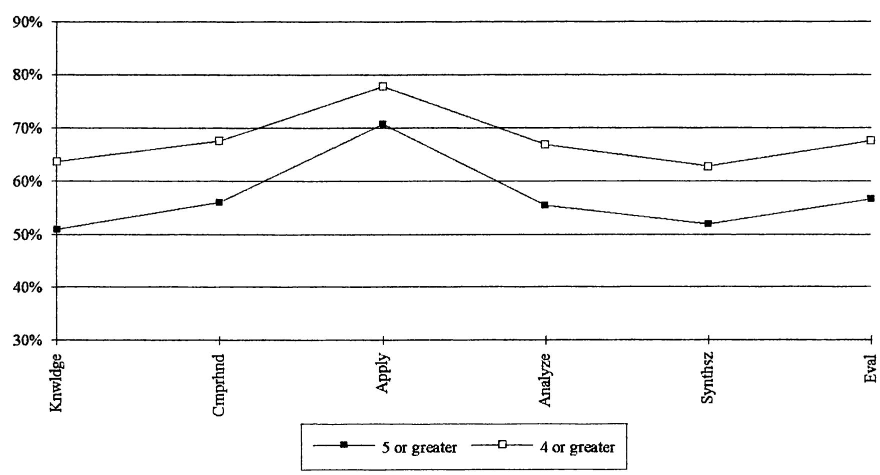

Figure 32. Acceptance Percentage as a Function of Response Value - Competencies

primary function of technologists at hiring. Figure 33 shows the responses to those three statements.

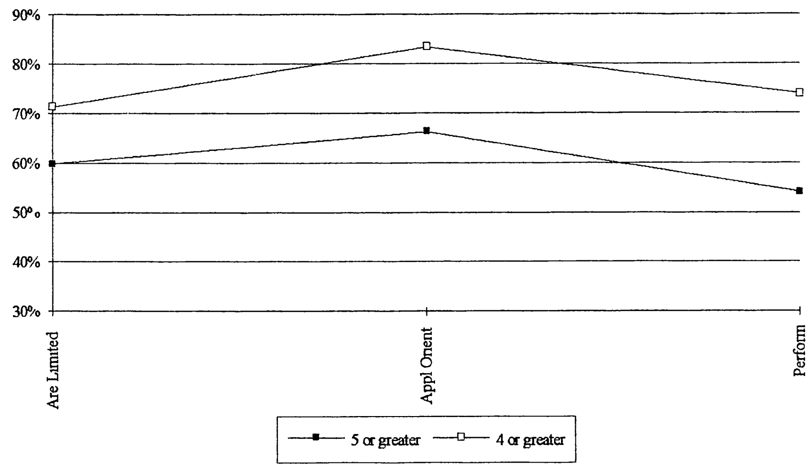

Figure 33. Acceptance Percentage as a Function of Response Value

The above pages summarize the instrument, procedure and findings of the study. Details of those topics are found in Chapters III and IV.

Conclusions

Based on evaluation of the study findings the following conclusions are made:

1. Differentiation exists between technologists and engineers as reflected by current industrial utilization patterns.

Supervisors report that although technologists are used in all job functions, they are not utilized at the same rates as engineers. Technologist utilization rates range from 50% for research and development to 84% in field service. Concurrently utilization rates for engineers range from a low of 66% in field service to a high of 98% in research and development. Figure 34 shows the distribution of utilization rates for both technologists and engineers.

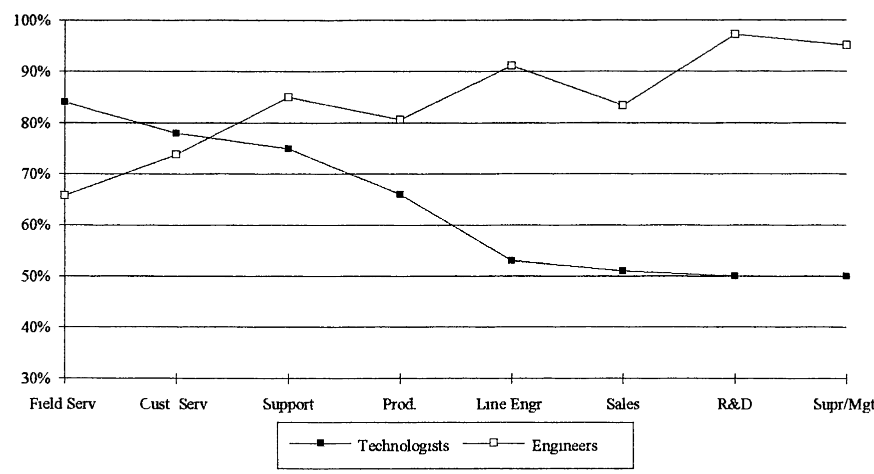

Figure 34. Technologists and Engineers by Assigned Job Function

Technologists are utilized at a greater rate than engineers, only in field service and customer service; in the other defined functions, engineers are utilized at higher rates. Present utilization rates seem to favor engineers. Because of this existing condition across a broad spectrum of both geographic and type of industry, it is reasonable to conclude that utilization differentiation does exist.

2. There exists differentiation among the job assignments that supervisors believe technologists are capable of performing.

A review of the findings discloses a wide variance. As mentioned previously, ambiguity in interpretation is removed by limiting the term "agreement" to only those scores of ≥5, since a score of 4 is value-neutral. The graph in Figure 35 shows that 92% agree that technologists can be used in support engineering, whereas 60% agree that technologists

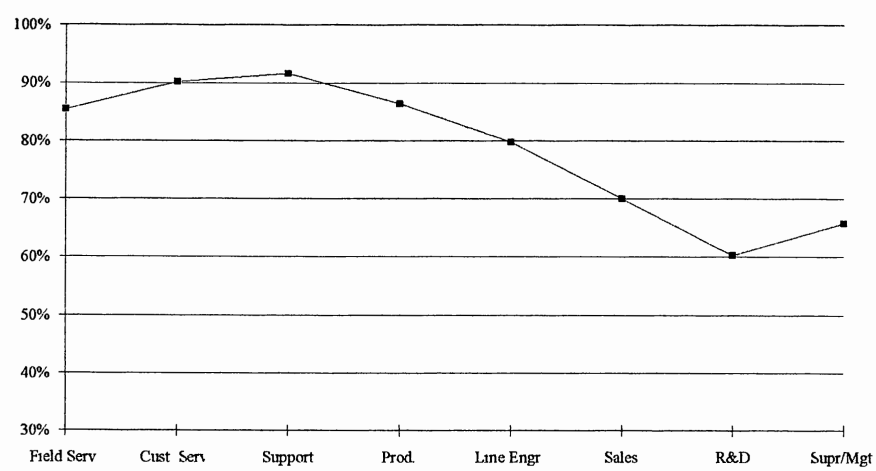

Figure 35. Percentage Awarding Score of Five or Greater

can be used in research and development. The remaining six job functions have acceptance rates between these two limits.

3. There exits a disparity between current utilization patterns of technologists and supervisor's assessments of technologist's capabilities.

Supervisors believe that technologists are "capable" of being used across the engineering job spectrum in greater percentages than are presently utilized by industry. Figure 36 compares reported technologist utilization with rates of supervisor's acceptance of technologist's capability for

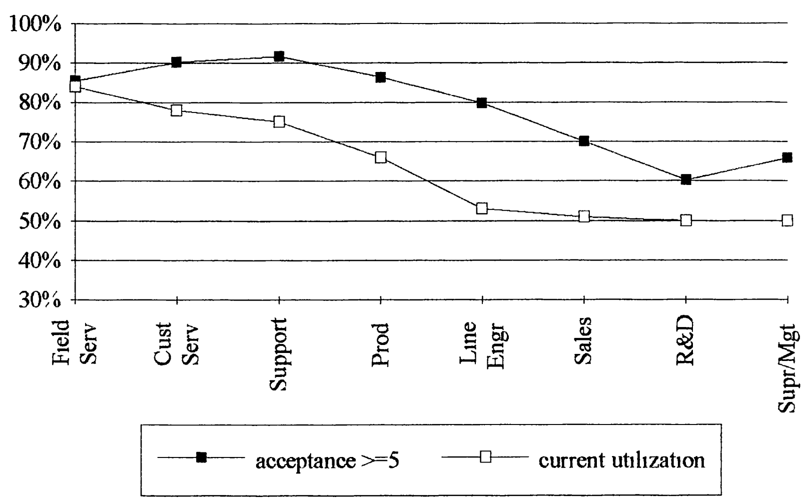

Figure 36. Acceptance by Supervisors of Technologists by Job Category versus Present Industrial Utilization

those same functions. As before, the rate of acceptance is determined by limiting the criteria for acceptance to scores ≥5.

