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A Content Comparison of Nontechnical Curricula for Engineers

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A CONTENT COMPARISON OF NONTECHNICAL CURRICULA FOR ENGINEERS

by

Bryan Lynn Lundgren

A Dissertation Submitted to the Faculty of The Graduate College in partial fulfillment of the requirements for the Degree of Doctor of Education Department of Educational Leadership

Western Michigan University Kalamazoo, Michigan June 1989
The purpose of the study was to compare and critique the non-technical curricula content of three Bachelor of Science in Engineering (BSE) degree program model curricula. Curricula content areas that are similar were critiqued by employers of engineers. Model curricula importance and first year BSE nontechnical skill performance were rated by engineering supervisors. The main postulate is that differences among actual, model, and employer-desired nontechnical curricula are factors that may influence curricula change in engineering education. A secondary purpose was to investigate whether the proportion of nontechnical courses to total required courses in BSE college degree programs changed between 1975 and 1985 and how actual proportions compare with recommended proportions.

Three BSE model curricula were compared for similarities. Nine nontechnical categories were named and described using a decision rule that the category must be contained in at least two of the three models. Twenty-nine supervisors of engineers were surveyed by mail to obtain ratings of first year BSE employees' skill levels. Six of the nine nontechnical categories were rated "often required for job performance." The six are: (1) oral skills, (2) written skills, (3) professionalism, (4) ethics, (5) human relations ability, and (6)
learning ability. Five of the six (excluding ethics) skills importance to job performance ratings differed above the .05 significant difference level with first year BSE employee skills performance ratings.

The secondary investigation indicated that in the 1980 top 10 ranked BSE college programs there was no difference between 1975 and 1985 requirements for proportion of required nontechnical credits. However, the average percentage of required credits (17%) was closer to engineering program study commission recommendations (20%) than to the Accreditation Board of Engineering and Technology minimum requirement (12.5%).

The major conclusion was that five of six (oral skills, written skills, professionalism, human relations ability, learning ability) BSE program nontechnical skills rated by engineering supervisors as most important for job performance were not as well performed by first year BSE employees as supervisors desired. This indicates that supervisors may expect skill improvements to take place either on the job or through continuing education. Colleges could also better prepare BSE graduates in the five nontechnical skills categories.
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A content comparison of nontechnical curricula for engineers

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Bryan Lynn Lundgren
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CHAPTER I

THE PROBLEM

The purpose of this study was to compare and critique the non-technical curricula content of three Bachelor of Science in Engineering (BSE) degree program model curricula. Curricula content areas that are similar were critiqued by employers of engineers. Model curricula importance and first year BSE graduate nontechnical skill performance were rated by engineering supervisors. The main postulate is that differences among actual, model, and employer-desired nontechnical curricula are factors that may influence curricula change in engineering education. A secondary purpose was to investigate whether the proportion of nontechnical courses to total required courses in BSE college degree programs changed between 1975 and 1985 and how actual proportions compare with recommended proportions.

The nontechnical dimension of the Bachelor of Science in Engineering curricula was selected because 1980's engineering work practices were believed to be changing away from engineering technical tasks and toward more nontechnical tasks such as management and human relations tasks (Hurt, Russell, McGuire, & Nickel, 1986; Rutt, Minton, & Copp, 1986). In this chapter the problem situation is described and the purpose and importance of the study is given. Research questions, postulates, rationale, hypotheses, study scope, and study limits are stated.
Change in the BSE curricula was investigated by: (a) describing some model and employer-desired categories of nontechnical curricula; (b) comparing actual curricula, model curricula, and curricula needs employers have expressed; and (c) researching changes in the proportion of nontechnical to total required BSE curricula between 1975 and 1985. The investigation should provide useful information to engineers interested in education, engineer employers who participate in or sponsor undergraduate or continuing education, and educators who serve engineers.

Uses and Users of the Study

College administrators, professors, and instructors responsible for engineering curricula development are likely to be interested in comparisons among actual and model BSE curricula that prepare engineers for jobs. The employer ratings of nontechnical skills and other findings of the study may influence nontechnical curriculum choices of students and of curriculum planners at engineering colleges. Continuing education providers including engineering societies, colleges, universities, and industrial trainers are also expected to be interested in the nontechnical curricula of the BSE degree. The information provided may help guide change of both BSE and continuing education curricula which supplements BSE curricula. Continuing education is believed to be important in the engineering profession to enable practitioners to keep up with new knowledge. This is evidenced through widespread corporate encouragement and sponsorship of continuing education for engineers (Cabot, 1978;
Culbertson, 1974; Malott, 1978; Ping, 1981).

Working engineers and organizations that employ them are expected to be interested in nontechnical BSE curricula. Skills obtained from nontechnical curricula required for the BSE degree are assumed to influence hiring decisions, continuing education decisions, and training decisions of engineering employers. Continuing education is thought to enhance engineering group performance of sponsoring organizations and to help engineers maintain and advance their careers (Steinberg, 1985). This is an assumption because effectiveness measures for continuing education are not widely used. Due to the lack of such measures engineers and their employers have not quantified the worth of continuing education (Steinberg). Findings in this study may also help participants in BSE programs and in continuing education programs weigh the relative professional usefulness of continuing education in certain nontechnical subjects.

Definitions

An engineer is defined as a graduate of a four-year Bachelor of Science in Engineering (BSE) program accredited by the Accreditation Board of Engineering and Technology (ABET). An accredited BSE degree and continuing education is valued by most members of the engineering profession and their employers. An accredited BSE degree is also believed to provide a basic knowledge base from which engineers start and develop a particular technical practice or expertise (ABET, 1985). The ABET defines engineering as "that profession in which knowledge of the mathematical and natural sciences gained by study,
experience, and practice is applied with judgment to develop ways to use, economically, the materials and forces of nature for the benefit of mankind" (p. 98). The ABET definition implies that the engineer must be working in and have knowledge of the field of engineering. A broader definition of engineer is used for some United States engineering statistics. An engineer is someone with background or training acquired through the completion of four years of college with a major in physical, life, or mathematical sciences (National Science Foundation, 1984). This broad definition of engineer was not used because the definition includes biology and mathematics. The ABET does not accredit biology and mathematics programs and employers do not generally recognize biologists and mathematicians as engineers.

Nontechnical engineering curricula is defined as humanities, social sciences, business, and communications. Varying definitions of nontechnical curricula are a problem, making proportion comparisons inaccurate. The ABET (1985) definition of nontechnical engineering curricula includes only humanities and social sciences; however, communications and economics are expected to be taught in engineering courses. Business curriculum including economics was considered to be either technical or to be classified under the Bachelor of Arts in Business degree program in some studies (Kline, 1984). Business curriculum was classified nontechnical in this study for the purpose of being consistent with other authors (Hurt et al., 1986; Rutt et al., 1986). Many engineering colleges offer a five year BSE and Bachelor of Arts in Business dual degree program.
Pursuing a fifth year business degree is a method for engineers to develop their nontechnical knowledge and to have such knowledge recognized by obtaining a second degree. Foreign languages and physical education were considered nontechnical courses in surveys between 1885 and 1934 but due to declining popularity and need were dropped from consideration as nontechnical courses (Kline). Neither foreign language nor physical education courses were assumed to be degree requirements. Curricular data containing foreign language or physical education requirements were modified to be comparable with curricular data not having such requirements.

Problem Situation

Some department chairs of electrical engineering (Grogan, Tan, Meyers, & Gaylord, 1979) believed that the nontechnical BSE curriculum was not emphasized enough. Support is given to this viewpoint from the engineering job marketplace, where 1980's work practices were said to be changing toward nontechnical tasks (Hurt et al., 1986; Rutt et al., 1986). Committees of three major engineering curricula studies recommended that 20% of the BSE curricula be nontechnical (Grinter, 1955; Hammond, 1944; Walker, 1968). However, the ABET (1975, 1985) only required 12.5% of the curricula to be nontechnical in an accredited BSE program.

An increase of nontechnical curricula quantity and responsiveness to required job skills in the BSE curricula may reduce job turnover. Engineering job change or turnover may be due in large part to the lack of human skills (assume nontechnical), and not to the lack
of technical skills (Katz, 1955). Some psychologists also postulated that nontechnical curriculum has a stronger relationship to job retention than technical curricula (Maslow, 1971; Rogers, 1980).

Guidance about selection of nontechnical courses is valuable because formal educational experiences have some disadvantages for those seeking them. Formal education can be costly and time consuming. Classes may be difficult to find and inconvenient to attend (Adam, 1984). Guidance about choosing formal nontechnical continuing education may be provided to engineers and the organizations for which they work by investigating nontechnical BSE curricula.

Purpose of the Study

The purpose of this study was to compare and critique the nontechnical curricula content of Bachelor of Science Engineering degree programs with model curricula and employer needs. Model curricula importance and first year BSE nontechnical skill performance were rated by supervisors of first year BSE graduates. The main postulate was that differences among actual, model, and employer desired nontechnical curricula are factors that may influence curricula change in engineering education. A secondary purpose was to investigate whether the proportion of nontechnical courses to total required courses in BSE college degree programs changed between 1975 and 1985 and how actual proportions compare with recommended proportions. A major goal was to provide engineers, employers of engineers, and engineering educators with some information that will help them make better decisions about selecting nontechnical curricula for initial
education (BSE) and continuing education of engineers. In the years following 1982, information about future jobs will become more critical. Such information should help engineering students select occupations and should help working engineers direct their continuing education choices (Freedman, 1982).

Research Questions

1. To what extent are there similar nontechnical curricula content descriptions of skill outcomes among three BSE model curricula (ABET, 1985; C. J. Baldwin, Cahn, Forman, Lehman, & Wischmeyer, 1979; Walker, 1968)?

2. What are engineering supervisor ratings of skills described in two out of three model curricula (ABET, 1985; C. J. Baldwin et al., 1979; Walker, 1968) of: (a) nontechnical skill importance to job performance, and (b) skill behavior of first year BSE graduates?

3. How do engineering supervisor ratings of skills described in two out of three model curricula (ABET, 1985; C. J. Baldwin et al., 1979; Walker, 1968) compare between categories: (a) nontechnical skill importance to job performance, and (b) skill behavior of first year BSE graduates?

4. Has the proportion of nontechnical to total required courses for ABET accredited BSEE degree programs in the top 10 United States engineering colleges (Glower, 1980) changed between 1975 and 1985?

5. How does the proportion of nontechnical to total required courses for ABET accredited BSEE programs in the top 10 United States engineering colleges (Glower, 1980) compare with the proportion
Conceptual Assumptions (Postulates)

The main postulate is that the differences among actual and model nontechnical BSE curricula are factors that may direct curricula change in engineering education. The employer rating of model curricula is a study representing the comparison of actual and employer-desired engineering curricula. The survey of employers adds two dimensions: (1) the importance of nontechnical skills to job performance, and (2) the nontechnical skill behavior of first year BSE graduates.

A secondary postulate is that there was a shift in engineering task requirements in the 1980s toward nontechnical tasks such as human relations tasks and business management tasks (Hurt et al., 1986; Rutt et al., 1986). BSE curricula changes are assumed to respond to clearly evident job task and skill changes. College curricula changes may not respond to job task and skill changes for as long as 10 years after job task and skill changes have first happened. The measurement of the proportion of nontechnical to total required courses for accredited BSE degree programs between 1975 and 1985 and the comparison of actual proportions to recommended proportions is a method to study possible nontechnical curricula changes in colleges of engineering. Theoretical support for this postulate comes from some human-relations management theories developed between 1950 and 1975 and from expert opinions and case studies of changes in
engineering job skills and tasks between 1965 and 1986. The measure­ment and comparison of the proportion of non-technical engineering curricula was a replication of part of previous engineering program content research done between 1885 and 1968 (Kline, 1984). This past research was reviewed to compare percentages of non-technical curriculum. Actual percentages were compared with percentages recommended in selected curricula studies (Grinter, 1955; Hammond, 1944; Walker, 1968).

Rationale and Theoretical Framework

In an effort to quantify successful American business management practices in the 1980s, eight business principles (Appendix A) were developed (Peters & Waterman, 1982). The principles emphasize non-technical job skills. In suggesting the development of a new theory to explain business success, the authors used their research and eight principles to argue against rational (assume technical) management theories, and to argue for people-oriented (assume non-technical) management theories. The shift to non-technical people-oriented theories of management is assumed to have a similar implication for engineering tasks and skills.

Maslow's (1970) hierarchy of needs is a human growth or maturity theory that identifies various motivations for human behavior. Some authors that interpret and apply the theory to work organizations (Schwartz, 1983; Sergiovanni & Starratt, 1983) have indicated that behavioral motivations at work are largely human needs motivations (assume support of non-technical) and that much individual growth or
maturing happens in the human relations (assume nontechnical) dimensions. Maslow (1971) stated that an education in the arts was the best education to support human growth according to his hierarchy of needs theory. Other writers supported the need for emphasis on human relations skills (Katz, 1955; Rogers, 1980) but did not suggest training or curricula appropriate for the emphasis.

Statements of Hypothesis

The five statements of hypothesis follow the five research questions in order:

1. The nontechnical content descriptions of skill outcomes of nontechnical course content categories is the same among: (a) ABET accredited Bachelor of Science in Electrical Engineering (BSEE) degree programs from the top 10 ranked engineering colleges (Glower, 1980), (b) the ABET (1985) curricula requirements, (c) the Walker (1968) model curricula, and (d) the Institute of Electrical and Electronics Engineers (IEEE) (C. J. Baldwin et al., 1974) model curricula.

2. Supervisor ratings of first year BSE graduates: (a) nontechnical skill importance to job performance, and (b) nontechnical skill behaviors will be reported. These data quantify opinions that selected employers have of nontechnical skill category importance.

3. There is no significant difference at the $p = .05$ level in each curricula content category of supervisor ratings of first year BSE graduates between: (a) nontechnical skill importance to job performance, and (b) nontechnical skill behaviors.
4. There was no change in the proportion of nontechnical to total required course content for ABET accredited BSEE degree programs between 1975 and 1985. Programs were from the top 10 United States colleges as ranked by 1979 proportion of program graduates' awards and citations in the field of engineering (Glower, 1980).