The disparity between actual utilization rates and the rate at which supervisors indicate that utilization can occur has gaps ranging between 10% and 27%. With the sole exception of field service, present industrial utilization of technologists lags the rate at which supervisors report that those technologists can be utilized. Perhaps this condition is due to past hiring practices, and that these gaps will narrow as prevailing supervisor opinion diffuses throughout industry. Since the study does not address this issue, it is mentioned only as speculation.

4. Differentiation exists as reflected by assessments of the cognitive competencies of technologists relative to those of engineers.

A score of 7, indicating strong agreement with the cognitive statements, correlates to judging technologists as adequate as engineers. Scores of 5 or 6 also indicates adequacy, but to a lesser degree. Since value-neutral, 4, is not a rejection of the statement it is also interpreted as adequate.

A graph of the percentages of respondents who assigned scores of ≥4 and ≥5 to statements comparing the cognitive competencies of technologists to those of engineers is shown in Figure 37. In the definitive case of scores ≥5, the majority of respondents agree that technologists possess a degree of adequacy with respect to engineers. A finding of adequacy, albeit at a marginal level, is reinforced when the mean of those responses is considered as seen in Figure 38.

Seventy percent of supervisors agree that technologists are adequate in the competency of application. Adequacy is also reflected in computation of the mean of all responses for cognitive competencies. Recognizing that all the competencies lie between 4 and 5, with an average of the collective mean at 4.41, the conclusion that technologists possess competencies to a lesser degree than engineers is supported.

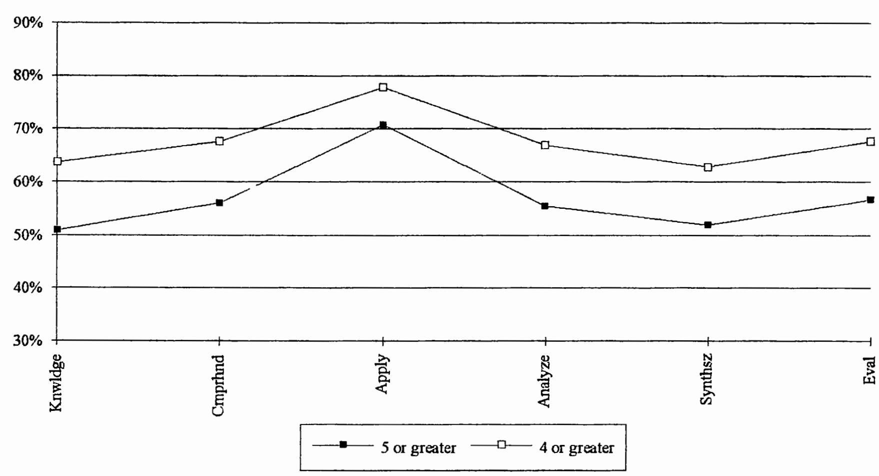

Figure 37. Percentage of Respondents Indicating Acceptance

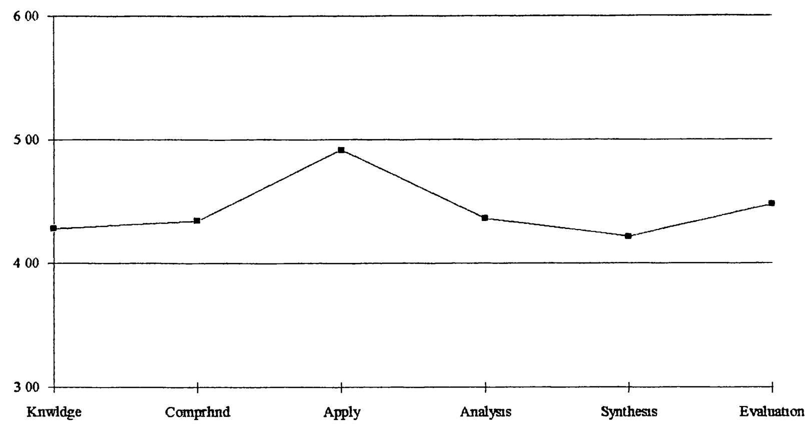

Figure 38. Response Mean - Cognitive Competencies

5. The cognitive competencies of knowledge and comprehension are not sufficiently developed in technologists.

According to Bloom (1956), the cognitive competencies form a measurable hierarchy of increasing complexity. Therefore, it is considered unusual that technologist's competency of application is judged higher than those of the more basic competencies of knowledge and comprehension. Again, Figure 38 shows the respective mean for both knowledge and comprehension is below that of application. That fact supports a conclusion that the competencies of knowledge and comprehension need strengthening to ensure that understanding forms the foundation for the intelligent application of engineering processes.

6. There is a disparity between supervisory acceptance of technologists for specific job functions and assessments of their cognitive competencies.

As stated previously, the average of the means assigned to technologist's cognitive competencies is 4.41, a statistically neutral value. Yet, between the limits of 60% and 92% of respondents assign a score of ≥5 to assertions that technologists can be used in research and development and customer service functions. The fact that a majority of supervisors agree that technologists can be used in any job function, while assessing competencies that lie in the value-neutral range does not appear consistent. The disparity between supervisory acceptance for various job functions and cognitive competency is unexplained from the data.

7. There is a disparity between supervisory acceptance rates for complex job functions and the belief that technologists are limited in growth opportunities.

Sixty-six percent of respondents agree that technologists can be used in supervision or management. Another 60% also agree that technologists can be used in research and development. Yet 60% believe that technologists are limited in growth opportunities. Such a belief, and the opinion that technologists can be used in positions of higher responsibility seem mutually exclusive. This disparity is unexplained from the data.

8. There is a correlation between the intended purpose of the technology curriculum and the recognition that technologists are application-oriented.

From Figures 34 and 35 it is apparent that respondents rank technologists higher in the competency of application than in the others. Also, when asked to respond to the statement, "Technologists are more applications oriented than engineers", participants agreed. The mean score for the previous statement was 5.1, and 66% assigned a value of ≥5.

As discussed in Chapters I and II, a primary motive for establishing a separate technology curriculum was to preserve and emphasize the application aspect of the engineering enterprise. The fact that respondents score 70% for technologist's application competency, and also judge them application-oriented, shows congruence between the intended purpose of the curriculum and the success of the program's intent.

9. For a technologist to be capable of performing in any of the eight job functions identified in the study, a level of cognitive competency congruent to that in engineers is not necessary.

Industrial supervisors agree that technologists can be used in every job category identified in the survey. Although they differentiate, in that 92% accept technologists for customer service while 60% accept technologists for research and development, in all cases a majority accept technologists in all functions. Only 51% and 56% of supervisors agree that technologists are adequate in the respective competencies of knowledge and comprehension. In fact, the only competency which exceeds 60% agreement of adequacy is that of application, which is just over 70%. Also, as previously mentioned, the average of the means for all competencies is 4.41. Apparently, levels of adequacy congruent to those in engineers is not necessary for a majority of supervisors to agree that technologists are capable of being used in any job function.

Recommendations

Based upon the discussions and conclusions contained herein, the following actions are recommended:

a. that educators revise the technology curriculum to further focus on, and to strengthen the development of the cognitive competencies of knowledge and comprehension as defined by Bloom.

b. that similar studies be conducted in the other fields of engineering technology, such as mechanical, chemical, civil and industrial.

c. that a mechanism be developed to educate engineering supervisors about technologist's capabilities, and their position within the engineering spectrum.

d. that a study be undertaken to identify the mechanism causing the disparity between supervisory acceptance level of technologists and the perception that technologists have limited growth opportunities.

e. that a study be conducted of electrical engineers to map their various cognitive competency scores as identified by industrial supervisors.