5. There is no difference between the proportion of nontechnical to total required courses when comparing the mean proportion of the top 10 United States engineering colleges (Glower, 1980) and the ABET requirement (ABET, 1975, 1985). A comparison of mean proportion of the top 10 colleges to the proportion recommended by three engineering program study commissions (Grinter, 1955; Hammond, 1944; Walker, 1968) is reported.

Scope and Limits of the Study

The scope of the study was limited to one engineering degree program, the Bachelor of Science in Electrical Engineering (BSEE) degree. Limiting the data to BSEE degree programs necessitated assuming that other engineering programs such as mechanical, chemical, civil, and industrial also change similarly if a generalization to most engineering programs was to be made. The small sample of the top 10 ranked electrical engineering colleges was useful as a method, but was not statistically valid to draw conclusions about the changes throughout the United States BSE programs. The various definitions of nontechnical curricula (ABET, 1985; Hurt et al., 1986; Kline, 1984; Rutt et al., 1986) become a limitation when comparing ABET nontechnical curricula proportion to other proportions. The small
sample of 25 engineering supervisors' rating of 72 BSE engineer employees' skills was not representative of all engineering employers. The engineering employers' ratings are measured through an engineering supervisor opinion survey. Opinion data are less reliable than actual performance measures but are much more feasible to obtain. The wording and interpretation of the 5-step rating scales is a limitation inherent in a survey rating instrument.

Curricula outcomes as described in model curricula are compared for the extent of similarities and are rated by employers. Other factors that affect curricula outcomes such as curricula design, instruction methods, instructor behavior, classroom facilities, and teaching aids were not researched. The ABET (1985) requires accredited engineering colleges to survey graduates in order to review outcomes and relate them to the BSE programs. A reasonable correlation between BSE program graduate skill and performance outcomes and skill and performance outcomes described by college catalogs was assumed.

Importance of the Study

Some department chairs of electrical engineering (Grogan et al., 1979) believe that the nontechnical BSE curriculum was not emphasized enough. In support of this, engineering work practices were said to be changing away from technical tasks and toward more nontechnical tasks such as management and human relations tasks (Hurt et al., 1986; Rutt et al., 1986). Committees of three major engineering curricula studies recommended that 20% of the BSE curricula be
nontechnical (Grinter, 1955; Hammond, 1944; Walker, 1968); however, the ABET (1975, 1985) only required 12.5% of the curricula to be nontechnical in an accredited BSE program. Differences in actual and model BSEE curricula were investigated by comparing nontechnical curricula content of BSEE programs and three model curricula. Employer importance ratings of nontechnical skills provide the additional dimensions to the nontechnical curricula comparison study. These dimensions are: (a) importance of nontechnical skills to job performance, and (b) skill behavior of first year BSE graduates. The comparisons may provide information about possible changes in nontechnical content of BSE curricula and should provide useful information to engineers, employers of engineers, and educators who serve engineers.

Summary

Content analysis and survey methods were used in this study. The content analysis method was used to examine similarities in nontechnical content of model BSE curricula. Measuring the proportion of nontechnical to total BSE curricula between 1975 and 1985 was a replication of part of previous engineering program content research done between 1885 and 1968 (Kline, 1984). These measurements are provided to determine if the actual percentage of nontechnical curricula are still below the percentage recommended in curricula studies (Grinter, 1955; Hammond, 1944; Walker, 1968). Employer ratings of nontechnical skills provide some additional dimensions to the nontechnical curricula comparison study. These dimensions are:
(a) importance of nontechnical skills to job performance, and (b) skill behavior of first year BSE graduates. The examination and comparison of nontechnical BSE curricula and employer importance ratings should be of interest to engineers, engineer employers, educators, and professional societies that serve engineers in the United States.

In Chapter II, literature related to the problem is reviewed, particularly in the subject area of educational curricula for engineers. In Chapter III the content analysis method of research is presented and the sample selection and data collection procedures are reviewed. Analysis and interpretation of the data collected are in Chapter IV. A summary of the investigation, the findings, conclusions, and recommendations are in Chapter V.
CHAPTER II

LITERATURE REVIEW

The purpose of this study was to compare and critique the non-technical curricula content of three Bachelor of Science Engineering (BSE) degree program model curricula. Curricula content areas that are similar were critiqued by employers of engineers. Model curricula importance and first year BSE graduate nontechnical skill performance were rated by supervisors of first year BSE graduates. The main postulate is that investigation of differences among actual and model nontechnical curricula are factors that may influence curricula change in engineering education. A secondary purpose was to investigate whether the proportion of nontechnical to total required BSE college degree programs changed between 1975 and 1985 and how actual proportions compare with recommended proportions. The literature review is presented in four parts: (1) a general history of the engineering profession and discussion of the increase of professional work based on knowledge application from 1950 to 1985; (2) a review of studies pertaining to engineering education curricula changes between the technical and nontechnical; (3) a review of some theories, studies, and opinion articles that may be used to explain curricula change and possible relationships with engineering job task shifts between technical and nontechnical; (4) a discussion of general and adult education and adult learning principles and theories.
Beyond the year 1986, in mechanical and industrial engineering fields, both engineering job tasks and engineer career goals are expected to change toward increasing nontechnical content. An assumption was made (Hurt et al., 1986) that the change of engineering job tasks in response to industry needs creates a similar change in college curricula. A similar assumption (Rutt et al., 1986) was that the change of engineering job tasks in manufacturing in the years following 1986 will be increasing in nontechnical task percentage. The changes are expected to create an increased demand by engineers for formal nontechnical continuing education and training. Determining curricula trends is important to help increase the effectiveness and worth of engineering education (Steinberg, 1985).

History

The technical job tasks of the engineering profession evolved with the industrial revolution of the 1800s (Perrucci & Gerstl, 1969) and with the "knowledge revolution" of the 1970s (Drucker, 1985). The number of employed professionals in the United States has increased 67%, from 5 million in 1960 to 8.5 million in 1976 (Freedman, 1982). In 1982 there were approximately 1.5 million employed engineers in the United States, or 1.4% of the employed population. In the 1985 population of working engineers, 75% were employed in business or industry and 25% worked in government. In the population of working engineers 28% work in management and 72% do not (National Research Council, 1985).
Between 1875 and 1975 United States employment went through two major changes in predominant job type. The first was the evolution from farm labor, the predominant job in the 1880s, to industrial labor, the predominant job in the 1950s. The second change was the evolution to knowledge labor, the predominant job in the 1970s (Drucker, 1985; Naisbitt, 1984). Basic engineering knowledge is usually gained by obtaining a four-year Bachelor of Science college degree from engineering institutions accredited by the American Board of Engineering and Technology (American Board of Engineering and Technology, 1985; National Research Council, 1985). Knowledge for and maintenance of a specific technical practice or expertise are most often developed on the job aided by formal continuing education courses, journal reading, and conference attendance (Adam, 1984).

Many educational concerns of the electrical engineering profession in 1984 reflect educational issues and concerns dating from 1885 (Kline, 1984). Changing nontechnical course content to be more relevant to engineering work and increasing the amount of nontechnical course work are historical concerns dating from 1885. A similar concern about quantity of courses was resolved by some educators (Zorpette, 1984) proposing a five-year BSE degree. Since most students could get a second business degree or a master's degree in the fifth year, the five-year BSE degree has not been adopted by colleges.

Authors of four major studies on engineering education reported measurements of combined nontechnical course percentages of humanities, social sciences, and languages (see Table 1). The studies were Burdell in 1956, Jackson in 1939, Mann in 1918, and Wickendon in 1929.
(cited in Adam, 1984). These percentages ranged between 11% in 1939 to 17% in 1955. Burdell (1956) recommended that nontechnical course percentages be increased to 20% from the average 17% he measured in 130 U.S. colleges. Three other study committees made recommendations that the ratio of nontechnical to total curricula be increased to 20% (Grinter, 1955; Hammond, 1944; Walker, 1968). The percentages of nontechnical to total curricula content of four-year engineering degree programs are reported in Table 1. The seven studies reported recommendations relating to nontechnical courses as follows: (1) Mann (cited in Kline, 1984) advocated a "return to fundamentals," (2) Wickendon (cited in Kline, 1984) emphasized "social sciences for management training," (3) Jackson (cited in Kline, 1984) updated and supported the Wickendon report (4) Hammond (1944) placed the importance of humanities to the engineer as equal to the importance of the basic sciences, (5) Grinter (1955) recommended quantified curricula requirements and suggested that humanities and social sciences account for 20% of the total required curricula, (6) Burdell (1956) supported Grinter and recommended that curricula development be a continuous process, and (7) Walker (1968) supported Grinter in recommending that humanities and social sciences account for 20% of the curricula and in emphasizing the importance of humanities to the engineer.

Two trends in engineering education between 1918 and 1968 were: (1) the standardization of basic technical knowledge and purpose that enable engineering students to practice in a variety of occupations, and (2) the broadening of curriculum content to include more social
Table 1

<table>
<thead>
<tr>
<th>Report author</th>
<th>Dates published</th>
<th>Percent nontechnical</th>
<th>Data source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mann</td>
<td>1918</td>
<td>13% in 1885</td>
<td>MIT &amp; Cornell</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16% in 1900</td>
<td>10 U.S. colleges</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14% in 1915</td>
<td>10 U.S. colleges</td>
</tr>
<tr>
<td>Wickendon</td>
<td>1923-29</td>
<td>13% in 1923</td>
<td>10 U.S. colleges</td>
</tr>
<tr>
<td>Jackson</td>
<td>1939</td>
<td>11% in 1939</td>
<td>10 U.S. colleges</td>
</tr>
<tr>
<td>Hammond</td>
<td>1940, 44</td>
<td>20% recommended&lt;sup&gt;a&lt;/sup&gt;</td>
<td>79 accredited U.S. colleges</td>
</tr>
<tr>
<td>Grinter</td>
<td>1952-55</td>
<td>20% recommended&lt;sup&gt;a&lt;/sup&gt;</td>
<td>122 accredited U.S. colleges</td>
</tr>
<tr>
<td>Burdell</td>
<td>1956</td>
<td>17% in 1955</td>
<td>130 U.S. colleges</td>
</tr>
<tr>
<td>Walker</td>
<td>1968</td>
<td>20% recommended&lt;sup&gt;a&lt;/sup&gt;</td>
<td>156 accredited U.S. colleges</td>
</tr>
</tbody>
</table>

<sup>a</sup>No survey results were reported but ABET requires a minimum of 12.5% nontechnical courses for accreditation.

and humanistic studies and management training. During the 50-year span between 1918 and 1968, four-year engineering programs moved from specialty training for an occupation to a more liberal and general program that allowed engineering graduates to obtain a wider variety of jobs and play a more flexible role in society. The broadening of engineering education to include nontechnical courses was assumed to help practicing engineers better to understand, interpret, and serve...
the needs of society. This change in engineering education also helped engineers to adapt to and to lead in more rapid technical change, and to carry out their job tasks more efficiently by communicating and managing well. In a survey of educators from 156 engineering institutions, 70% said engineers would have an increased social role between 1968 and 1978 (Walker, 1968).

Since 1944, the ABET (1985) has required social sciences and humanities curriculum to be 12.5% of the total credits required to obtain a BSE degree (16 out of 128 semester hours). Also, since 1944, three major engineering study task forces have recommended that nontechnical curriculum be increased to 20% of the curriculum (26 out of 128 semester hours) (Grinter, 1955, Hammond, 1944, Walker, 1968). The actual required nontechnical course content of the top 10 engineering colleges will be compared with the 12.5% required by the ABET and the 20% recommended. This measures what proportion of nontechnical courses to total required courses the top 10 engineering colleges consider important. This is also a partial replication of measurements last made in 1955 (Burdell, 1956). If work practices in engineering are changing away from engineering technical tasks and toward nontechnical tasks, the top 10 colleges are expected to respond to this job market change and to require more than the 12.5% minimum nontechnical courses.

Engineer Job Level Classification

The United States Bureau of Labor Statistics has quantified eight levels of advancement for engineers in private industry. The
levels of advancement above Level III have an increasing requirement of management and people skills (Wright, 1982). This ladder of progression supports an additional argument that engineers need to gain more management and people (assume nontechnical) skills as they advance in rank. Engineer advancement levels, with paraphrased descriptions, are listed in Table 2.

Table 2
Engineer Job Levels in Private Industry

<table>
<thead>
<tr>
<th>Level</th>
<th>Description of level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineer I</td>
<td>Learn the job at the entry level. A BSE degree in engineering is required but no experience is necessary.</td>
</tr>
<tr>
<td>Engineer II</td>
<td>Perform routine, closely supervised work in minor engineering projects.</td>
</tr>
<tr>
<td>Engineer III</td>
<td>Manage minor engineering projects and use independent judgment.</td>
</tr>
<tr>
<td>Engineer IV</td>
<td>Plan and conduct engineering jobs under general supervision. The engineer may oversee the work of a few technicians or engineers.</td>
</tr>
<tr>
<td>Engineer V</td>
<td>Supervise, coordinate, review work of a small staff of engineers.</td>
</tr>
<tr>
<td>Engineer VI</td>
<td>Implement major engineering programs and supervise a large staff of engineers.</td>
</tr>
<tr>
<td>Engineer VII</td>
<td>Direct subordinate supervisors and impact engineering activities throughout the organization.</td>
</tr>
<tr>
<td>Engineer VIII</td>
<td>Manage engineering in a medium size or larger company and represent the firm to the marketplace.</td>
</tr>
</tbody>
</table>
Research Literature

Technical training was not sufficient for engineers' job advancement in 1986. Education programs in behavioral management, humanities, and the social sciences were believed to be required to advance (Hurt et al., 1986). These assertions were based on Hurt's job experience and supported with some management theory which is presented later in this chapter. In the 1980s, industry needed engineers who could manage and facilitate. Two assumptions of Hurt et al. are: (1) there is a link between college education curricula and industry needs, and (2) engineers will develop management skills through undergraduate college, graduate programs, and formal continuing education programs. Particular courses of value suggested were psychology, law, ethics, interpersonal skills, and leadership, with the last being the most important. Humanities and social science nontechnical courses usually comprised between 13% and 14% of the accredited BSE curricula in the 1980s. Three unidentified colleges were selected: (1) major university, (2) small university, and (3) five-year co-op college. Five BSE degrees were chosen: (1) electrical, (2) mechanical, (3) civil, (4) chemical, and (5) industrial. The nontechnical to technical ratio did not vary significantly among the five curricula or the three colleges (Hurt et al., 1986).