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APPENDIXES

APPENDIX A

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STATES FROM WHICH RESPONSES WERE

RECEIVED - All SURVEYS

STATES FROM WHICH RESPONSES WERE

RECEIVED - All SURVEYS

First Mail Survey	Second Mail Survey	Telephone Survey
Arkansas	Alabama	Alabama
California	California	California
Colorado	Colorado	Colorado
Illinois	Florida	Connecticut
Indiana	Georgia	Delaware
Iowa	Illinois	Florida
Kansas	Kansas	Iowa
Maryland	Maryland	Illinois
Massachusetts	Massachusetts	Massachusetts
Michigan	Michigan	Maryland
Minnesota	Minnesota	Michigan
Mississippi	Missouri	Minnesota
New Hampshire	Nebraska	Missouri
New Mexico	New Hampshire	Nebraska
New York	New Jersey	New Hampshire
Ohio	New Mexico	New Jersey
Oklahoma	New York	New Mexico
Pennsylvania	North Carolina	New York
Tennessee	Oklahoma	Ohio
Texas	Oregon	Oklahoma
Washington	DC	Pennsylvania
Wisconsin	Texas	Tennessee
	Virginia	Texas
	Washington DC	Washington DC
	Washington	Washington

APPENDIX B

-

INDUSTRIES ASSOCIATED WITH RESPONDENTS

INDUSTRIES ASSOCIATED WITH RESPONDENTS

Acquisition Systems	Local Area Networks
Aerospace	Magnetic Materials
Aircraft Industry	Manufacturing
ASICs	Measurement Products
Avionics	Medical Electronics
CAE Systems	Medical Supplies
CATV Networks	Microelectronics
Chemical Industry	National Laboratory
Communications	Network Systems
Computer Design	Nuclear Power
Computer Integration	Oil Field Services
Computer Services	PBX Equipment
Computer Systems	Peripherals - Printers
Construction	Petroleum
Consulting	Research and Development
Circuit Card Manufacturing	Satellites
Data Communications	Semiconductors
Data Systems	Software
Defense Electronics	Space
Defense Industry	Switching Systems
Electric Utilities	Systems Engineering
Electronic Design	Technical Consulting
Electronics Design	Technical Services
Firmware Design	Telecommunications
Government	Test Equipment
Higher Education	Transducers
Imaging	Voice Mail
Information Services	Workstations

APPENDIX C

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SURVEY GLOSSARY

GLOSSARY

Engineer	person possessing a Bachelor of Science in **Electrical** Engineering (BSEE) or equivalent.
Technologist	person possessing a Bachelor of Science in **Electrical** Engineering Technology (BSET, BSEET) or equivalent.
Customer Service/Support:	after-sales technical support (including training) rendered to a customer in the use or application of company designs, products, processes, or services.
Field Service:	those technical activities associated with the installation or maintenance of company designs, products, processes, or services.
Line Engineering:	engineering effort directly involved in crafting or refining those designs, products, processes, or services which are the primary "line" of the company. Uses established technology or methods.
Manufacturing/Production:	those engineering activities required to perform and/or support the companies' manufacturing or production activities.
Marketing/Sales:	activities associated with marketing the companies' designs, products, processes or services.
Research & Development:	those engineering activities directed towards creating or developing new or improved designs, products, processes, or services through the use of new technology or methods.
Supervision/Management:	first level supervision and/or management of company technical and/or other activities.

Support Engineering: those technical activities whose chief purpose is to support Line Engineering with assistance and/or services. Includes functions such as Quality, Reliability, Maintainability, Standards, Testing, etc.

APPENDIX D

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SURVEY INSTRUMENT

SURVEY INSTRUMENT

— A NATIONWIDE PROJECT —

INVOLVING

ENGINEERING AND SCIENTIFIC SUPERVISORS

TO

IDENTIFY TASK ASSIGNMENTS

AND TO

ASSESS COMPETENCIES

OF

BS ELECTRICAL ENGINEERING TECHNOLOGISTS

AS COMPARED TO

ELECTRICAL ENGINEERS

All responses are CONFIDENTIAL. Access to your response without your permission will not be granted.

Your Address ____

Your City ______________________ State ________ ZIP ______

Employer's Principal Product ______________________________

ALL QUESTIONS REFER TO ELECTRICAL ENGINEERS AND TECHNOLOGISTS

1 Please estimate the number of **Technologists** at your company by an X in the appropriate box

less than 50 = ____	between 50 & 100 = ____	greater than 100 = ____

2 Please do the same for **Engineers**

less than 50 = ____	between 50 & 100 = ____	greater than 100 = ____

3 Please X all appropriate categories of jobs to which your company assigns Technologists (T) and/or Engineers (E) as their **principal** function (ignore categories which are not applicable to your company)

	T	E		T	E
Customer Service/Support			Marketing/Sales		
Field Service			Research & Development		
Line Engineering			Supervision/Management		
Manufacturing/Production			Support Engineering		

I (Please indicate your degree of agreement/disagreement by placing an X where appropriate)

Technologists can be used in	Agree: strongly	Agree: moderately	Agree: slightly	neutral	Disagree: slightly	Disagree: moderately	Disagree: strongly
a Line Engineering							
b Support Engineering							
c Research & Development							
d Manufacturing/Production							
e Marketing/Sales							
f Customer Service/Support							
g Supervision/Management							
h Field Service							

II (Please indicate your degree of agreement/disagreement with the following statements by placing an X where appropriate)

	Agree				Disagree		
	strongly	moderately	slightly	neutral	slightly	moderately	strongly
a Technologists possess adequate **KNOWLEDGE** of engineering and mathematical principles (compared to that attribute in engineers)							
b Technologists possess adequate **COMPREHENSION** of engineering and mathematical knowledge (compared to that attribute in engineers)							
c Technologists possess adequate ability to **APPLY** engineering principles in crafting a design process or service (compared with the ability of engineers)							
d Technologists possess adequate ability to **ANALYZE** a design product process or service using quantitative methods for functionality and suitability (compared with the ability of engineers)							
e Technologists possess adequate ability to **SYNTHESIZE** or craft a design product process or service by integrating techniques methods or procedures (compared with the ability of engineers)							
f Technologists possess adequate ability to develop the criteria by which to technically **EVALUATE**, or judge the merit of a design product process or service (compared with the ability of engineers)							
g Technologists are **LIMITED** in growth opportunities							
h Technologists are **ORIENTED** more towards applications than engineers							
i Technologists are primarily hired to **PERFORM** engineering functions							

III Other data

a Check if you have a degree in technology ☐ engineering ☐

b If you possess a degree in a field other than technology or engineering please indicate ______ ______ ____

c If you possess no degree please indicate your field of expertise ________________________ ______ __

d Check if you directly supervise technologists and/or engineers ☐

e If so how many technologists?________engineers?________

f If you do not directly supervise technologists and/or engineers, how many working levels separate you from those employees?________

g Please give us YOUR concept of the difference(s) between a technologist and an engineer (this is optional but if you have the time we would appreciate your opinion)

____

____

____

____

____

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____

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____

____

FINIS THANK YOU VERY MUCH FOR YOUR TIME AND EFFORT!!!

WE APPRECIATE IT

PROJECT DIRECTOR
398 Cordell South
Oklahoma State University
Stillwater, OK 74078

APPENDIX E

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PERSONAL OPINIONS OF THE DIFFERENCES BETWEEN TECHNOLOGISTS AND ENGINEERS

PERSONAL OPINIONS OF THE DIFFERENCES BETWEEN TECHNOLOGISTS AND ENGINEERS

The following are copies of the comments included in Section III, question g., asking the respondent to provide their personal concept of the differences between technologists and engineers. Not all respondents chose to do so. Nevertheless, all comments that were made are herein included.

Question g., Section III: Please Give Us **YOUR** Concept Of The Difference(S) Between A Technologist And An Engineer:

"Almost all technicians are focused on the bottom line - Produce something that works - now: Not all engineers are that focused. Too many engineers tend to go off on theoretical/intellectual tangents which, for most of them, is not their primary job."