Student desire to increase the people-related (assume nontechnical) content of engineering jobs was exemplified in a 1985 Purdue University survey reporting that 50% of industrial engineering students chose the field because of the people emphasis. The first
indication of engineer desire for people-related work is that 90% of the industrial engineering students expect to reach a management position sometime during their career. A second indication of engineer desire for people-related education (assume nontechnical) is that 22,000 of 120,000 American Society of Mechanical Engineers members chose the management division as their first area of interest. The choice of the management division was over 34 other technical divisions. Only 3% were expected to join the management division if the divisions were assigned equal probability for membership, but 18% chose the management division (Hurt et al., 1986). A third indication of engineer desire for nontechnical continuing education was the top technical interests of electrical engineers. A survey asked an open ended question of 1,154 electrical engineer respondents out of 4,000 surveyed. The question was, what topics and courses relating to their careers would they have "high interest" or "interest" in? Of all 5,554 topics and courses listed, 1,886 or 34% were nontechnical including management, consulting, communication, and personal development courses (Adam, 1984).

The Society of Manufacturing Engineers (SME) Continuing Professional Development (CPD) and Continuing Education Division (Rutt et al., 1986) predicted a shift in the ratio between technical and nontechnical job skills toward the nontechnical for manufacturing engineers. The driving force for this change was believed to be the introduction of computer integrated manufacturing in most areas of industry. This assumption was based on SME staff experience with members, on CPD training 437 students in 1985, and on 1,823 survey
questionnaires (out of 6,558) returned to the SME in 1978 (Battelle, 1979). Manufacturing engineer tasks were expected to change from predominantly specialty technical work to predominantly generalist work. The task changes should include more planning, multidisciplinary engineering, and building of task teams at both the engineering and the production levels in manufacturing organizations. Manufacturing engineers were assigned increased responsibility for planning, designing, and justifying systems for production of products between 1969 and 1979 (Battelle, 1979). The CPD recommended three approaches for acquiring new skills and knowledge: (1) job experience; (2) reading journals, articles, and books; and (3) formal education and training. A survey of 4,000 randomly selected Institute of Electrical Engineers members (Adam, 1984), with 1,154 valid returns, supported Rutt et al. (1986) by indicating that 64% rated job assignment, 45% rated technical publications, and 29% rated formal continuing education as their first or second preferred means of continuing their education. The chosen role of the SME is to provide journals, articles, and books for manufacturing engineers. The role of the CPD division is to provide formal training classes for manufacturing engineers.

Continuing education, as well as the BSE curricula, was expected to correlate with engineer job task changes. An important determinant of engineer advancement from engineer Level I through Level VIII was assumed to be additional education, particularly in management, communication, and human relations. Organizations that provide education services for working engineers were expected to respond to
engineer advancement desires with curricula that could train engineers in needed job skills. Continuing education was a popular endeavor for engineers with over two-thirds of employed engineers seeking some formal continuing education on a regular basis (Adams, 1980). Most engineers were equipped academically and are self-motivated to pursue continuing education without requiring external help (Adams, 1980; L. V. Baldwin & Down, 1981). Most engineers also had decision-making and analytical skills to select and complete education experiences on their own. Regular attendance of formal continuing education activities was correlated with growth in compensation for engineers (Morris, 1978).

Courses that directly enhance job performance were popular with engineers and employers as well (Belitsky, 1978). This can be an argument for linking job task types with similar types of continuing education courses. Engineers select programs of study with many factors in mind. These factors include program availability, need for the knowledge, personal desire, company support, cost in time and dollars, and overall career strategy (Adams, 1980).

A tendency between 1967 and 1982 called "high tech—high touch" was identified as an effort to balance the human element in jobs with the increase of the technical, computer, and information elements. Research was based on content analysis of major city newspapers and magazines, and job trend analysis in five key indicator states between 1977 and 1982. The technical element in technical jobs already existed in abundance, so there should be an increase in the human element (assume nontechnical) to balance the technical. The number
of technical jobs will increase in years beyond 1984, requiring a larger quantity of people to be trained. Workers with technical skills will need nontechnical skills, particularly communication skills, to deal with the information based technical jobs (Naisbitt, 1984). The implication is that the nontechnical content of technical jobs will increase in the 1990s.

Lifelong learning or continuing education will increase in quantity and importance beyond 1985. Adults taking formal education increased from 13 million in 1969 to 20 million in 1982. In 1972, 13.6% of the United States labor force completed 16 years of school; in 1978, 16.9% did; and in 1990, 21.7% are projected to complete 16 years (Freedman, 1981). The average education level in the United States is expected to rise, and the basic curricula of education should be changing to emphasize job skills required in the 1990s. To emphasize job skills, the "reading, writing, and arithmetic" based 1st-through-12th grade curricula can be supplemented with a "learn, think, and create" curricula targeted toward the changing, high-technology, information based jobs (Naisbitt, 1985). The "learn, think, and create" curriculum emphasizes skills that make job or career change easier. Such skills were assumed to be more nontechnical than the "reading, writing, and arithmetic" skills.

In a review of research about the advantages of occupational education in obtaining and holding a job, many factors that affect employment age were postulated (Herr, 1977). The review was assumed to have relevance to identifying dependent variables or factors that influenced obtaining and holding an engineering job, although the
review was of general occupations and included high school graduates. Many of the factors identified in the review favored the nontechnical or people skills over the technical skills in getting and keeping jobs. Cited as major reasons for not keeping a job were: (a) lack of information about worker and employer relations, (b) not knowing employer expectations, or (c) an inability to accept supervision or to get along with co-workers. Basic workplace interpersonal skills were considered more important than technical job skills which could be readily obtained through on the job training or additional formal education and training. General literacy, good work attitudes, and appropriate work habits (such as showing up on time to meetings) were also important in obtaining and holding a job. Particular interpersonal skills of importance included the nontechnical communication skills of reading, writing, and speaking. Also important were group organization skills and knowledge that allowed one to interact effectively with workgroups and the employer organization. The interpersonal relationship skills, or the ability to get along with individual co-workers and supervisors could aid in obtaining and keeping a job. Some less important nontechnical skills were decision making, physical and mechanical dexterity, and intellectual reasoning (Herr, 1977).

Accreditation of Engineering Programs

The Accreditation Board of Engineering and Technology (ABET) is the sole agency responsible for accreditation of United States institutions offering programs leading to degrees in engineering. The
ABET is recognized by the United States Department of Education and the Council on Postsecondary Accreditation, and has accredited engineering schools since being founded by engineering societies in 1932. The objectives of the ABET are: (a) to identify to the public programs that meet accreditation criteria, (b) to stimulate improvement in engineering education, and (c) to guide engineering education development (ABET, 1986).

The ABET development of curricula objectives and content provides a leadership function for engineering institutions and may reflect some engineering job market requirements and changes. The 1975 and 1985 minimum curricular content required to allow a Bachelor of Science in Engineering program to become certified by the ABET is shown in Table 3. Between 1975 (ABET, 1975) and 1985 (ABET, 1985), the recommended ratio of social sciences and humanities (nontechnical) to technical courses (expressed as the percentage of nontechnical to total curricula) remained at 12.5%. In both 1975 and 1985, the minimum requirements for a program to obtain certification was 3 years of defined curricula plus 1 year of elective courses. The total semester credit hours of study were 128 credit hours taken at a rate of 32 semester credit hours per year. If quarter hours were used at 48 hours per year, 196 quarter hours were required for a BSE accreditation. All programs chosen for the research were accredited four-year Bachelor of Science Electrical Engineering degree programs. Any change found in the nontechnical to technical ratio between 1975 and 1985 was attributed to the one year of unspecified curricula. The one year of curricula not prescribed in the four-year programs
can change the nontechnical curricula percentage of total curricula. This change can range from a 12.5% minimum (16 out of 128 semester credit hours) if all technical courses are taken for the year of elective courses to a 37.5% maximum if all nontechnical courses are taken for the unspecified year. Also, ABET (1985) requires English writing and speaking to be developed and demonstrated within the technical curricula; therefore, 12.5% will be considered an absolute minimum.

Table 3

<table>
<thead>
<tr>
<th>ABET Curricula Requirements for Bachelor of Science in Engineering Degree Program Accreditation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975 requirements</td>
</tr>
<tr>
<td>1. 0.5 year mathematics</td>
</tr>
<tr>
<td>2. 0.5 year basic science</td>
</tr>
<tr>
<td>3. 1.0 year engineering sciences</td>
</tr>
<tr>
<td>4. 0.5 year engineering design</td>
</tr>
<tr>
<td>5. 0.5 year humanities and social sciences</td>
</tr>
</tbody>
</table>

Note. Prescribed nontechnical to technical ratio (expressed as a percentage of total curricula) is the same in 1975 and 1985 at 0.5 year nontechnical to 4.0 years prescribed courses or a 12.5% ratio.

The ABET recommendations for humanities and social sciences curricula were stronger in 1985 than in 1975. In 1985, the ABET recommended the development in engineering students of:
(1) a capability to delineate and solve in a practical way the problems of society that are suggestible to engineering treatment, (2) a sensitivity to the socially-related technical problems which confront the profession, (3) an understanding of the ethical characteristics of the engineering profession and practice, and (4) an ability to maintain professional competency through life-long learning. (p. 98)

In 1975, recommendations were similar, but did not include an understanding of the ethical characteristics (Point #3) of the engineering profession and practice (ABET, 1975).

The 1985 recommendation emphasized the role of humanities and social sciences as an integral part of the engineering program. The 1985 curricula objectives description included three paragraphs describing goals of humanities and social science courses and one paragraph describing goals of written communication competency for a total of one-half page of description of nontechnical curricula (ABET, 1985). The 1975 curricula objectives description had only one paragraph (one-sixth page total) that described humanities. Social sciences goals and written communication were not discussed in the 1975 document.

The ABET (1984) had four major evaluation criteria other than curriculum: (1) the faculty is "the heart of any program" (p. 3), (2) the administration should create a "favorable administrative climate" (p. 3), (3) facilities for and methods of instruction should include laboratories, instructional aids, library, and computer facilities, and (4) a survey of program graduates so "the department can report on the character of careers of a representative sample" (p. 4). The ABET survey of program graduates requirement Point d indicates an interest in graduate accomplishments and reinforces the
research decision to choose among the top 10 electrical engineering programs based on a 1980 ranking of program graduate awards and citations.

Engineering Curricula Models

The three model curricula are reviewed, compared, and summarized in this section. The first research question seeks to compare non-technical BSEE curricula of three model curricula. The three model curricula selected are the ABET (1985) curriculum required for BSE program accreditation, the IEEE (C. J. Baldwin et al., 1979) model BSEE program curriculum, and the Walker (1968) committee curriculum.

ABET Model Curriculum

The ABET (1986) curriculum supports the following definition of engineering:

Engineering is that profession in which knowledge of the mathematical and natural sciences gained by study, experience, and practice is applied with judgment to develop ways to utilize, economically, the materials and forces of nature for the benefit of mankind. (p. 6)

There are five curricula outcome objectives that are supposed to prepare the BSE candidate to become an engineer. All of these objectives include nontechnical goals. The objectives are the development of: (a) a capability to delineate and solve in a practical way the problems of society that are susceptible to engineering treatment, (b) a sensitivity to the socially-related technical problems which confront the profession, (c) an understanding of the ethical characteristics of the engineering profession and practice, (d) an
understanding of the engineer's responsibility to protect both occupational and public health and safety, and (e) an ability to maintain professional competency through life-long learning.

IEEE Model Curriculum

The IEEE (C. J. Baldwin et al., 1979) model curriculum was developed by a committee of five managers from large industrial employers. The committee was formed to address dissatisfaction with engineering curricula expressed at IEEE meetings, engineering education conferences, and in conversations with engineering managers. The model curriculum was guided by the desire to better suit the needs of students as they enter the job market, and the needs of the employer as they expect engineers to perform. The model was put forth to help schools and the ABET to change curricula to better suit job market needs, not to replace the ABET accreditation requirements.

The five managers were asked to develop independently a model curriculum that did not necessarily have to meet accreditation guidelines. Through a series of meetings and compromises, models that resulted were synthesized into the single model presented. The recommendations were grouped into eight categories, three of which are nontechnical: (1) communications skills, (2) political and economic sciences, and (3) other humanities and social sciences. The committee's recommendation summary for changing ABET curricula were to: (a) increase credit hours to 140 from 128 (ABET, 1985), (b) increase nontechnical curricula to 24% of the program from 12.5% (ABET, 1985), (c) increase emphasis on the nontechnical subjects of
communications, political sciences, and economic sciences, (d) teach that interpersonal relationships are a factor in career success, and (e) increase emphasis on technical interdisciplinary subjects in mechanical engineering. Three of the five recommendation categories were to increase nontechnical curricula emphasis. None of the managers find fault with the technical portion of the electrical engineering curricula.

Walker Model Curriculum

The American Society of Engineering Education sponsored a committee which carried out 5 years of studies to provide a modern set of goals for engineering education (Walker, 1968). Data were gathered from engineering educators, working engineers, and employers of engineers throughout the United States. Past studies were reviewed in order to note trends. Recommendations were made in hopes of improving engineering education to better meet employer, employee, and societal needs. In a survey of educators and engineering graduates from 156 institutions, 70% responded that the social role of engineers would increase between 1968 and 1978.

The major trend noted was an increasing unity of purpose and uniformity of graduation standards among the various branches of the BSE programs. Evidence of this trend was an increasing emphasis on teaching basic technical knowledge and a broadening of content in the nontechnical direction. These factors were believed to enable the BSE graduate to practice in a greater variety of occupations. Engineering education had "developed from a group of occupationally
oriented specialties into a liberal program of rather general nature" (Walker, 1968, p. 374). The committee suggested that the breadth of the BSE programs was likely to increase in future years and should provide a "richer understanding of social and economic forces that will influence and be influenced by technology" (p. 375). The core of engineering mathematics, engineering science, and analysis should be tempered with natural science, social science, humanities, and communication arts. This curriculum change should allow "graduates to assume their role as college-educated citizens in our society" (p. 382).