"In my limited experience, it seems to depend on the time they could spend on formal education and their desire to excel at one thing. Many of the Technologists on whom I rely determined their goals after several years of career jumping after college. The true engineers seemed to have picked a goal prior to or very early in college. This end result is still based on the amount of job effort and the basic intelligence of the individual. But a strong educational base is required for a successful career."

"I view technologists as engineers who have absorbed techniques and moved to broader and visionary tasks."

"In a former position at another company, I supervised both new graduate engineers and technologists. We were doing software R&D. In general, the engineers performed better at interdisciplinary (software, hardware, and mechanical) design and analysis projects. They had a noticeable advantage in communication theory, calculus, and physics. However, after the initial 2 years of training and experience, the technologists and engineers were comparable."

"Technologists seem to possess a practical 'hands on' knowledge whereas engineers are more theoretical and more capable of mathematical analysis."

"My feeling is that engineering is more involved with design work or verification of fundamental concepts. The technologist responsibilities are more in the area of implementation."

"The best ET is as good as any engineer. In fact, the President of our company is a technologist (ET). Below 'best,' the curve drops rapidly. Generally from C+ and below, they are more suited for support, CAD work, and similar."

"Technologists are primarily line workers with limited mathematical and scientific background. In my experience they do not have the background or inclination to perform creative engineering work. I would strongly recommend against any student's taking a four-year technologist degree."

"I think technologists focus more on working directly with current and projected future technology, whereas engineers do more 'what if' studies."

"While I think the real difference is more one of circumstance in early career choices, I know that many people assume that technologists are merely "doers" rather than 'thinkers' (i.e., engineers)."

"The technologists has gone after the application oriented, almost vocational/manufacturing pursuit, whereas the engineer has chosen the more academically demanding path and has persevered."

"Technology changes; and right now it is changing very quickly. What does the technology graduate do 10, 15, 20, 25 years down the road. I am faced with this problem of having to manage people who have worked hard all their lives but have not kept up their skills."

"In the right individual, the degree is less significant than his/her interest and drive. In my experience, engineers who do well in their degree courses tend to be better equipped to work in design and development than technologists. Overall, I prefer the discipline of an engineer."

"Technologists are more oriented towards analysis than engineers. However, engineers are better to understand the system if the process on equipment is very complex. The analytical background of the technologist should be coupled with the real world complex system analysis and solutions. Businesses need to work with more information and ambiguity. The skill of complexity analysis and abstraction technique will be fundamental for success. A strong analytical background will definitely help to influence the products and processes."

"I have met two technologists in my current assignment. One has enormous potential for leadership, theoretical R&D, and application. The other I would never have hired into the company. But that is the range also encountered for engineers. It makes this questionnaire difficult due to lack of knowledge of a technologist's expected capabilities and a lack of breadth of experience with them."

"This seems to be chiefly a distinction in <u>depth</u> of teaching at a technical level. Degree type or depth has little bearing on job growth or areas of responsibility in our company. Individual factors are much more important. All degree tracks must emphasize flexibility and continued educational responsibilities."

"Engineers synthesize/design products/systems. Technologists perform support functions. Both should work as a team performing complementary functions."

"A technology degree should be supplemented with additional mathematics and engineering education. To be successful, the technologist should have theoretical background beyond that normally taught in ECT. Engineering students often lack practical know-how needed to be effective in industry. Neither EE nor ECT degrees will guarantee success. The individual must be a top proactive student and fill in gaps not provided by a particular program. ECTs should go on to pursue a MS degree in Engineering."

"A technologist does not have the full complement of knowledge, understanding, and experience required of an electrical engineer."

"Technologists are primarily oriented towards the more practical aspects of engineering. Engineers are typically more oriented toward design and analysis."

"A technologist is equivalent to a "super tech" technician, whereas an engineer is primarily tasked with design of circuits and systems as well as support and approval of Engineering Change Orders for existing products. The technologist is primarily involved with the practical testing and lab check-out of such ECOs. Technologists are generally suited for field service, customer service, and manufacturing engineering."

"The difference between a technologist and an engineer is the degree of familiarity and depth of knowledge in field."

"A technologist accomplishes methods and procedures developed by engineers in the design, development, testing, productions, operations, and retirement of a system. This implies the ability to apply scientific and engineering information to produce the technical results that are desired. When the technologist understands the underlying scientific and engineering theory, he/she becomes an engineer."

"I have always considered an engineering technologist to be an individual with an associate's 2-year degree. In the absence of possessing better knowledge, I would put the technologist on the back burner when it comes to hiring."

"A technologist is someone trained to do a specific job who often becomes an expert in the details of a particular area, but he may be ignorant of the big picture, whereas the engineer is someone who able to design and create, come up with new ideas, be aware of performance and possible options. An engineer is much more aware of what is out there when making decisions. Technologists often eventually get M.S. degrees and become 'engineers.'"

"The technologist generally has a broader area of courses at the BS level, several less EE courses but more courses across the board. The engineer generally has more specific EE courses than the technologist so knows more in depth, but he has less course work in broader subject areas."

"The engineer has completed all courses developed for the engineering profession; and upon graduation and certification, he or she is a qualified engineer. Technologists are trained in less depth in engineering, mathematics, and science so would not independently do senior engineering projects except under professional engineers' supervision. (My understanding of their training may be incorrect)."

"'How to' are technologists; "
'why' are engineers."

"Technologists are missing basic fundamentals. There is a great deal of inconsistency among different technologists, whereas engineers all have the same basic knowledge."

"At this particular company, we have good technologists, some are better than engineers."

"This company hires mostly employees with higher degrees and with five or more years of experience. My concept is that engineers are more theoretical oriented, whereas technologists are more application oriented. Both apply to our work in this company."

"Engineers are primarily involved in conceptual development, solutions, development and implementation of extensive computer simulations to evaluate the effectiveness of the concepts. They normally pursue PhDs to complement and enhance their analytical capabilities. Technologists serve as the system implemented and project engineered for flight and application program. They can enhance their career opportunities by obtaining a M.S. in an engineering discipline."

"Technologists have a 2-year degree with hands-on experience and do not want to be burdened with the day-to-day administrative functions of the engineer. The engineer has a 4-year degree with little hands-on experience."

"The one technologist I supervised was a Kansas State University 1985 graduate. His position was systems engineer, performing tests and evaluations on Navy weapons systems. He seemed somewhat lacking in basic knowledge, but our engineers also lacked specific preparation in computer and software systems engineering. The technologist lacked confidence in proceeding with innovative tasks. He indicated that he sees now that he should have earned an engineering degree."

"Engineers build technologies. Technologists understand what technology can do for a business."

"The technologist is oriented to "hands-on" tasks - debugging, de-bottlenecking, verification of tests, manufacturing, etc. Engineers are lacking in advanced calculus and statistics, physics, chemistry, etc."

"Technologists are underrated and are often given jobs that engineers don't have time to complete. They get less pay for doing the same job as the engineer."

"A technologist can apply himself or herself to more access than engineers are trained for and a technologist is more practical."

"My experience with technologists shows they are typically hard-working, results-oriented folks. I do believe, however, that they have a limited range of capabilities, making them less suitable for R&D as well as management of such activities. I have not met a technologist who has **not** regretted pursuing an Electrical Engineering degree instead!!"

"Technologists are thought of as possessing a 2-year degree. They implement technical tasks and are narrow and limited in career growth except to engineering. Engineers are thought of as a 4-year degree person. They plan, design, and implement technical tasks. They are broad and have expanded career growth."

"Differences strongly depend on the individual. Initial training is but one factor in future success. We rarely hire technologists at MTS but will promote based on performance. Generally, technologists are broader in scope and are more versatile but less capable of detailed design and evaluation tasks. Aptitude and desire are controlling factors. We tend to view technologists as 'general engineers' with somewhat lower capability to do highly technical work."

"I would consider a technologist as an up-dated apprentice/journeyman grade, somewhat better educated than previous entry level 2-year personnel (generally assigned in the past to draftsman functions)."

"In my experience, technologists work best at well-defined production type tasks where detailed analysis and varied background are not required."

"For non-research related work, technologists are hired, whenever possible, to save on salary since they seem to be able to perform at the same level as engineers in this area."

"A technologist performs a very important **support** role in technological development. With the increasing emphasis on engineering productivity, the technologist is becoming more important. Engineers must be utilized more efficiently in the technological **development** phases while technologists are critical to moving technology to market and after market support. Most high tech companies are slow to recognize the importance of technologists, however."

"Engineers create, design, implement; technologists implement, debug manufacturing processes, maintain, and service. Engineers possess the ideas and begin the projects; technologists implement, phase out, and end the projects."

"Technologists have a poor reputation compared to engineers. I find no difference--many technologists do better work than the engineers. Engineers think of solutions and evaluate results. Technologists perform under directions of an engineer."

"Technologists are primarily used to support engineering; but after years of practical experience, they can function as an engineer."

"Most technologists are <u>associates</u>, typically younger and less mature than new engineers. Over time, this distinction disappears. Many technologists return to school and obtain engineering degrees. Some are primarily interested in <u>teaching</u> technology at various levels, including high school. I professionally regard experienced technologists and engineers as roughly equal--but the lack of an advanced degree will normally be a hiring discriminator at most companies."

"A technologist is an associate engineer. At our company, we equate a 4-year degree in ECT with a 2-year associate in EE."

"Technologists generally have less theoretical base. They have more "hands on" training and approach. They frequently have less training outside their specialty."

"It is extremely difficult to hire a technologist (having to clear OPM register and not being able to offer any incentive pay) compared with electrical engineers (for which this company has direct authority) at the entry level. We hire mostly engineers, computer engineers, and computer scientists at entry level. Technologists come to us at journeyman level--at which time relevance of work experience counts more heavily than bachelor's curriculum in hiring decisions. The government contracts for much of its line engineering and R&D, so that government engineers and technologists do mostly system engineering (which is not well covered in most curricula) rather than EE, CE??, or CS."

"We don't differentiate between the technologist and the engineer. We do mostly software. The tasks associated with design and production are the most difficult - planning, etc. Their ability to do these is more important. The actual design and construction is easy compared to all the other functions."

"I assume that a technologist would learn more about "what," some about "how," and less about "why," compared to an engineer. Over time, an engineer would tend toward a narrower specialty in great depth, while a technologist would be less specialized."

"Technologists have conceptual understanding of engineering discipline, i.e., they possess knowledge to converse on engineering topics and have an aptitude for learning engineering in more depth through on-the-job training. I view a technologist as a perfect fit for sales support or systems engineering support to sales personnel."

"The quality of an employee's work (engineer or technologist) is primarily the employee's work habits - not their education."

"A technologist is a person who could not finish an engineering program. This may be due to barriers to entry, financial, or program difficulty. While they are usually good performers, they often are not great performers and they carry a LABEL for life."

"A technologist has a much broader view of the technology, industry, marketing and strategic directions, with limited depth of the technology in comparison to the engineer."

"A technologist depends more on experience and knowledge in a particular field; an engineer has a much broader base of fundamental principles and theoretical considerations which he can draw upon in his job."

APPENDIX F

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SURVEY DATA

SURVEY DATA

<u>Column Headings & Meaning:</u>

Sta:	State
Product:	Principle product of respondent's company
T:	Technologist population category of company
E:	Engineer population category of company
	Technologists, Engineers, or both are assigned by respondent's company to:
'1':	Customer Service/Support
'2':	Marketing/Sales
'3':	Field Service
'4':	Research & Development
'5':	Line Engineering
'6':	Supervision/Management
'7':	Manufacturing/Production
'8':	Support Engineering
	Respondent's indication of where "Technologists can be used in":
Ia:	Line Engineering
Ib:	Support Engineering
Ic:	Research & Development
Id:	Manufacturing/Production
Ie:	Marketing/Sales
If:	Customer Service/Support

Ig:	Field Service
	Response to phrase beginning "Technologists possess adequate":
IIa:	Knowledge
IIb:	Comprehension
IIc:	ability to Apply
IId:	ability to Analyze
IIe:	ability to Synthesize
IIf:	ability to Evaluate
	Generalized portion of Section II:
IIg:	Technologists are limited
IIh:	Technologists are application oriented
IIi:	Technologists are hired to perform engineering
Degree:	Respondent's degree
Suprvse?	Does respondent directly supervise
T's:	Number of technologists supervised
E's:	Number of engineers supervised
Levels?	Number of working levels removed from direct supervision