Summary of Model Curricula

The ABET (1985) curriculum was the weakest of the three models in nontechnical percentage, scope, and outcome statements. If ABET were to define communications and economics as nontechnical curricula, the weakness would be largely overcome and ABET nontechnical proportion would be more comparable with IEEE and Walker proportions (see Table 4). The IEEE curriculum (C. J. Baldwin et al., 1979) has 24% of total BSEE program credits as nontechnical (92% more than the ABET accreditation requirement). The Walker (1968) curriculum has 20% of total BSE program credits as nontechnical (60% more than the ABET accreditation requirement). Both IEEE and Walker models listed courses in the communications category and the political and economic sciences category. The ABET has no nontechnical percentage or credit hour recommendations for these categories. (See Table 4.)

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<table>
<thead>
<tr>
<th>Nontechnical category</th>
<th>ABET 12.5% curriculum</th>
<th>IEEE 24% curriculum</th>
<th>Walker 20% curriculum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum nontechnical proportion</td>
<td>12.5%</td>
<td>24%</td>
<td>20%</td>
</tr>
</tbody>
</table>
| Communication skills | (0% of credits)
Exercises of personal crafts are not acceptable. Courses must have some theory or history. | (9% of credits)
English comp. and rhetoric (6 cr.)
Literature and composition (3 cr.)
Technical presentation and speech (3 cr.) | (No % balance)
Oral and written in all courses
Engineering graphics |
| Political and economic sciences | (0% of credits)
Accounting, management, finance do not fulfill the humanities and social science objectives. | (9% of credits)
Economics theory (3 cr.)
Economics of business (3 cr.)
Modern political trends (3 cr.)
Legal issues for engineers (3 cr.) | (No % balance)
Economics
Political science |
| Humanities and social sciences | (12.5% of credits)
Objectives: (1) full awareness of responsibilities to society, (2) consideration of nontechnical factors in decision making. | (6% of credits)
Psychology of interpersonal relationships (3 cr.)
Electives (6 cr.) | (No % balance)
History
Philosophy
Psychology
Sociology
Electives
One course per term. |

*Note: ABET (1985) expects the development and demonstration of some of these skills to take place within technical courses. No credits or percentage of curriculum is specified.*
Management Theory Support

Eight principles describing management practices of successful American businesses and industries were used to support the proposition that beyond the 1980s, business management tasks would de-emphasize technical functions such as accounting, finance, decision analysis, and tight control. Nontechnical functions such as customer and worker communications, relationship building, enhancing worker autonomy, and practicing participative management would be emphasized. Case study examples in many instances indicated that engineers, as well as managers, can employ the eight principles, most of which (Appendix A) describe nontechnical job tasks and skills (Peters & Waterman, 1982). The assumption was that when successful businesses and industries excelled at nontechnical tasks, job requirements, particularly for technical jobs, would change to emphasize development and utilization of nontechnical tasks. Case study examples of successful businesses and industries were used to create a foundation of descriptive research for the development of a people-oriented, non-analytic (assume nontechnical) management theory. Case study examples of unsuccessful businesses and industries were used as an argument against existing rational (assume technical) management theory.

The theory of human motivation, often known as Maslow's (1970) hierarchy or pyramid, has been applied to work organizations to explain behavior and personal growth in the working environment. Work was assumed to be in large part a social experience with the
meaning of work existing in human interrelations. As a person psychologically matures in the working organization, the lower levels of Maslow's hierarchy motivate behavior less and higher levels motivate behaviors more. The levels from lowest to highest can be named: (a) physiological needs, (b) safety needs, (c) social needs, (d) ego needs, and (e) self-fulfillment needs (Sergiovanni & Starratt, 1983). Maslow's hierarchy is a theory which describes how humans develop relations with others and, in this application, mature in the work environment (Schwartz, 1983). Thus, the process of moving up the motivation hierarchy in the work organization is a (assume nontechnical) process of maturation and of satisfying human needs. Maslow (1971) discussed education in relation to his theory. He implied that education's major role was helping people grow in human (assume nontechnical) dimensions. He selected education in the arts as being the kind of education closest to the psychological and biological core that would best assist in human growth.

Adult Education and Learning Theory

Adult education theory is newer than general education theory. Adult education theory was proposed as a separate theory only in the 20th century. Adult education study is also newer than general education study. The American Association for Adult Education was founded by the Carnegie Corporation of New York in 1926. The first doctoral degree in adult education was awarded by Columbia University in 1935 (Robinson, 1979).
The pedagogy (Greek for "leader of children") model of education is an ideology based on assumptions about teaching that came out of European monasteries between the 7th and 12th centuries. This model was assumed to underlie most of the United States kindergarten-through-12th grade instruction and many of the college and adult education courses. The pedagogy model makes the teacher responsible for deciding what will be learned, how the content matter will be learned, when the subject will be learned, and if the facts are necessary to know at all.

The androgogy (Greek for "leader of adults") model (Knowles, 1984) of education takes exception to the application of the pedagogy model to adult education. The androgogy model differs from the pedagogy model in six major assumptions about learners. Table 5 outlines these six differences. Although the theory of androgogy does not favor technical over nontechnical, the theory describes teaching norms that best respond to the learner.

A general learning theory that more specifically identifies elements that can help instructors plan lessons and courses, conduct instruction, and assess learning is an information processing theory (Gagne, 1974). The theory identifies eight phases of the act of learning. The information processing theory classifies the eight acts into a systems model with inputs (stimulation received by the learner), processes (the learner's mind), outputs (learner behavior), outcomes (learner performance), and feedback (learner perception of behavior change). The phases, systems model category, and brief descriptions are in Table 6.
Table 5
Comparisons of Assumptions About Learners: Pedagogy Model Versus Androgogy Model

<table>
<thead>
<tr>
<th>Assumption</th>
<th>Pedagogy assumption</th>
<th>Androogy assumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The need to know</td>
<td>The teacher and administration determine what children need to know in order to shape their lives.</td>
<td>Adults want to know why they must learn, how content applies to their experience, and how knowing will help them achieve their own goals.</td>
</tr>
<tr>
<td>2. Self-concept of the learner</td>
<td>Teachers view children as dependent and provide order and direction thus reinforcing dependence.</td>
<td>Adults lead self-directed, independent lives, yet in formal education situations often regress to a dependent state they experienced in school as children.</td>
</tr>
<tr>
<td>3. The role of experience</td>
<td>Experience is not seen as a worthwhile learning resource because children have so little. Teacher centered instruction brings a homogeneity to the classroom.</td>
<td>Adults want to incorporate their wealth of experiences into educational activities. Teachers should recognize and utilize the heterogeneous experiences of the learners.</td>
</tr>
<tr>
<td>4. Readiness to learn</td>
<td>Readiness is determined by the teacher and administration usually by applying uniform educational standards.</td>
<td>Readiness is determined by the adults when they need to know in order to cope with real life situations at work, home, or community.</td>
</tr>
<tr>
<td>5. Orientation to learning</td>
<td>Learners are taught using a subject-centered approach.</td>
<td>Learners usually respond best to task, problem, or life centered approaches.</td>
</tr>
<tr>
<td>6. Motivation</td>
<td>Motivators are teacher and parent approval or disapproval.</td>
<td>Motivators stem from using knowledge in task or problem situations.</td>
</tr>
</tbody>
</table>
Table 6
Eight-Phase Information Processing Learning Theory

<table>
<thead>
<tr>
<th>Phase name (system category)</th>
<th>Description of phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Motivation (input to learner)</td>
<td>Incentive motivation is established by communicating a goal to be achieved and by generating within the learner an expectancy; the anticipation of reward for reaching a goal.</td>
</tr>
<tr>
<td>2. Apprehension (input to learner)</td>
<td>The learner must attend, usually by listening or reading for meaning, to teaching stimulation. Attention is narrowed selectively to perceive stimuli that are believed to relate to the achievement of the learning goal.</td>
</tr>
<tr>
<td>3. Acquisition (process within the learner)</td>
<td>Apprehended information is stored in the brain's short term memory in coded form called a learned entity. Little is known about the truth of this concept.</td>
</tr>
<tr>
<td>4. Retention (process within the learner)</td>
<td>The learned entity stored in the short term memory enters into long term memory and may either be permanent or slowly &quot;fade.&quot; Little is known about the truth of this concept.</td>
</tr>
<tr>
<td>5. Recall (process within the learner and output from the learner)</td>
<td>The learned entity is retrieved from memory when cues similar to or within the context of learning (Steps 1-4) are perceived by the learner.</td>
</tr>
<tr>
<td>6. Generalization or transfer (process within and output from the learner)</td>
<td>This step is the retrieval of the learned entity when new and different cues or contexts are perceived by the learner.</td>
</tr>
<tr>
<td>7. Performance (output and outcome from the learner)</td>
<td>The learner exhibits an observed performance of what was learned when cues are perceived by the learner.</td>
</tr>
<tr>
<td>8. Feedback (feedback)</td>
<td>The observed performance (by self or others) is compared with the anticipated goal. When the goal is achieved, a process of reinforcement or reward takes place.</td>
</tr>
</tbody>
</table>
Range of Literature Investigated

Literature from engineering and education books and periodicals between the years 1976 and July 1986 was investigated. Some literature prior to 1976 and some 1987 and 1988 literature are also cited but the search of these dates was not thorough. The primary literature source was the Western Michigan University library. The search was done using the card catalog and periodical indexes. The Western Michigan University computer data base of approximately 4 million books 1976 through June 1986 was also used to search for library books. An ERIC search and a Compendex search of periodical literature between 1980 and July 1986 was performed. Research was also done at the Society of Manufacturing Engineers library in Dearborn, Michigan.

Summary

The review of literature has been presented in four parts: (1) a general history of the engineering profession and discussion of the increase of professional work based on knowledge application from 1950 to 1986; (2) a review of studies pertaining to engineering task changes or engineering education curricula changes between the technical and nontechnical; (3) a review of some theories, studies, and opinion articles that may be used to explain engineering job task shifts between technical and nontechnical; and (4) a discussion of general and adult education and adult learning principles and theories. In the first part a brief background of the engineering
profession was presented. In the second part leaders of three major engineering curricula studies made recommendations that the ratio of nontechnical to total curricula be increased to 20% (Grinter, 1955; Hammond, 1944; Walker, 1968). Other studies (Burdell, 1956; Adam, 1984) show the ratio of nontechnical to total curricula has fallen short of 20%. In the third part, theories and studies that could explain some engineering job trends and the importance of nontechnical job skills such as interpersonal relationship skills and communication skills were reviewed (Adam, 1984; Herr, 1977; Hurt et al., 1986; Rutt et al., 1986). Curricula shift from technical to nontechnical was recommended to improve the BSE curricula (Grinter, 1955; Hammond, 1944; C. J. Baldwin et al., 1979; Walker, 1968). In response to the issue of the importance of continuing education of engineers that was highlighted in much of the literature, an adult education theory (Knowles, 1977) and a general learning theory (Gagne, 1974) were presented in the fourth part.
CHAPTER III

RESEARCH DESIGN AND METHODOLOGY

The purpose of this study was to compare and critique the non-technical curricula content of three Bachelor of Science in Engineering (BSE) degree program model curricula. Curricula content areas that are similar were critiqued by employers of engineers. Model curricula importance and first year BSE nontechnical skill performance were rated by supervisors of first year BSE graduates. The main postulate is that differences among actual, model, and employer-desired nontechnical curricula are factors that may influence curricula change in engineering education. A secondary purpose was to measure the change in the ratio of nontechnical to technical curricula in some BSE programs between 1975 and 1985 and to compare the actual proportions with recommended proportions. The ratio was expected to be changing away from technical curricula and toward non-technical curricula.

In this chapter, the sampling plan, the research methods, and research designs are described. The two research tools are: (1) a content analysis to categorize and compare nontechnical curricula among three model curricula (ABET, 1985, C. J. Baldwin et. al., 1979; Walker, 1968) and (2) a survey of employer rating of skills of new BSE graduate engineers. Comparisons were made of nontechnical curricula proportions of 10 top ranked (Glower, 1980) engineering
colleges with the three model curricula recommendations for nontechnical curricula proportions. All colleges selected were accredited by the Accreditation Board of Engineering and Technology (ABET) for the Bachelor of Science in Electrical Engineering (BSEE) degree. The data came from 1975 and 1985 college catalogs and a comparison of the ratios of nontechnical to technical curricula is presented and compared with prior studies (Adam, 1984). Engineering supervisors were not randomly selected but are assumed to be representative of all engineering supervisors. Supervisors were selected so as to be reasonably diversified in the demographic characteristics of company size, geographical location, and company type. The representative selection was used because of the difficulty of finding random lists of supervisors of engineers. Engineering jobs are not easily quantified and are not homogeneous in nature.

Selection Procedures for Institutions to Be Studied

BSE program curricula from the 10 highest ranked colleges were studied. The criterion for choosing the 10 highest ranked was the number of undergraduate engineering citations in Who's Who in Engineering (cited in Glower, 1980) per 1,000 alumni of the program. The highest ranking schools were selected because their engineering programs are likely to lead in curriculum development that responds to the education requirements of the engineering job marketplace.

The top three colleges and bottom three ranked colleges of the group of 10 were compared to see if ranking is correlated with nontechnical curriculum quantity. The ranking used program graduate
citations and was assumed to be an indicator of relative job market-place approval of each college's engineering program. Selecting 10 colleges also limited the amount of research to a reasonable level. The selections are listed in the Table 7 ranked list of colleges. A request for 1975 and 1985 catalogs was made of the department of archives (Appendix B) at all 10 colleges and those responding are used for the analysis. A follow-up request for catalogs was sent to colleges not responding the first time. Seven of the 10 colleges responded with complete data. Three did not have catalogs or did not respond. Catalogs within 2 years of 1975 or 1985 are used when 1975 or 1985 catalogs are not available.