Sts	Product	T	E	'1'	'2'	'3'	'4'	'5'	'6'	'7'	'8'	Ia	Ib	Ic	Id	Ie	If	Ig	Ih	IIa	IIb	IIc	IId	IIe	IIf	IIg	IIh	IIi	Degree	Suprvse?	T s	E s	Levels?
IL	Telecomm	3	3	TE	E	TE	TE	TE	E	TE	TE	7	7	7	7	5	7	5	7	5	5	7	6	7	5	1	6	6					2
PA	Aerospace	1	3	E	E		E	E	E	TE	TE	6	7	5	7	7	7	7	7	6	6	7	7	6	7	7	6	5	E	Y	3	8	
PA	R&D	2	3	T	E	T	F	T	T	T	E	6	7	6	7	7	7	5	7	5	5	6	5	5	6	2	7	5	T	Y	4	16	
CA		1	1		E	E	TE	E	T	E	E	3	2	6	5	4	2	6	4	6	6	6	4	6	6	6	3	2	E	Y	1	4	
CA	Telecomm	1	1		E		TE	T	TE	T		7	4	6	7	5	5	6	3	6	5	7	6	6	5	3	6	7	E	Y	0	3	
PA	Magnetic Mat 1	1	1	TE		TE	TE	TE	TE	TE	TE	7	7	7	7	7	7	7	7	5	6	6	6	5	4	1	7	6	E	Y	6	4	
NC	CATV Nets	1	1	TE		E	TE	TE	TE	TE	TE	7	6	5	6	4	3	4	2	3	2	5	4	2	3	2	6	5	E	Y	1	2	
PA	Construction	1	3	TE	TE	E		T	TE		E	7	7	7	7	7	7	7	7	7	6	6	7	6	6	7	7	7	E	Y	2	18	
MA	Utilities	3	3	E	E	E	E	TE	E	TE	TE	6	6	1	5	2	2	1	6	1	1	2	1	1	1	1	5	5	E	Y	10	30	
CA	Consulting	3	3				TE	TE	E		TE	6	7	6	7	5	5	5	6	6	5	6	5	3	3	3	6	3	E	Y	0	6	
MN	PBX	1	1			T	TE	T			E	6	6	5	6	6	6	6	7	6	6	6	5	5	6	1	6	6					2
NM	Design	3	3				E	TE	E		TE	5	7	3	6	3	7	3	7	3	2	5	5	3	5	3	5	5		Y	1	6	
NY	Computers	1	3	E	E	E	E	E	E	E	E	5	5	1	5	2	2	3	4	4	5	5	5	3	3	1	5	4	E	Y	0	8	
KS	Telecomm	3	1	T	T	T	E	T	TE	E	T	6	6	1	2	7	7	4	6	1	1	2	4	4	6	7	6	2		Y	1	4	
TX	Telecomm	3	3	E		E	TE		E		TE	5	5	7	6	5		4	5	6	7	6	7	6	6	3	2	6	E	Y	4	8	
TX	Electronics	3	3	T	E	T	E		E		TE	5	5	4	6	5	6	4	6	5	6	5	6	5	6	2	6	6	E	Y	0	4	
TY		3	3				TE		E		TE	5	7	7	7	5	7	5	7	5	5	5	5	5	5	4	4	6		Y	1	12	
TY		1	1	TE			TE	TE	TE		TE	6	6	6	6	6	6	6	6	4	4	4	4	4	4	4	4	4		Y	0	3	
NJ	Info Services	3	3	TE	TE	TE	TE	TE	TE	TE	TE	6	6	6	6	6	6	5	6	6	6	6	6	5	5	2	6	6		Y	0	1	
AL	Computers	2	2	TE		TE	E	TE	E	TE	T	6	6	4	6	4	7	4	7	5	5	4	2	2	2	4	4	6					
TY	Defense Elec	1	3				TE		TE	TE	TE	7	7	7	7	7	7	7	7	6	6	7	7	7	7	6	4	6	E	Y	1	4	
CO	Defense	1	2			E	E	E	E	E	E	2	3	2	5	6	6	5	6	3	3	2	2	1	1	3	3	5		Y	0	1	
CO	Computers	3	3	TE	TE	TE	E	E	TE	TE	TE	2	6	2	6	7	6	6	6	2	2	5	5	5	5	4	7	5		Y	3	4	
WA	Software	1	3		TE		E	TE	E			7	7	4	4	7	4	7	4	3	2	3	3	5	6	6	4	6	E	Y	1	25	
VA	Network Systems	3	3	TE		TE		TE	E		TE	7	7	5	7	6	7	7	7	6	6	6	5	5	5	3	7	7	T	Y	10	4	
TY	Data Systems	1	3	E	E	TE	E	TE	E	TE	E	5	7	3	4	3	6	4	7	5	5	6	3	3	3	1	7	3	E	Y	0	4	
CA	Measurement Prod	1	1	T		T	E	E	E	T	T	5	6	4	5	5	6	2	6	4	6	5	3	5	5	2	5	4	E	Y	0	7	
CA	Satellites	3	3				E	TE	TE	TE	TE	5	5	3	5	6	6	6	6	1	1	1	1	2	3	4	6	4		Y	0	30	
FL	Communications	1	3	TE	E	T	TE	E	E	E	TE	6	6	6	5	5	6	5	6	2	2	6	5	1	1	3	3	5	E				3
TX	Research	3	3	TE	E	TE	E	E		E	E	6	7	5	6		7	5	6	1	2	5	1	5	1	4	4	1	E	Y	0	5	
MA	Voice Mail	1	2	TE		TE	E	TE	E	TE	E	7	7	5	6	4	6	4	6	6	6	5	5	5	5	3	3	6	E				3
VA	Defense	1	3				E	E	E	E	E	4	5	4	7	3	3	4	7	2	2	2	1	1	2	2	4	4		Y	0	20	
MD		2	2					TE	TE		TE	7	7	7	5	4	5	6	5	7	6	6	6	6	7	1	5	7	E				
IL	Telecomm	3	3	TE	E	TE	E		E		T	6	6	3	6	2	5	1	6	2	4	5	3		4	2	3	4	E	Y	4	7	
DC	Gov't	3	2	T			TE		TE		TE	4	6	4	7	7	7	7	7	5	6	7	5	3	6	7	7	4	T	Y	14	3	
NC	Medical Elec	1	1	T	T	T	E	E	E	E	E	1	5	1	4	7	6	2	3	2	2	5	3	1	2	3	5	2	E	Y	1	0	
IL	Telecomm	3	3	TE	TE	TE	TE	TE	TE	TE	TE	6	6	3	6	4	5	6	6	5	4	5	5	3	3	3	4	4	E				
CA	LAN's	1	1	T	T	T	E	E	E	T	T	2	7	1	7	6	7	1	7	5	5	5	2	1	2	5	6	2	E	Y	0	2	
VA	Gov't	3	3	TE		TE	TE	TE	TE		TE	6	6	5	7	7	7	6	7	5	5	6	4	3	3	4	4	5	E				2
CA	Aircraft	3	3	TE	E	TE	E	E	E	TE	TE	2	7	1	6	3	7	2	7	3	2	7	2	2	2	6	7	6	E	Y	3	30	
CO	Data Comm	1	2	TE	E	TE	TE	TE	E	E	TE	6	6	3	4	5	5	4	6	4	5	6	3	2	2	3	5	5	E	Y	5	20	
CA	Sateillites	3	3	TE	E	TE	E	TE	E	TE	T	6	7	5	7	3	6	4	6	4	3	7	7	4	6	1	4	6		Y	6	72	
OK	Oil Field Svc's	3	3	T	E	T	E	E	E	E	E	6	7	6	6	3	7	5	7	5	6	7	5	3	6	5	6	2	E	Y	1	7	
MA		1	1	T		T	TE		E	E	E	5	6	7	5	3	5	5	6	3	3	5	3	4	5	2	3	5		Y	0	7	
WA	Software	3	3	E	T	E	TE			E	TE	4	4	7	7	6	7	4	4	6	5	6	6	7	7	7	1	1	E	Y	20	60	
NJ	Aerospace	1	3		E		E	E	E	F		1	4	1	4	2	4	4	4	5	5	6	4	6	5	1	7	4	E	Y	4	20	
NJ	Defense	1	1	TE		TE	TE	TE	TE		TE	7	7	7	7	7	7	7	7	4	4	4	4	4	4	6	2	4	E	Y	4	5	
NY	Curcuit Cards	1	1	TE	E		TE	TE	E	T	TE	5	7	3	6	5	7	5	7	2	5	5	3	3	6	3	3	3	E	Y	2	5	
NH	Telecomm	1	1	T			E	E	T		E	2	4	1	5	5	6	6	6	3	4	2	2	2	5	4	5	2	E	Y	6	15	
MA	LAN's			T	T	T	E	E	T	E	T	2	5	2	3	6	6	6	6	5	3	2	4	2	6	6	6	2					2
NE	Software	1	1	TE	TE	TE	TE	TE	TE	TE	TE	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	4	4			5	5	
IL	Telecomm	3	3	TE	E	TE	TE	TE	E		TE	7	7	6	7	6	7	4	7	3	2	5	3	3	3	2	6	5		Y	30	120	
IL	Switching Sys	3	3	TE		TE	TE	TE	E	TE	TE	6	6	5	7	4	5	1	5	1	1	1	1	2	1	1	2	2					1
CA	Computers	1	2	TE	TE	T	TE	TE	TE	T	TE	7	7	7	7	7	7	7	7	5	5	6	6	6	7	3	4	5	E	Y	1	2	
MI	Telecomm	1	1	T		T	TE	TE	TE		TE	6	7	5	7	7	7	6	6	2	6	6	5	3	4	5	5	3	E	Y	4	2	