Survey Data Collection

Employer curricula rating was measured by using a questionnaire administered to a selected sample of supervisors of new BSE engineers. A new BSE engineer was one who received a BSE degree within the past one year. Addresses, supervisor names, supervisor job titles, and company names were obtained from a professional engineering association which requested not to be named. A sample of 150 names was selected from a mailing list by a computer program which skips a constant number of names before picking a name. Mailing list names selected all had the job category of engineer supervisor. One hundred supervisors were prequalified by explaining the survey in a letter (Appendix C) and requesting that the supervisor indicate willingness to participate by signing and returning an enclosed postcard. Demographic data from the respondents are presented and
Table 7
Bachelor of Science Electrical Engineering Programs
Ranked by 1979 Achievements of Graduates

<table>
<thead>
<tr>
<th>Rank</th>
<th>Citations per 1,000 students</th>
<th>College name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>21</td>
<td>Columbia University</td>
</tr>
<tr>
<td>2.</td>
<td>18</td>
<td>University of Pennsylvania</td>
</tr>
<tr>
<td>3.</td>
<td>17</td>
<td>Stanford University</td>
</tr>
<tr>
<td>4.</td>
<td>10</td>
<td>Cornell University</td>
</tr>
<tr>
<td>5.</td>
<td>10</td>
<td>Massachusetts Institute of Technology</td>
</tr>
<tr>
<td>6.</td>
<td>9</td>
<td>Ohio State University</td>
</tr>
<tr>
<td>7.</td>
<td>9</td>
<td>Iowa State University</td>
</tr>
<tr>
<td>8.</td>
<td>8</td>
<td>University of Michigan</td>
</tr>
<tr>
<td>9.</td>
<td>7</td>
<td>Northwestern University</td>
</tr>
<tr>
<td>10.</td>
<td>7</td>
<td>Princeton University</td>
</tr>
</tbody>
</table>


analyzed to indicate the sample is diversified by geography, company size, and company type. Twenty-eight supervisors responding to the participation request letter were sent the survey. Raw data from the surveys are compiled to rate model curricula content importance and new engineer performance level.

Survey data were collected by: (a) obtaining a mailing list from a professional engineering society, (b) selecting names from the mailing list and mailing prequalification request forms, (c) mailing
surveys to prequalified engineering supervisors, and (d) mailing a follow-up survey to engineering supervisors. The survey administration data are presented in Table 8.

A mailing list was obtained from a professional engineering society 8 months before the last survey response was received. One hundred and sixty names were received June 1988. List names ranged between 1 and 27 months old with a mean age of 14 months. One hundred and one prequalification requests were mailed 2 months after receiving names. Fifty-nine names were not used because most came from Michigan and California which were overrepresented. Twenty-nine signed prequalification postcards were received within one and one-half months. Twenty-nine surveys were mailed within 1 month, and 17 responses were received within another month. Second surveys were mailed within one-half month of receiving the 17th response. Nine additional survey responses were received within two months of mailing the second request. A total of 26 surveys out of 29 prequalified supervisors were received for a 90% response rate. One of the 26 survey responses was not usable. The supervisor returned the unfilled survey with a note stating that he did not supervise engineers.

Survey Population and Sample Size

Population and sample size information are reported in Table 9. Responses from 25 supervisors were gathered. Data from one of the 25 will be treated separately because it represents 151 cooperative education engineers. The responses omitting cooperative education
### Table 8
Survey Administration Data

<table>
<thead>
<tr>
<th>Event description</th>
<th>Number</th>
<th>Event time</th>
<th>Cost to research</th>
<th>Hours to research</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Age of society list</td>
<td>N.A.</td>
<td>1-27 mo. old</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14 mo. mean</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Supervisor names received from society</td>
<td>160</td>
<td>0.0 mo.</td>
<td>$20</td>
<td>10 hr.</td>
</tr>
<tr>
<td>3. Prequalification requests mailed</td>
<td>101</td>
<td>2.0 mo.</td>
<td>$47</td>
<td>6 hr.</td>
</tr>
<tr>
<td>4. Prequalification requests returned</td>
<td>33</td>
<td>1.5 mo.</td>
<td>N.A.</td>
<td>3 hr.</td>
</tr>
<tr>
<td>5. Prequalification &quot;yes&quot; responses &quot;no&quot; response</td>
<td>29</td>
<td>N.A.</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td>&quot;not employed here&quot;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;company bankrupt&quot;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Surveys mailed</td>
<td>29</td>
<td>1.0 mo.</td>
<td>$30</td>
<td>5 hr.</td>
</tr>
<tr>
<td>7. First surveys returned</td>
<td>17</td>
<td>1.0 mo.</td>
<td></td>
<td>N.A.</td>
</tr>
<tr>
<td>8. Second survey sent</td>
<td>29</td>
<td>0.5 mo.</td>
<td>$30</td>
<td>4 hr.</td>
</tr>
<tr>
<td>9. Second surveys returned</td>
<td>9</td>
<td>2.0 mo.</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td>10. Unusable survey manager does not supervise engineers</td>
<td>1</td>
<td>N.A.</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td></td>
<td><strong>8 mo.</strong></td>
<td><strong>$127</strong></td>
<td><strong>28 hr.</strong></td>
</tr>
</tbody>
</table>

**Note.**
1. Event time total is the sum of Events 2 through 9.
2. Research cost is mail, telephone, and copy costs rounded to the nearest dollar.
3. N.A. is the abbreviation for "not applicable."

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engineers represent evaluations of 78 first year BSE degree engineers between the years 1975 and 1985. The total population of supervisors is estimated to be 125,000 (Table 6, Item 6). The total population of first year BSE degree engineers between January 1975 and December 1985 is 660,000 (U.S. Department of Commerce, 1986). The sample size of 25 supervisors and 78 first year BSE engineers was not representative of the estimated populations; however, the size was sufficient to indicate strong differences or to be a pilot study for additional research. Research cost and research time were limited to reasonable levels by selecting a small sample size.

Table 9
Population and Sample Size Information

| 1. Engineers in the 1980 U.S. labor force | 1,675,900 |
| (National Science Foundation, 1985) |
| 2. BSE degrees conferred 1975-1986 | 660,000 |
| (U.S. Department of Commerce, 1980, 1988) |
| 3. Estimated number of supervisors of first year BSE graduate engineers | 125,000 |
| (Calculated by dividing Item 3 by the survey average span of control of 5.29) |
| 4. Number of BSE engineers represented by 25 survey responses | 78 |
| 5. Number of BSE engineers represented by the one co-op program survey response | 151 |

Content Analysis

Content analysis is the research procedure used to categorize verbal, written, or behavioral data for the purposes of
classification, summarization, and tabulation (Fox, 1969). Content analysis is also defined as a technique for making inferences by objectively and systematically identifying specified characteristics of messages (Budd, Thorp, & Donahew, 1967). Content analysis was used to categorize, compare, and combine nontechnical curricula of three model curricula (ABET, 1985; C. J. Baldwin et al., 1979; Walker, 1968). Each model is categorized by finding outcome statements of engineer behavior. These outcome statements are organized in Table 10 into four categories.

There are two levels of content analysis: manifest and latent. Manifest content analysis is strictly bound by the subject response or text, with nothing read into the data or assumed about the data. Manifest content analysis is used to analyze technical versus total credits in the BSE degree programs. Latent content analysis is a method used to interpret the meaning of the response or text to uncover underlying motivations or intent (Fox, 1969). Latent content analysis was used to analyze outcome statements of engineer skill behavior in the three model curricula. Latent content analysis has lower reliability and validity than manifest content analysis. Therefore, findings from the latent text analysis are only used to find clearly evident skill outcome statements and not to discover less evident statements. A synthesis of the outcome statements from the three model curricula into a single set of skill categories (Table 12) increases validity and reliability over simply organizing the statements (Table 10).
Table 10
Nontechnical Engineering Curricula: Outcome Based Skills Statements

<table>
<thead>
<tr>
<th>ABET skills statements</th>
</tr>
</thead>
</table>

**Communications**

1. Competency in written communication in the English language is essential for the engineering graduate.

2. Oral communications skills in the English language must be demonstrated.

**Political and economic sciences**

1. The engineer will make economical use of materials and forces of nature for the benefit of mankind.

**Humanities and social sciences**

1. The engineer will have full awareness of professional responsibilities to society (example: ethics, health, safety, welfare).

2. The engineer will consider nontechnical factors in decision making (example: socially-related technical problems).

**Other**

ABET has no other nontechnical skills statements.

<table>
<thead>
<tr>
<th>IEEE skills statements</th>
</tr>
</thead>
</table>

**Communications**

1. The engineer will be able to write and orally present technical reports and proposals.

2. The engineer will be able to write and analyze exposition, argument, logic, and rhetoric.

3. The engineer will be able to speak to groups and to use visual aids.
Table 10—Continued

IEEE skills statements—Continued

Political and economic sciences

1. The engineer will be able to explain national politics and economics effects on business.

2. The engineer will be able to explain, use, and calculate business economic functions.

3. The engineer will be able to explain and use some laws relating to engineering.

Humanities and social sciences

1. The engineer will be able to explain and use some psychology of interpersonal relationships.

Other

1. Electives will "enhance the all-around growth of the individual as a professional engineer" (not behaviorally demonstrable).

Walker skills statements

Communications

1. The engineer will be able to organize thoughts logically and to express them lucidly and convincingly in oral and written English.

Political and economic sciences

1. The engineer will be able to understand the evolution of the social organization within which we live and the influence of science and engineering on its development.

2. The engineer will be able to recognize and to make a critical analysis of problems involving social and economic elements, to arrive at an intelligent opinion about them, and to read with discrimination and purpose toward these ends.
Walker skills statements—Continued

**Humanities and social sciences**

1. The engineer will know about some of the great masterpieces of literature and will understand their setting in and influence upon civilization.

2. The engineer will develop moral, ethical, and social concepts essential to a satisfying personal philosophy, to a career consistent with the public welfare, and to a sound professional attitude.

**Other**

1. The engineer will attain an interest and pleasure in the pursuits of continuing education.

The content analysis process has the following four attributes: (1) units of text must be clearly defined, (2) categories into which units are sorted must be exhaustive, (3) categories into which units are sorted must be mutually exclusive, and (4) categories must have a rationale or theory to guide placement of text and to give meaning to the findings (Fox, 1969). To implement the content analysis research, a six-stage process compatible with the four attributes is used (Budd, et al., 1967). The six stages are listed and defined in Table 11.

**Category and Measurement Descriptions**

Category definition, data coding and sorting rules, and measurement scales need to be described for the four research questions. Manifest content analysis is the research tool for the first research
Table 11
Six-Stage Content Analysis Research Process

1. Formulate the research question, theory, and hypothesis.
2. Select a data sample and define categories.
3. Code the data using objective rules.
4. Categorize and scale the coded data.
5. Compare scaled categories with other variables.
6. Interpret findings according to theory or concepts.

question. Question 1 was: To what extent are there similar content
descriptions of skill outcomes among three BSE model curricula (ABET,
1985; C. J. Baldwin et al., 1979, Walker, 1968)? The first part of
Question 2 was: What are engineer supervisor ratings of skills
described in two out of the three model curricula (ABET, 1985; C. J.
Baldwin et al., 1979; Walker, 1968) of: (a) nontechnical skill
importance to job performance, and (b) skill behavior of first year
BSE graduates? Means and standard deviations are reported for each
skill in both category (a) and (b). Question 3 was: How do ratings
of skills described in two out of three model curricula (ABET, 1985;
C. J. Baldwin et al., 1979, Walker, 1968) compare between: (a) non-
technical skill importance to job performance, and (b) skill behavior
of first year BSE graduates compare? A t test comparing mean ratings
of the same skills between categories of (a) and (b) is the research
tool for the second part of the second research question. Question 4
was: Has the proportion of nontechnical to total required courses
for ABET accredited BSEE degree programs in the top 10 United States engineering colleges (Glower, 1980) changed between 1975 and 1985? Latent content analysis is the research tool that supports Research Question 4. Question 5 was: How does the the proportion of nontechnical to total required courses for ABET accredited BSEE programs in the top 10 United States engineering colleges (Glower, 1980) compare with the proportion required by ABET (1975, 1985) and by three engineering program study commissions (Grinter, 1955; Hammond, 1944; Walker, 1968)? A comparison of mean college nontechnical to total required BSE curricula to recommended nontechnical to total curricula will be the research tool for the fourth research question.

There is no standard or accepted definition of a nontechnical course or of a technical course. The operational definition for this study is that nontechnical courses include humanities and social science courses (ABET, 1986), but exclude physical education (Kline, 1984), business education (Hammond, 1944; Grinter, 1955; Walker, 1968), and Reserve Officer Training Corps (Burdell, 1956). The operational definition of technical courses is: (a) all engineering courses and (b) preparatory or adjunct courses for engineering including mathematics, physics, and chemistry. These operational definitions allow comparisons to be made with past studies. The definitions do not allow testing of the postulate that engineers are doing more managerial work and less technical work because managerial or business training is considered technical.

The measurement of nontechnical to total required credits is converted from credit hours to a percentage ratio or proportion. A
percentage ratio was used in the historical studies (Burdell, 1956; Hammond, 1944; Grinter, 1955; Kline, 1984; Walker, 1968) and made semester hours and quarter hours comparable. Credit hour data is presented in Table 14. Required credits constitute 3 out of 4 years of the Bachelor of Science in Engineering degrees (ABET, 1986).

Engineering Curricula Models

Outcome-based skills statements from the three models summarized in Chapter II are presented in this section. In the IEEE (C. J. Baldwin et al., 1979) model, the skills statements are contained in the course content descriptions (Appendix G). In the Walker (1968) model, statements are in the discussion on nontechnical curricula (Appendix H). The ABET (1975) model outcome statements (Appendix I) are worded broadly or vaguely. The wording makes specific skills difficult to define, measure, or demonstrate. The ABET statements are useful to compare with or to support the more specific Walker or IEEE statements. Table 12 lists excerpted ABET, IEEE, and Walker skills behavior statements organized into categories to help make the comparisons easier. Outcome statements of engineer skill behavior are organized into categories used by the IEEE model and suggested by the other models. The four categories are: (1) communications, (2) political and economic sciences, (3) humanities and social sciences, and (4) other. The statements were compared with each other to note similarities and differences. Similar skills statements appearing in at least two models were condensed and synthesized to be used in the employer survey to rate first year BSE graduate nontechnical skills.
Table 12
Skill Category and Description Synthesis for the Employer Survey

<table>
<thead>
<tr>
<th>Skill category</th>
<th>Skill description</th>
<th>Model references</th>
</tr>
</thead>
<tbody>
<tr>
<td>Written communication</td>
<td>Able to express ideas clearly and make logical arguments in writing.</td>
<td>IEEE: English composition and rhetoric, lit. and comp.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Walker: Goal 3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ABET: Requirement 4G</td>
</tr>
<tr>
<td>Oral communication</td>
<td>Able to express ideas clearly in speech and to make group presentations.</td>
<td>IEEE: Technical presentation and speech</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Walker: Goal 3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ABET: Requirement 4G</td>
</tr>
<tr>
<td>Economics</td>
<td>Able to use budgets, cost analysis, and other economic methods in business engineering decision making.</td>
<td>IEEE: Economics of business, economics theory</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Walker: Goal 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ABET: Requirement 4C, elective course, requirement 4H</td>
</tr>
<tr>
<td>Human relations ability</td>
<td>Able to get along and function well with others.</td>
<td>IEEE: Psychology of interpersonal relationships</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Walker: Goals 1 and 5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ABET: Requirements 4A and 4B</td>
</tr>
<tr>
<td>Professionalism</td>
<td>Exhibits proficient engineering methods, standards, and character.</td>
<td>ABET: Requirements 4A and 4H</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Walker: Goal 5</td>
</tr>
<tr>
<td>Ethics and morals</td>
<td>Exhibits a system of moral principles, values, and conduct in decision making.</td>
<td>IEEE: Electives goal statement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Walker: Goal 5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ABET: Requirement 4H</td>
</tr>
<tr>
<td>Skill category</td>
<td>Skill description</td>
<td>Model references</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-----------------------------------------------------------------------------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td>Social responsibility</td>
<td>Exhibits good judgment, sound thought, and is trustworthy when considering public welfare in decision making.</td>
<td>ABET: Requirements 4A and 4H Walker: Goal 2</td>
</tr>
<tr>
<td>Learning ability</td>
<td>Able to learn new ideas, methods, and behaviors.</td>
<td>ABET: Requirement 4G Walker: Goals 2 and 6</td>
</tr>
<tr>
<td>Continuing education</td>
<td>Pursues education by reading journals, taking classes, or seminars.</td>
<td>ABET: Curricular Objective 2.4 Walker: Goal 6</td>
</tr>
</tbody>
</table>
Employers rated nontechnical skills in two dimensions as follows: (1) importance of nontechnical skill categories to job performance, and (2) actual nontechnical skill level of first year BSE engineers.

Syntheses of Curricula Models for Survey Design

The three engineering curricula models are simplified and combined to form skills descriptions for the employer survey. The rule for a skill category synthesis is that two or more of the three models (ABET, 1975, C. J. Baldwin et al., 1979; Walker, 1968) must refer to the skill. In addition, the skill must be one that is demonstrable and applicable on most engineering jobs. For example, a skill involving knowledge of our national political system would not be demonstrable or applicable in most jobs. Skill references may be in the form of course content descriptions, skills statements, or program objective statements. Skill category names and skill category descriptions are chosen to best represent the model descriptions while remaining concise and brief (see Table 12).

Employer Survey

The employer survey was intended to represent engineer employers' critiques of the entry level engineers with accredited BSE degrees. The engineering job market is subdivided by employer category into industrial jobs, government jobs, and consulting (independent engineering) jobs. Engineering work in sales, marketing, management, operations, and other categories was ignored as not being primarily engineering in nature. Also, entry level engineers were
not likely to get work in those areas without years of experience. Consulting jobs were ignored in the survey as being unlikely for entry level engineers to get. Consulting jobs are independent in nature and are usually filled by a Level III (Wright, 1982) engineer or higher. Level I engineers represent the entry level and are most likely to be represented by selecting supervisors working in industry.

Engineering supervisors employed in industry were selected for the employer survey. The supervisors were qualified with survey questions about their supervisory responsibilities for first year BSE engineers. Qualified supervisors were expected to be most familiar with the relationship between job requirements for engineers and skills of new BSE engineers. The measurement of the rating of importance to job performance of various nontechnical skills is reported. The measures represent engineer manager valuation of the various model nontechnical curricula categories. The measure of supervisor observations of first year BSE employee performance in nontechnical skills categories is also reported and is compared with the skill importance to job performance.

The sample of engineering supervisors was selected from a professional engineering society mailing list database. The society asked not to be named. The society also limited the data to non-member names due to a policy of not allowing outsiders to mail items to members. Organizational support or permission for the professional engineering society to do the mailing to members was not available. This list was available to the researcher and was
believed to adequately represent engineer supervisors in industry. The professional society has approximately 5% to 10% of all engineers as members (approximately 100,000 members out of 1,000,000 or 2,000,000 total engineers). An unknown number of nonmembers communicate with the society to obtain printed materials, to attend seminars, and to obtain other services. The researcher assumes that the nonmember list was reasonably representative of engineer supervisors in industry and obtained demographic data to help support the assumption (Appendix J).

Supervisor Questionnaire Design

Engineering supervisors were prequalified by sending a letter (Appendix C) describing the survey and asking them to participate. Supervisors who signed and returned an enclosed postcard were sent the survey. The survey questionnaire was sent with a cover letter (Appendix D). The letter contained a brief overview, a confidentiality statement, and a thank-you statement of appreciation. The survey (Appendix F) has qualifying questions, demographic information questions, and questions asking supervisors to rate skill importance to the job and to rate skill behaviors exhibited. Skill rating questions have skills listed in Table 12 and constitute the body of the survey. A 6-step scale is defined for each of the skill rating questions. Steps 1 through 5 are assumed to represent equal differences in ratings. A 6th "zero step" represents a "not applicable" rating and is reported as a skill that is not applicable to the job or a behavior which is unknown. The survey was mailed to 29
supervisors of engineers. In order to increase the return rate the questionnaire was short, taking about 15 minutes to answer. Also, a second request letter (Appendix E) was sent to increase return rate.

Statistics Used for Survey Analysis

The mean of each skills rating and standard deviation of each skills category is reported (Appendix K). These descriptive statistics compile the judgmental information from the supervisors who were surveyed. An interval scale in which each interval is equal was assumed to be appropriate for the five-step scales that are in the survey. Scale point descriptions were worded to be understood as equal to each other for the ratings of: (a) non-technical skill importance to job performance, and (b) skill behavior of first year BSE graduates. Scale descriptions for skill importance to job performance also included wording to account for frequency of need on the job. Thus, a skill could be somewhat important but be infrequently needed and thus rate low. Ordinal and ranking scales apply but are not assumed because the scale descriptions were written to attempt to obtain equal rank intervals between the five steps. Assuming the interval scale allows the statistics of mean and standard deviation to be used.

The comparison between the ratings of: (a) non-technical skill importance to job performance, and (b) skill behavior of first year BSE graduates will be a ranking of the (a) category in order of rating and a t test of each (a) and (b) mean to discover significant difference at or above the \( p = .05 \) level (Borg & Gall, 1984). Three
The assumptions to use the t test are assumed to be met by the ratings. The assumptions are: (1) the ratings are measured on an interval scale, (2) ratings are normally distributed, and (3) variances are equal. The interval scale assumption is discussed in the previous paragraph.

Survey Sample Size

A small sample size of 25 was selected for reasons of economy and time savings. The small sample had the advantage over a large sample of being: (a) lower cost, (b) quicker, and (c) easier to calculate. A small sample is able to test a significant hypothesis or to provide descriptive data for a significant difference. Statistics appropriate for small samples were used to estimate sampling error (Isaac & Michael, 1981). In a review of several hundred studies, the sample size for a descriptive survey of a national population of persons was in excess of 1,000 (Sudman, 1976). Even assuming the survey was seeking a dichotomous "yes" or "no" type of response with a probability of .95 that the sample proportion would fall within .05 range of sample error would require a sample of 394 (Isaac & Michael). The cost of obtaining 25 responses was $127 of printing and mailing expenses plus 28 hours of labor (Table 11). The estimated cost of obtaining 400 to 1,000 responses is $2,500 to $6,000 plus 200 to 500 hours of labor. The professional engineering society that provided survey names declined to sponsor or support a mailing for reasons of economy and because they usually develop their own surveys for their own purposes.
Nontechnical Curricula Proportion
Comparison and Interpretation

Nontechnical to total required credit is compared between 1975 and 1985. Since a standard deviation is unknown, a rule is used to determine what constitutes a significant change in nontechnical to total required curricula proportion. The requirement for significant change is 10% of the requirement (12.5% minimum nontechnical curricula). This is a 1.3% change in the total ABET required minimum curricula.

The major concepts used for comparison and interpretation of the data are the historical studies of nontechnical content of Bachelor of Science in Engineering programs and the ABET 12.5% minimum social sciences and humanities (assume nontechnical) requirement for program accreditation. A change in ABET (1987) accreditation wording allowed the possibility of less than the 1986 12.5% requirement by stating that 16 credits are required or 12.5% is required. If 16 credits is chosen for a program of more than 128 credits, the percentage would be less than 12.5%. There was, with one exception, a significant change in nontechnical to total curricula proportion between the preaccreditation era 1885, 1915 (Mann, cited in Adam, 1984), 1923 (Wickendon, cited in Adam, 1984), 1939 (Jackson, cited in Adam, 1984), and the ABET accreditation era starting in 1940. The 12.5% ABET social sciences and humanities percentage requirement was instituted in 1940 (ABET, 1984). Using the rule that 1.3% change in nontechnical to total curricula constitutes significant change, the change between the 1885 through 1939 years is significant and ranges
from a 2.7% to 5.7% increase in nontechnical proportion. An excep-
tion is the year 1900 (Mann, cited in Adam, 1984) which had only 0.7% change.

Summary

The purpose of this chapter was to present the design of the study, selection of sample, collection of data, and analysis of data. The primary research tool was a content analysis and comparison of BSE curricula of the top 10 ranked engineering colleges with model curricula. A secondary research tool was an employer rating of model curricula categories. All colleges selected were accredited by the Accreditation Board of Engineering and Technology (ABET) for various BSE degrees. Three model curricula were selected for comparison: (1) ABET (1985), (2) IEEE (C. J. Baldwin et al., 1979), and (3) Walker (1968). The nontechnical curricula categories contained in at least two of the three models are listed and defined in terms of observable skills for an employer survey. The survey of engineering supervisors asked to give their opinions by rating the skill definitions that represent nontechnical curricula categories. Two dimensions of the nontechnical skills categories are measured and compared: (1) the rating of nontechnical skills importance to job performance, and (2) the rating of nontechnical skills observed in first year BSE engineers.

A replication of part of Kline's (1984) study was done to compare actual nontechnical curricula proportion required to obtain a BSE degree. Nontechnical requirement data come from 1975 and 1985
college catalogs of the top 10 ranked U.S. engineering colleges. A
comparison of any changes in the proportion of nontechnical to tech­
nical curricula is presented. Also, the mean nontechnical proportion
of the 10 colleges will be compared with ABET (1975, 1985) require­
ments and with recommendations of selected engineering education
study committees (Grinter, 1955; Hammond, 1944; Walker, 1968).
CHAPTER IV
ANALYSIS AND INTERPRETATION OF DATA

The purpose of this study was to compare and critique the non-technical curricula content of three Bachelor of Science in Engineering (BSE) degree programs with model curricula. Curricula content areas that are similar were critiqued by employers of engineers. Model curricula importance and first year BSE nontechnical skill performance were rated by supervisors of first year BSE graduates. The main postulate is that differences among actual, model, and employer-desired nontechnical curricula are factors that may influence curricula change in engineering education. A secondary purpose was to investigate whether the proportion of nontechnical courses to total required courses in BSE college degree programs changed between 1975 and 1985 and how actual proportions compare with recommended proportions.

In this chapter facts and data are presented in order to address each research question. Statistics suited for small sample sizes were used to analyze the supervisor rating of BSE nontechnical curricula items. Data are presented from a search to determine the proportion of nontechnical curricula in BSE programs of the top 10 ranked colleges. The nontechnical curricula study partially replicates similar studies done between 1885 and 1956 (Kline, 1984).
Research Question 1 was: To what extent are there similar non-technical curricula content descriptions of skill outcomes among three BSE model curricula (ABET, 1985; C. J. Baldwin et al., 1979; Walker, 1968)? This question needed the research tool of content analysis to produce a qualitative answer in the form of the non-technical categories of the supervisor survey. Nine non-technical categories were obtained by synthesizing similar skill descriptions in the three curricula models (Table 10). The rule for the synthesis is that at least two of the three models must describe the non-technical category as a skill requirement. Two non-technical categories from the IEEE (C. J. Baldwin et al., 1979) model (Table 8), political science and law, were not supported by the other two models. The nine categories were used in the survey to obtain employer job requirements and first year BSE engineer job performance ratings of each category.

Employer Ratings of Nontechnical Skills

Research Question 2 was: What are engineering supervisor ratings of skills described in two out of three model curricula (ABET, 1985, C. J. Baldwin et al., 1979; Walker, 1968) of: (a) nontechnical skill importance to job performance, and (b) skill behavior of first year BSE graduates? Nine nontechnical categories were named and described as the answer to Research Question 1. Twenty-nine supervisors of engineers were surveyed (Appendix F) to obtain ratings of
first year BSE employees' skill levels in the nine categories and to obtain supervisors' ratings of category importance to job performance (Appendix J). Six of the nine nontechnical categories were ranked 4.00 or more "often required" for importance to job performance (Table 13). The six are: (1) oral skills, (2) written skills, (3) professionalism, (4) ethics, (5) human relations ability, and (6) learning ability.

Research Question 3 was: How do engineering supervisor ratings of skills described in two out of three model curricula (ABET, 1985; C. J. Baldwin et al., 1979; Walker, 1968) compare between categories: (a) nontechnical skill importance to job performance, and (b) skill behavior?

Five of the nontechnical skill importance to job performance ratings differed at the .05 significance level with first year BSE employee nontechnical skill ratings (Table 13), last two columns). The five were: (1) oral skills, (2) written skills, (3) professionalism, (4) human relations ability, and (5) learning ability.

The survey of 25 supervisors of first year BSE degree engineers was used to gather qualitative data to compare with the synthesis of the three model curricula (ABET, 1985; C. J. Baldwin et al., 1979; Walker, 1968). The raw data, means, and standard deviations are presented in Appendix J. Supervisors of first year BSE graduates were asked to rate model curricula content items in two dimensions: (a) the importance of nontechnical skills to job performance, and (b) the nontechnical skill behavior of first year BSE graduates. Data for each group are ranked from highest mean to lowest mean in four
Table 13
BSE Supervisor Rating of Importance of Nontechnical Skills

Importance to Job Performance Rating Scale description:
5  The skill is mandatory for job performance.
4  The skill is often required for job performance.
3  The skill is desirable and is occasionally needed on the job.
2  The skill is of some use but is generally not needed on the job.
1  The skill is not needed on the job.