MO	Chemicals	1	3		E	E	E	F	E	E	TE	5	7	6	6	4	4	5	4	4	5	5	5	5	5	2	6	6	E	Y	15	25	
ca	Gov't	1	3				TE		TE			4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		Y	0	8	
MA	Computers	1	3	T			F	E	E		TE	5	7	3			7	7		3	2	5	2	2	2	3	4	7	E	Y	2	8	
OR	Test Eqpt	3	3			T	E	TE	E	T	TE	4	4	1	7	4	6	1	7	3	5	3	2	2	2	2	4	4	E	Y	0	12	
OP		1	1	T	TE	T	E	E	E	T	T	6	6	7	6	6	7	4	7	3	3	5	6	3	7	6	6	3	E		2	20	
VA	Services	1	1	TE	TE	TE	TE		TE		TE	7	7	7	7	7	7	7	7	7	7	7	7	7	7	3	3	6		Y	2	5	
VA	Systems Eng'r	1	3	E			TE	TE	TE		TE	6	6	6	6	7	6	7	6	6	6	5	6	6	6	3	3	5		Y	0	4	
CA	ASIC's	2	2	TE	TE	TE	TE	TE	TE	TE	TE	6	6	3	3	6	7	3	6	6	5	6	5	5	5	5	6	6	E	Y	0	8	
CA		3	3	E	TE	E	T	E	TE	E	E	4	4	7	5	6	2	6	1	6	6	5	6	7	7	6	3	5	E	Y	2	4	
CA	Imaging	2	1	T	TE	T	E	TE	E	T	TE	3	5	5	7	4	4	2	4	3	3	4	2	1	4	4	6	6	E	Y	1	6	
NJ	Microelectronics	3	3	TE	E	T	E	E	E	TE	T	5	6	4	6	5	6	4	6	4	5	6	5	4	4	5	6	4	E	Y	6	7	
VA	Gov't	1	3	E			E		E			5	6	2	5	7	7	1	7	6	5	5	3	3	4	3	5	6	E	Y	0	40	
GA	Avionics	1	2			TE	E	E	TE	TE	TE	5	6	5	6	6	6	6	7	5	6	5	6	5	6	3	6	5		Y	5	35	
NM	Defense	1	2	TE	TE	TE	TE	TE	TE	TE	TE	5	6	4	6	7	7	5	7	6	5	6	5	4	6	3	6	5	E	Y	1	14	
MD	Firmware Design	3	3	TE	E	T	TE	E	TE	F	TE	6	7	5	6	5	7	7	7	5	6	7	7	7	6	2	7	5	E	Y	2	12	
IL	Telecomm	3	3	T		T	TE	E	E		TE	3	5	5		2	5	3	6	4	4	4	4	4	4	4	4	4		Y	0	6	
NH	R&D	3	3				TE		E		T	7	7	2	7	7	7	2	7	4	1	3	4	5	2	2	6	4	E	Y	2	2	
CA	Workstations	3	3	TE	TE	TE	TE	TE	TE	TE	TE	7	7	7	7	7	7	7	7	4	4	4	4	4	4	4	4	4	E	Y	0	2	
OR	CAE Systems	1	3	TE	E		TE	E	E		E	5	7	5	6	5	7	5	7	5	5	3	5	4	6	5	6	5		Y	2	16	
IL	R&D	1	1	TE			TE		E				7	6				7		6	7	7	6	7	6	4	7	5	E	Y	2	4	
CA	Aerospace	3	3	TE	TE	TE	TE	TE	TE	TE	TE	7	7	6	7	7	7	7	7	5	6	5	5	6	6	2	6	6	E	Y	5	20	
CA	Services	1	1	T	T	T	E	E	TE	E	TE	6	7	5	3	7	7	7	7	5	5	7	7	7	7	7	6	3		Y	8	8	
VA	Systems Eng'r	1	1					TE				6	6	3	6	3	5	4	3	2	3	3	3	3	2	1	4	4		Y	1	2	
MA	R&D	2	3	TE			TE		E			4	5	3	5	6	5	5	6	3	4	5	5	3	3	2	5	5	E				1
CO	Communications	1	1	T	T	TE	TE	E	E	T	E	5	6	5	5	6	6	6	6	5	5	5	3	5	3	2	4	5		Y			1
NJ	Computers	1	3	TE	TE	TE	TE	TE	TE	TE	TE	5	6	5	6	7	7	7	7	6	6	6	6	5	6	6	1	4	E	Y	1	4	
TY	Computer Svcs	3	3	TE	TE	TE	TE		TE		TE	4	6	5	6	7	7	5	7	3	3	5	2	3	3	3	6	3	E	Y	5	90	
CA	Aerospace	3	3			T	E	T	TE		TE	7	7	4	7	7	7	5	7	5	3	3	4	3	3	3	6	5	E	Y	10	120	
MD	Software	1	1				TE		E		TE			6						5	4	6	2	2	2	5	3	6		Y	3	5	
VA	Consulting	3	3	TE			TE		TE		TE									6	6	6	6	6	6	7	6	6		Y			
VA	Software	2	3	E	TE	TE	TE	E	TE	TE	TE	4	6	7	7	6	4	6	4	6	6	6	4	6	4	4	6	4	E	Y	10	0	
WA	Avionics	3	3	T	E	TE	E	E	E	TE	TE	6	6	1	6	2	6	5	6	3	4	3	2	4	4	3	6	3	E				
MD	Software	3	3	E	E	E	E	E	E	T	T	7	7	5	7	7	7	7	7	2	4	5	6	5	6	6	6	2	E	Y	3	9	
CA		3	3	T		E	E	E	E		T	1	5	2	6	1	7	1	6	3	3	3	3	1	5	1	5	2	E	Y	0	5	
MD	Computer Svc's	3	3	TE	E	TE	E	T	TE	E	TE	5	5	6	6	3	6	3	6	2	2	2	2	6	1	4	5	5	T	Y	8	0	
MD		1	1	TE			E	E	TE		TE	5	6	5	6	5	6	3	6	3	3	5	3	3	5	1	6	5		Y	0	3	
CO		3	2	E		T	E	T	E	T	T	5	7	7	7	3	7	5	7	5	5	7	5	5	7	6	5	2	E	Y	0	4	
WA		3	3			E	TE	TE	TE	TE	TE	6	7	6	6	4	7	7	7	4	4	4	3	1	2	2	6	2	E				2
CA		3	1	TE	TE	T	TE	TE	TE	TE		6	6	6	7	6	6	5	6	3	3	3	3	3	6	1	7	6					
MD		2	1	T	T				TE		T	6	6	3	4	7	7	2	6	2	5	2	5	1	6	3	3	3		Y	0	3	
MD	Telecomm	3	3	E	E	T	TE	TE	E	TE	TE	6	6	6	7	2	6	2	7	4	6	6	2	5	5	1	6	6	E	Y	10	20	
IA	Avionics	3	3	TE	E	TE	E	E	TE	TE	TE	5	7	1	6	2	6	7	7	6	6	7	6	3	2	2	7	3	E	Y	2	6	
IL	Telecomm	3	3	TE	TE	TE	E	E	E	T	TE	6	2	2	6	6	6	2	6	2	6	2	6	2	2	2	6	6	E	Y			
MO	Aerospace	1	2	E		E	E	E	TE	E	E	6	6	2	6	6	6	6	6	2	6	2	2	2	2	2	6	6	E	Y	0	2	
OK	Software	1	1	TE	E	TE	E		TE		TE	6	6	3	6	2	6	6	6	3	3	6	3	5	3	2	6	2		Y	0	1	
TX	Medical Supplies	3	3	TE	TE	T	TE	TE	TE	TE	TE	6	7	6	6	6	5	6	6	6	5	6	6	6	6	5	5	5	E	Y	5	1	
TX	Gov't	3	3	TE		TE	TE	TE			TE	6	6	5			7	3	6	2	2	3	5	2	5	1	6	6	E	Y	4	76	
IL	Transducers	1	1	E	E		E	TE	E	TE	TE	3	6	1	6	6	6	4	7	1	1	6	2	2	1	1	6	6	E				1
VA	Consulting	3	3	E			TF	E	TE		E	6	2	7	1	6	6	6	2	2	2	3	3	5	6	6	2	2	E	Y	5	20	
VA	Acquisition Sys	1	1							E		6	6	7	7	6	6	7	7	4	6	6	4	6	6	4	3	4	E	Y	0	8	
CA	Defense	3	3	TE	TE	E	E	TE	TE	T	E	6	2	1	6	5	5	7	3	2	3	5	3	2	1	5	4	5		Y		7	
NM	R&D	2	2	TE		T	E	TE	TE		TE	6	7	2			6	6	7	3	5	6	3	7	3	2	6	2		Y	2	1	
NM	R&D	3	3	E			TE		TE		E		6	7			6	6		7	6	6	6	6	7	7	4	4	T				
MA	Communications	3	3	TE	TE	TE	TE	TE	TE	TE	TE	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	3	5	E	Y		15	
NJ	Telecomm	3	3	TE		T	E	E	E	TE	TE	2	6	2	4	2	6	2	6	5	6	2	6	2	6	2	2	6		Y		25	
CT	Aerospace	3	3	E	E	E	T	T	TE	TE	E	2	6	6	2	2	4	2	2	6	2	2	5	5	6	2	6	6		Y	3	5	