First-year BSE Performance Rating Scale description:
5  The skill was already highly developed.
4  The skill was adequately developed.
3  The skill was developed with brief training or coaching.
2  The skill was inadequate but was acquired with in-depth training.
1  The skill needed so much training to develop that it was not adequately acquired.

Means and standard deviations

<table>
<thead>
<tr>
<th>Skill importance</th>
<th>BSE job skill level ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Weighted means</td>
</tr>
<tr>
<td></td>
<td>25 managers</td>
</tr>
<tr>
<td></td>
<td>25 mgr. Co-op N = 78 N = 229</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
</tr>
<tr>
<td>Oral skills</td>
<td>4.48</td>
</tr>
<tr>
<td>Professionalism</td>
<td>4.44</td>
</tr>
<tr>
<td>Learning ability</td>
<td>4.44</td>
</tr>
<tr>
<td>Ethics</td>
<td>4.36</td>
</tr>
<tr>
<td>Writing skills</td>
<td>4.28</td>
</tr>
<tr>
<td>Human relations</td>
<td>4.28</td>
</tr>
<tr>
<td>Social resp.</td>
<td>3.84</td>
</tr>
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</table>

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Table 13—Continued

<table>
<thead>
<tr>
<th>Skill importance</th>
<th>BSE job skill level ratings</th>
<th>Weighted means</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>25 managers</td>
<td>3.64</td>
<td>0.69</td>
</tr>
<tr>
<td>N = 78</td>
<td>25 mgr. Co-op</td>
<td>N = 229</td>
</tr>
<tr>
<td>Finance</td>
<td>3.40</td>
<td>0.80</td>
</tr>
</tbody>
</table>

Note. In last two columns _N_ is the number of first-year BSE employees in the weighted mean.

A _t_-Test Comparison Between Skill Importance to Job Rating and Actual BSE Performance Rating

<table>
<thead>
<tr>
<th></th>
<th><em>t</em></th>
<th><em>df</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Oral skills</td>
<td>6.115^a</td>
<td>45</td>
</tr>
<tr>
<td>Writing skills</td>
<td>5.265^a</td>
<td>45</td>
</tr>
<tr>
<td>Professionalism</td>
<td>4.865^a</td>
<td>45</td>
</tr>
<tr>
<td>Human relations</td>
<td>3.994^a</td>
<td>45</td>
</tr>
<tr>
<td>Learning ability</td>
<td>3.803^a</td>
<td>45</td>
</tr>
<tr>
<td>Ethics</td>
<td>2.247</td>
<td>44</td>
</tr>
<tr>
<td>Finance</td>
<td>2.240</td>
<td>43</td>
</tr>
<tr>
<td>Social resp.</td>
<td>1.140</td>
<td>45</td>
</tr>
<tr>
<td>Cont. education</td>
<td>-1.019</td>
<td>43</td>
</tr>
</tbody>
</table>

^a These skill importance and skill performance rating comparisons exceed the 2.36 critical value for the .05 significant difference level.
categories: (1) BSE supervisor rating of nontechnical skill importance to job performance (abbreviated "skill importance"), (2) BSE supervisor rating of average skill level of first year BSE graduate engineers (abbreviated "BSE skill level"), (3) BSE supervisor rating of average skill level of first year BSE graduate engineers weighted for number of BSEs supervised (abbreviated "weighted BSE skill level"), and (4) BSE supervisor rating of average skill level of first year BSE graduate engineers weighted for number of BSEs supervised including 151 cooperative education engineers (abbreviated "weighted skill level with 151 co-op BSEs"). The four ranked categories are presented in Table 13.

Data from 1 of the 25 supervisors are treated separately from the other 24. The 1 supervisor (Appendix J, Item 17) supervised 150 first year BSE engineers and wrote a note stating that he administered the company cooperative education program. The data may not be representative because the numbers of students were in multiples of 25 (75 electrical engineers, 50 mechanical engineers, and 25 industrial engineers) and because the supervisor probably supervised most as students and not as first year BSE graduates. The data are included in the unweighted version of the analysis.

Nontechnical Curricula Proportion

Research Question 4 was: Has the proportion of nontechnical to total required courses for ABET accredited BSEE degree programs in the top 10 United States engineering colleges (Glower, 1980) changed between 1975 and 1985? Data for the analysis of proportion of
nontechnical-to-total required BSE curricula are presented in Table 14. The analysis for nontechnical curricula proportion change used a rule that a significant change percentage is greater than 10% of the 12.5% ABET accreditation requirement. The 10% change of the 12.5% ABET nontechnical requirement was a 1.3% change in the total curricula. The nontechnical curricula proportion of total curricula is presented in column 3 of Table 6. Six of seven colleges did not change. At one of the seven colleges (Iowa State University) BSE program requirements for nontechnical proportion increased between 1975 and 1985.

Research Question 5 was: How does the proportion of nontechnical to total required courses for ABET accredited BSEE degree programs in the top 10 United States engineering colleges (Glower, 1980) compare with the proportion recommended by ABET (1975, 1985) and by three engineering program study commissions (Grinter, 1955; Hammond, 1944; Walker, 1968)? The mean 1975 and 1985 nontechnical to total required BSE program curricula ratio of seven colleges are presented in Table 14. The ratio is presented as descriptive data for comparison with the 20% recommendation made by United States engineering program study commissions and the 12.5% ABET requirement between 1975 and 1985 for BSE program accreditation. The mean nontechnical to total ratio of the seven colleges is 17.8% in 1975 and 18.8% in 1985 with a standard deviation of 2.8% in 1975 and 2.4% in 1985. Both 1975 and 1985 percentages are much closer to the study commissions' 20% recommendation than the 12.5% ABET minimum requirement for BSE program accreditation. To determine if college ranking correlates
Table 14

Proportion of Nontechnical to Total Required Program Curricula From Selected Engineering College Bachelor of Science Curricula

<table>
<thead>
<tr>
<th>Institution</th>
<th>Catalog years</th>
<th>Nontechnical/total raw credits</th>
<th>Nontechnical/total percent</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Columbia University</td>
<td>1975-76</td>
<td>28/128.5 sem. hr.</td>
<td>21.8%</td>
<td>Electrical eng.</td>
</tr>
<tr>
<td></td>
<td>1984-85</td>
<td>28/130.5 sem. hr.</td>
<td>21.5%</td>
<td>Electrical eng.</td>
</tr>
<tr>
<td>University of Pennsylvania</td>
<td>1975-76</td>
<td>7/40 courses</td>
<td>17.5%</td>
<td>All engineering</td>
</tr>
<tr>
<td></td>
<td>1983-85</td>
<td>7/40 courses</td>
<td>17.5%</td>
<td>All engineering</td>
</tr>
<tr>
<td>Massachusetts Institute of</td>
<td>1975-76</td>
<td>72/360 units</td>
<td>20.0%</td>
<td>Electrical eng.</td>
</tr>
<tr>
<td>Technology</td>
<td>1985-86</td>
<td>72/360 units</td>
<td>20.0%</td>
<td>Electrical eng.</td>
</tr>
<tr>
<td>Ohio State University</td>
<td>1974-76</td>
<td>30/215 tri. hr.</td>
<td>14.0%</td>
<td>Electrical eng.</td>
</tr>
<tr>
<td></td>
<td>1985-86</td>
<td>30/215 tri. hr.</td>
<td>14.0%</td>
<td>Electrical eng.</td>
</tr>
<tr>
<td>Iowa State University</td>
<td>1975-77</td>
<td>26/192 tri. hr.</td>
<td>13.5%</td>
<td>Electrical eng.</td>
</tr>
<tr>
<td></td>
<td>1985-87</td>
<td>21/133.5 sem. hr.</td>
<td>21.3%</td>
<td>Electrical eng.</td>
</tr>
<tr>
<td>University of Michigan</td>
<td>1975</td>
<td>24/128 sem. hr.</td>
<td>18.8%</td>
<td>Electrical eng.</td>
</tr>
<tr>
<td></td>
<td>1985</td>
<td>24/128 sem. hr.</td>
<td>18.8%</td>
<td>Electrical eng.</td>
</tr>
<tr>
<td>Northwestern University</td>
<td>1974-75</td>
<td>9/48 courses</td>
<td>18.8%</td>
<td>All engineering</td>
</tr>
<tr>
<td></td>
<td>1983-85</td>
<td>9/48 courses</td>
<td>18.8%</td>
<td>All engineering</td>
</tr>
<tr>
<td>1975 Mean</td>
<td></td>
<td></td>
<td>17.8%</td>
<td></td>
</tr>
<tr>
<td>1985 Mean</td>
<td></td>
<td></td>
<td>18.8%</td>
<td></td>
</tr>
</tbody>
</table>

Notes. 1. All BSEE programs are accredited by ABET and exceed the minimum 12.5% required nontechnical to total required curricula proportion.

2. Raw credit abbreviations are: (a) semester hour, sem. hr., (b) trimester hour, tri. hr., (c) semester course, sem. cor., (d) trimester course, tri. cor., and (e) unit, unit.

3. The comments column shows "electrical eng." if only the electrical engineering program was selected and "all engineering" if requirements were the same for all engineering programs.
strongly with nontechnical curricula requirements, two colleges from the top of the ranking (Columbia University, University of Pennsylvania) were compared with two from the bottom of the ranking (University of Michigan, Northwestern University). Top colleges ranked 1 and 2 had a 19.6% nontechnical BSE program requirement and bottom colleges ranked 8 and 9 had an 18.8% nontechnical BSE program requirement. This is not a significant change using the 1.3% rule stated before.
CHAPTER V

DISCUSSION

The purpose of this study was to compare and critique the non-technical curricula content of three Bachelor of Science in Engineering (BSE) degree programs with model curricula. Curricula content areas that are similar were critiqued by employers of engineers. Model curricula importance and first year BSE nontechnical skill performance were rated by supervisors of first year BSE graduates. The main postulate is that differences among actual, model, and employer-desired nontechnical curricula are factors that may influence curricula change in engineering education. A secondary purpose was to measure the change in proportion of nontechnical curricula in BSE programs between 1975 and 1985 to compare the actual proportion with recommended proportions. The nontechnical curricula study partially replicated similar studies done between 1885 and 1956 (Kline, 1984).

Research questions are answered and conclusions are presented in this chapter. Implications of this study and the relationship to other research is also discussed.

Model Nontechnical Curricula Comparison

Research Question 1 was: To what extent are there similar non-technical curricula content descriptions of skill outcomes among three BSE model curricula (ABET, 1985; C. J. Baldwin et al., 1979;
Walker, 1968)? Nine curricula content descriptions were similar (Table 12) and two were dissimilar. The two dissimilar were political science and law from the IEEE (C. J. Baldwin et al., 1979) model. The two categories were listed because the engineering profession had more political and legal involvements since the 1960s. Other non-technical categories such as ethics, morals, professionalism, and social responsibility can overlap with politics and law, making the latter categories redundant. The nine curricula content names and descriptions were used in the survey instrument (Appendix F) that provided data for Research Question 2.

Employer Ratings of Nontechnical Skills

Research Question 2 was: What are engineering supervisor ratings of skills described in two out of three model curricula (ABET, 1985; C. J. Baldwin et al., 1979; Walker, 1968) of: (a) nontechnical skill importance to job performance, and (b) skill behavior of first year BSE graduates? Six of the nine nontechnical skill categories were rated "often required" (4.00 or above) for importance to job performance. The six are: (1) oral skills, (2) written skills, (3) professionalism, (4) ethics, (5) human relations ability, and (6) learning ability. Eight of the nine categories (excluding finance) first year BSE performance ratings were "skill developed with brief training or coaching" (3.00 or above) for the unweighted means of 25 supervisors. Finance was rated by supervisors as both the least important skill for job performance and as the least developed skill of BSE graduates. Finance does not become an important job element.
Research Question 3 was: How do engineering supervisor ratings of skills described in two out of three model curricula (ABET, 1985, C. J. Baldwin et al., 1979, Walker, 1968) compare between categories: (a) nontechnical skill importance to job performance, and (b) skill behavior?

Five categories of nontechnical skill importance to job performance ratings differed above the .05 significant difference level to first year BSE employee nontechnical skill ratings. The five categories are similar to the six rated "often required" for job performance. The categories are: (1) oral skills, (2) written skills, (3) professionalism, (4) human relations ability, and (5) learning ability. The conclusion is that five of six BSE program nontechnical skills rated by engineer supervisors as most important to job performance were not as well developed or demonstrated by first year BSE employees as supervisors desired. This indicates that supervisors expected skill improvements to take place either on the job or through continuing education in order for BSE engineer skills to meet supervisor performance expectations.

There are many practical ways to develop the supervisor desired nontechnical skills. BSE program leaders can evaluate graduate performance in the five nontechnical skill areas and improve curricula in deficient areas. Engineers and their supervisors can work together to evaluate engineer performance in these skill areas and thus target specific skills that need improvement in an individual. Continuing education offers wide availability of public speaking
courses, technical and business writing courses, and psychology and business courses that can help improve human relations ability. Professional engineering associations can provide many opportunities to enhance professionalism and human relations ability as well as to obtain continuing education opportunities. Human relations ability and learning ability may be less easy to target or improve with specific courses; however, evaluation and knowledge of deficiencies can start the learning process (see Table 5, 1 The need to know; see Table 6, 1 Motivation).

Nontechnical Curricula Proportion

Research Question 4 was: Has the proportion of nontechnical to total required courses for ABET accredited BSEE programs in the top 10 United States engineering colleges (Glower, 1980) changed between 1975 and 1985? The proportion of nontechnical to total required courses for ABET accredited BSE degree programs in five of seven surveyed engineering colleges did not change between 1975 and 1985 (Table 14). One college, Iowa State University, increased the nontechnical curricula requirement and one college, Columbia University, decreased the nontechnical requirement. The mean 1975 nontechnical to total curricula requirement of seven colleges was 17.8% and the mean 1985 requirement was 18.8%. There was no significant change because the decision rule required a minimum of 1.3% difference.