NJ Aerospace	3	3	TE	TE	TE	E		E	E	TE	4	6	6	6	6	6	6	6	6	2	2	5	2	2	2	6	2		Y	7	8	
CT Software	1	1	TE	TE	TE	TE		E	E	TE	6	6	6	6	6	7	6	7	6	6	6	5	6	2	1	6	2	E	Y	8	4	
CT Computers	3	3	E		E	TE	E	E	E	E	5	6	6	6	6	6	6	6	6	6	6	3	5	6	2	7	2		Y	2	1	
MA Software	3	3	TE	E	TE	TE	E	TE	TE	TE	6	6	6	6	6	7	6	7	7	2	3	1	5	2	1	6	2	E	Y	12	6	
MA Computers	3	3	TE	TE	TE	E	TE	TE	TE	TE	7	7	2	6	6	6	5	6	2	2	6	5	5	2	2	6	3	E	Y			
MA Data Comm	2	2	T	T	T	E	E	E	TE	T	5	6	6	6	6	6	6	6	4	6	6	6	6	5	2	2	6		Y	10	2	
VA Systems	3	3	TE		TE	TE	TE	TE		TE	6	6	5	4	6	6	6	6	5	6	6	6	6	6	5	4	6		Y	2	1	
MN Software	1	1	T	T	T	E	E	TE	T	E	5	5	1	3	5	6	5	5	3	5	1	1	6	6	3	7	5	E	Y	4	2	
NE Telecomm	3	3			T	TE	E			T	3	6	3	5	5	6	6	6	3	5	6	3	6	6	2	5	3		Y			
TX Semiconductors	3	3			T	E	E	TE	E	T	5	6	3	6	5	5	3	6	6	5	6	6	6	6	1	6	3	E				4
PA Defense	3	3	E	E	T	E	E	E	T	E	5	6	2	6	3	5	1	7	2	2	5	5	3	2	1	7	2	E	Y		20	
PA Services	2	1	T	T	TE	E		E	E	E	7	6	6	6	5	6	7	6	1	1	1	6	6	7	5	6	5	E	Y	14	5	
TX Services	1	1	T	T	T	E	E	E	E	E	3	5	2	5	6	6	6	6	2	3	5	5	3	5	6	6	3	E	Y		1	
NH	3	3	E		E	E	E	E	E	E	6	6	6	6	6	6	5	7	6	6	6	5	5	3	7	5	7	T				1
FL Space	3	3			T	E	E	E	T	TE	2	7	1	6	7	7	1	6	2	4	7	2	1	2	2	7	6	E	Y	2	6	
MA Computers	3	3	T	E	T	E	T	E	T	E	6	7	6	7	7	7	7	7	6	6	7	6	7	7	1	1	4	E	Y			2
TX Petroleum	3	3	TE		TE	TE	TE	TE	TE	TE	5	6	6	6	5	6	5	6	4	4	5	5	5	6	5	4	4		Y			1
IL Telecom	3	3	T		TE	TE		E	TE	TE	6	7	6	7	4	5	3	6	3	3	6	5	5	3	2	6	4		Y	2		
CO Defense	3	3		E		E		E	TE	T	6	7	6	6	6	5	5	6	6	6	6	6	6	6	3	6	6	E	Y	6	20	
CO Telecom	3	3				E	TE		TE		7	7	7	7	4	4	5	7	6	6	4	4	6	4	7	6	3		Y			1
CA Computers	3	3	E			TE	E	TE	E	TE	6	6	7	7	4	6	6	4	2	4	4	6	6	4	2	4	4					
CA Computers	3	3	E	E	E	TE	E	E	E	E	6	5	7	5	5	5	6	5	7	7	6	6	7	7	6	2	6	E	Y		8	
CA Aerospace	3	3	TE		TE						6	6	7	6	6	5	6	2	6	6	6	6	4	6	1	7	6	E	Y			
TN Nuclear Power	3	3	TE		E	E	E	E	TE	TE	7	6	3	7	4	6	5	5	5	5	6	3	6	5	3	6	5	E	Y		20	
DE Chemicals	3	3	TE	E	TE	E	E	TE	TE	T	6	6	3	6	1	7	5	7	3	2	3	3	3	3	7	6	6					1
NJ Telecomm	3	3	T	T	T	TE	E	T	E	TE	5	7	1	1	7	7	7	7	7	7	7	5	1	5	7	7	6	E	Y	4	2	
CO Systems	1	3	T	E	TE	E	TE	E	T	E	7	7	6	7	6	6	6	7	7	6	7	6	6	5	2	7	5	E				1
CA Aerospace	1	3	E	E	E	E	E	E	E	E	6	7	6	6	4	7	5	7	6	6	7	6	6	6	4	7	7	E	Y	1	40	
NY Software	1	1									6	7	5	6	5	6	5	7	4	5	6	5	4	5	3	5	4	E	Y		1	
NH Communications	1	1			E	TE	E	TE		T	7	7	6	7	7	7	6	7	6	3	6	6	4	7	2	4	6		Y	3		
NJ R&D	3	3	TE	TE	TE	E	TE	E		TE	6	5	1	5	6	7	1	6	6	1	5	1	1	5	5	7	1					
CA Aerospace	3	3	E		T	E	E	TE	TE	TE	4	4	4	4	4	4	4	4	5	4	5	4	4	5	1	2	4	E				2
OH Software	3	3									6	6	7	7	6	5	6	6	2	2	2	2	2	2	6	6	2		Y	5	100	
CO Systems	3	3				E	E	E		T	5	7	6	6	5	6	6	6	5	5	6	6	5	5	2	5	5	E	Y	?	16	
AL Software	3	2	T		T	E	E	TE		TE	2	7	2			7	7	7	2	2	2	2	6	2	2	6	2		Y	5	3	
NJ Hardware	3	1	E		E	T	E	E	E	E	7	7	7	7	7		7		2	2	6	6	6	6	2	6	7		Y	10	15	
CA Space Tech	3	3	TE		TE	TE	TE	TE	TE	TE	6	6	7			6	7	5	4	4	5	4	4	4	2	6	4					
NY Communications	3	3	TE	E	T	TE	TE	E	TE	TE	7	7	6	7	7	7	7	7	7	6	7	6	7	6	2	7	7					
TX Software	1	1	TE	TF	TE	TE	TE	TE	TE	TE	6	6	6	7	5	6	2	6	5	5	5	5	6	6	3	6	6					1
NJ Communication	3	3	T	T		TE	TE	TE	E	E	7	7	6	3	4	6	4	6	4	2	2	1	1	4	4	7	4	E				
MA Software	1	1	T			E	E	T		E	2	6	1	7	7	7	7	7	6	6	2	6	5	7	7	2	4	E	Y	25	15	
TX Systems											7	6	3	2	7	6	1	6	2	2	1	2	1	2	7	4	6	E				
VA Nat'l Lab	3	3									6	6	1	7	7	7	6	7	2	2	4	6	1	1	1	6	6		Y	1	10	
TX Manufacturing	3	3	E	E	E	T	T	T	E	TE	6	5	7	6	3	5	4	3	6	6	6	5	5	6	5	5	6	E				2
MI Higher Ed	3	3									6	7	7	7	6	6	7	7	6	6	6	6	6	6	1	7	6	E				
CA Printers	1	2	TE	TE	TE	TE	TE	TE	T	TE	6	7	7	7	7	6	4	4	7	6	6	6	7	3	1	4	1		Y	7	5	

VITA

Thomas G. Bertenshaw

Candidate for the Degree of

Doctor of Education

Thesis: DETERMINING IF INDUSTRIAL SUPERVISORS DIFFERENTIATE BETWEEN ELECTRICAL ENGINEERING TECHNOLOGISTS AND ELECTRICAL ENGINEERS

Major Field: Higher Education

Biographical:

Personal Data: Born in Chicago, Illinois, October 18, 1935, the son of Louis G. and Elizabeth Maryann Bertenshaw. Married to SueMae Bertenshaw (nee Brown).

Education: Received Associate of Science Degree in Pre-Engineering from Ricker College at Houlton, Maine in May 1965; received Bachelor of Science Degree in Electrical Engineering from Oklahoma State University, July 1968; completed Master of Science Degree from Oklahoma State University, May 1969; received Master of Education Degree from the University of Maine at Orono, May 1977; completed requirements for Doctor of Education Degree from Oklahoma State University, December 1992.

Professional Experience: Communications-Electronics Engineer, United States Air Force, June 1961, to June, 1975.

Director of the Region III Northern Penobscot Vocational-Technical facility at Lincoln, Maine from September, 1976, to June, 1979.

Electrical Engineer at the Naval Weapons Support Center at Crane, Indiana, June, 1979 to May, 1980.

Senior Engineer at Kollsman Instrument Company, Merrimack, New Hampshire, from May, 1980 to May, 1981.