Research Question 5 was: How does the proportion of nontechnical to total required courses for ABET accredited BSEE programs in the top 10 United States engineering colleges (Glower, 1980) compare
with the proportion required by ABET (1975, 1985) and by three engineering program study commissions (Grinter, 1955; Hammond, 1944; Walker, 1968)? The nontechnical curricula proportion (18.8% in 1985) was much closer to the 20% proportion recommended by three engineering program study commissions (Grinter, 1955; Hammond, 1944; Walker, 1968) than to the ABET requirement of 12.5% for BSE program accreditation (ABET, 1975, 1985). The difference may be due either to colleges responding to an educational need for more than the 12.5% minimum nontechnical ABET requirement or to the omission of communications and economics requirements from the ABET nontechnical definitions. The ABET should change their nontechnical curricula definitions to include communications and economics categories (Table 4). These categories are important (C. J. Baldwin et al., 1979; Herr, 1977; Hurt et al., 1986; Walker, 1968) and should receive more emphasis in BSE programs.

Conclusion

Model nontechnical curricula are in agreement in 9 of 11 skill categories. The two dissimilar categories may be unnecessary, because those skills can be included within some of the other nine. Supervisors rated six (oral skills, written skills, professionalism, ethics, human relations ability, learning ability) of the nine categories as being "often required" for job performance. Supervisors rated BSE employee performance as being less demonstrated than desired in five of the six (oral skills, written skills, professionalism, human relations ability, learning ability) job performance
categories. The conclusion is that supervisors may expect skill improvements to take place. BSE program leaders should evaluate graduate performance in order to improve nontechnical curricula. Engineers and supervisors should work together to evaluate individual performance in the nontechnical skill areas. Continuing education, professional engineering society membership, and on the job training can provide opportunities for skill improvements.

Recommendation

No further study is recommended because each accredited college should study these and other BSE program factors relative to BSE graduate opinion as required by ABET (1985). Also, engineers and supervisors should study individual performance so that engineers can effectively plan to continue their professional development. The partial replication of the nontechnical curricula proportion studies should be done again by the next engineering program study commission.
Appendix A

Peters and Waterman: Eight Principles of Business Excellence
Peters and Waterman: Eight Principles of Business Excellence

1. The organization has a bias for action.
2. The firm is close to its customers (communicates well).
3. Autonomy and entrepreneurship is encouraged.
4. The operating philosophy is productivity through people.
5. Operations are hands-on and value driven.
6. The organization sticks to its primary business.
7. The organization has a simple form and lean staff.
8. The firm has simultaneous loose-tight properties. A small number of important factors are controlled tightly, but most factors of lesser importance are controlled loosely.
Appendix B

Letter to Obtain College Catalogs
Dear Archivist:

May I borrow or obtain photocopies of both the 1975 and 1985 college catalog? I am studying a decade of curricula change in the Bachelor of Science in Electrical Engineering program.

I am a Doctoral candidate in the Western Michigan University Department of Educational Leadership as well as a working electrical engineer. My dissertation research is to find how electrical engineering curricula has changed in the last decade in response to changing work requirements.

Please bill me for any copying costs or mailing costs. I will accept college catalogs 10 years apart such as 1976 and 1986 or 1974 and 1984 if the correct year is not available. Thank you for your assistance.

Sincerely,

Bryan Lundgren
Appendix C

Engineering Supervisor Survey: Request for Participation Letter
Dear Mr./Ms. Name:

Will you please take 10 minutes to complete the enclosed survey about job skills of new Bachelor of Science Engineering graduates? I am a working engineer completing a Doctorate of Education at Western Michigan University. The data from your survey will be used in my dissertation research.

An engineering association provided names of persons such as yourself who are receiving the survey. The information you give is confidential and will be used without names or company affiliation in my dissertation. Thank you for your time and for sharing your knowledge and experience.

Sincerely,

Bryan Lundgren
Appendix D

Engineering Supervisor Survey Cover Letter
Dear Sir:

Will you please take 15 minutes to complete and return the enclosed survey about job skills of newly-hired Bachelor of Science Engineering graduates? Your response may help improve engineering college curricula. I am a working engineer completing a Doctorate of Education at Western Michigan University. A professional association allowed me to use their member list to select a small number of engineering supervisors. Since the number to be surveyed is small, your response is important.

All information will remain confidential. No names of individuals or corporations will be reported in the dissertation. One possible use of information generated in the study is to guide curriculum changes that may improve engineering education. If you send your address, I will share survey results with you. Thank you for your willingness to share your time, knowledge, and experience.

Sincerely,

Bryan Lundgren
Appendix E

Engineering Supervisor Survey Second Request Letter
Dear Mr./Ms. Name:

You may not have received my survey sent out a month ago so I have enclosed a new copy. Will you please take 15 minutes to complete and return this survey about job skills of newly-hired Bachelor of Science Engineering graduates? Your response is important to properly validate the survey and may help improve engineering college curricula. I am a working engineer completing a Doctorate of Education at Western Michigan University. A professional association allowed me to use their member list to select a small number of engineering supervisors.

All information will remain confidential. No names of individuals or corporations will be reported in the dissertation. One possible use of information generated in the study is to guide curriculum changes that may improve engineering education. Thank you for your willingness to share your time, knowledge, and experience.

Sincerely,

Bryan Lundgren
Appendix F

Employer Survey for Supervisors of Bachelor of Science Engineer (BSE) Graduates
Employer Survey for Supervisors of Bachelor of Science Engineer (BSE) Graduates

1. How many years (rounded to the nearest year) have you supervised engineers?
   __________ years of supervising engineers

2. In the 10 years between January 1975 and December 1985 how many first-year engineers with Bachelor of Science Engineering degrees have you supervised?
   __________ first-year graduate engineers supervised

3. How many engineers do you presently supervise?
   __________ engineers

4. Please write the number of first-year graduate engineers supervised next to their degree.
   __________ B.S. Electrical Engineering
   __________ B.S. Mechanical Engineering
   __________ B.S. Chemical Engineering
   __________ B.S. Civil Engineering
   __________ B.S. Industrial Engineering
   __________ B.S. Other
   __________ B.S. Unknown
5. Rate the importance of the skills listed below using the following scale.

<table>
<thead>
<tr>
<th>Importance of skill</th>
<th>Skill description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>The skill is mandatory for job performance.</td>
</tr>
<tr>
<td>4</td>
<td>The skill is often required for job performance.</td>
</tr>
<tr>
<td>3</td>
<td>The skill is desirable and is occasionally needed on the job.</td>
</tr>
<tr>
<td>2</td>
<td>The skill is of some use but is generally not needed on the job.</td>
</tr>
<tr>
<td>1</td>
<td>The skill is not needed on the job.</td>
</tr>
<tr>
<td>0 UNKNOWN</td>
<td>The skill level has an unknown relation to the job.</td>
</tr>
</tbody>
</table>

**WRITTEN COMMUNICATION**
- Able to express ideas clearly and make logical arguments in writing.

**ORAL COMMUNICATION**
- Able to express ideas clearly in speech and to make group presentations.

**FINANCIAL PRACTICE**
- Able to use budgets, cost analysis, and other economic methods in business engineering decision making.

**HUMAN RELATIONS ABILITY**
- Able to get along and function well with others.

**PROFESSIONALISM**
- Exhibits proficient engineering methods, standards, and confident behavior.

**ETHICS AND MORALS**
- Exhibits a system of moral principles, values, and conduct in decision making.

**SOCIAL RESPONSIBILITY**
- Exhibits good judgment, sound thought, and is trustworthy when considering public welfare in decision making.
LEARNING ABILITY
Able to learn new ideas, methods, and behaviors.

CONTINUING EDUCATION
Pursues education by reading journals, taking classes, or seminars.

RESEARCH SKILLS
Able to do investigative or developmental research.

LABORATORY SKILLS
Able to define problems, design and perform experiments or tests.

6. Rate the average skill level of new Bachelor of Science Engineering college graduates in their first year on the job. The scale is as follows:

5 The skill was already highly developed.
4 The skill was adequately developed.
3 The skill was developed with brief training or coaching.
2 The skill was inadequate but was acquired with in-depth training.
1 The skill needed so much training to develop that it was not adequately acquired.
0 UNKNOWN The skill is not needed or the level level is unknown.

<table>
<thead>
<tr>
<th>Level of skill</th>
<th>Skill description</th>
</tr>
</thead>
<tbody>
<tr>
<td>WRITTEN COMMUNICATION</td>
<td>Able to express ideas clearly and make logical arguments in writing.</td>
</tr>
<tr>
<td>ORAL COMMUNICATION</td>
<td>Able to express ideas clearly in speech and to make group presentations.</td>
</tr>
<tr>
<td>FINANCIAL PRACTICE</td>
<td>Able to use budgets, cost analysis, and other economic methods in business engineering decision making.</td>
</tr>
</tbody>
</table>
HUMAN RELATIONS ABILITY
Able to get along and function well with others.

PROFESSIONALISM
Exhibits proficient engineering methods, standards, and confident behavior.

ETHICS AND MORALS
Exhibits a system of moral principles, values, and conduct in decision making.

SOCIAL RESPONSIBILITY
Exhibits good judgment, sound thought, and is trustworthy when considering public welfare in decision making.

LEARNING ABILITY
Able to learn new ideas, methods, and behaviors.

CONTINUING EDUCATION
Pursues education by reading journals, taking classes, or seminars.

RESEARCH SKILLS
Able to do investigative or developmental research.

LABORATORY SKILLS
Able to define problems, design and perform experiments or tests.

Thank you for your participation in this survey.

Note. Research skills and laboratory skills categories are technical categories. Data from these two categories are not reported.
Appendix G

IEEE Model Undergraduate Curriculum
Course Descriptions
Communication Skills

English Composition and Rhetoric—6 credits lecture

A composition course that provides basic instruction in the writing and analysis of expository prose, a study of logic and the principles of rhetoric, and the application to writing and analyzing exposition and argument. Frequent and extensive writing assignments, critically scored, are included.

Literature and Composition—3 credits lecture

Students will study rhetoric and logic at an advanced level and apply the principles to writing and analyzing exposition and argument, with materials drawn from literature, chiefly challenging modern prose fiction.

Technical Presentations and Speech—3 credits lecture

Experience in the written preparation of technical letters, memoranda, proposals, and reports written and oral. Experience in effective oral communication skills for the professional, including communication with individuals, small groups, and large audiences. Elementary graphics for the design and use of visual aids for improving effectiveness and impact of written and oral communications.

Political and Economic Sciences

Economic Theory—3 credits lecture

Introduction to economic analysis and its application to a free-enterprise system. An examination of the operation of a market economy to provide an understanding of how the size and composition of national output are determined; public and private sectors; government intervention elements of monetary and fiscal policy. International trade, comparative economic systems, including socialist, communist, and nationally subsidized economies and their impact on free market economics. The economics of competition.
Economics of Business Enterprise—3 credits lecture

Decision making in the business enterprises. Financial mathematics, time value and use of money, amortization, depreciation, taxes, economic selection and replacement, capital budgeting. Economics of research and product development, direct and indirect components of cost, pricing theory, enterprise management, the impact of corporate policy and environment on business decision making.

Legal Issues for Engineers—3 credits lecture

Contracts, terms and conditions of purchase and sale, warranties, liability, indemnification, damage theory, insurance, bids and specifications; patents, copyrights, trade secrets; problems of international trade, including letters of credit, governing law arbitration; legal and ethical positions of professionals, partnerships, and corporations.

Other Humanities and Social Sciences

Psychology of Interpersonal Relationships—3 credits lecture

Psychological needs of the individual, Maslow's hierarchy of needs, motivation theory. Self-perception as a behavior control mechanism. Routes to behavior modification. Theory and practice on the various frameworks of communications: individual-to-individual communications, including face-to-face communications; small group communications, including recognition and handling of various types of situations; large group interactions and communications. In the applied area, the study of team effectiveness. Organizational development and functioning, concepts of the formal and informal organization.

Approved Electives—6 credits lecture

Advisor approved courses to enhance the all-around growth of the individual as a professional engineer. Courses are recommended in philosophy, history of civilization, history of science, other history courses, sociology, psychology, literature.
Appendix H

Walker (1968) Goals of Engineering Education
Report Humanistic Social Studies Goals
The humanistic-social studies should be directed toward:

1. Understanding of the evolution of the social organization within which we live and of the influence of science and engineering on its development;

2. Ability to recognize and to make a critical analysis of a problem involving social and economic elements, to arrive at an intelligent opinion about it, and to read with discrimination and purpose toward these ends;

3. Ability to organize thoughts logically and to express them lucidly and convincingly in oral and written English;

4. Acquaintance with some of the great masterpieces of literature and an understanding of their setting in and influence upon civilization;

5. Development of moral, ethical, and social concepts essential to a satisfying personal philosophy, to a career consistent with the public welfare, and to a sound professional attitude;

6. Attainment of an interest and pleasure in these pursuits and thus of an inspiration to continued study.
Appendix I

1985 ABET Criteria for Accrediting Programs in Engineering, Humanities, Social Studies, and Related Curricular Objectives and Content
1985 ABET Criteria for Accrediting Programs in Engineering, Humanities, Social Studies, and Related Curricular Objectives and Content

(4a) Studies in the humanities and social sciences serve not only to meet the objectives of a broad education, but also to meet the objectives of the engineering profession. Therefore, studies in the humanities and social sciences must be planned to reflect a rationale or fulfill an objective appropriate to the engineering profession and the institution's educational objectives. In the interests of making engineers fully aware of their social responsibilities and better able to consider related factors in the decision-making process, institutions must require coursework in the humanities and social sciences as an integral part of the engineering program. This philosophy cannot be overemphasized. Further, this subject area must include some courses at an advanced level rather than be limited to a selection of unrelated introductory courses.

(4b) Such coursework must meet the generally accepted definitions that humanities are the branches of knowledge concerned with man and his culture, while social sciences are the studies of individual relationships in and to society. Examples of traditional subjects in these areas are philosophy, literature, fine arts, sociology, psychology, political science, anthropology, economics, and foreign languages other than a student's native language(s). Nontraditional subjects are exemplified by courses such as technology and human affairs, history of technology, and professional ethics and social responsibility. Courses are acceptable only if a substantial amount of material relating to cultural values is involved as contrasted to routine exercises to enhance the student's performance.

(4c) Subjects such as accounting, industrial management, finance, personnel administration, engineering economy, and military training may be appropriately included either as required or elective courses in engineering curricula to satisfy desired program objectives of the institution. However, such courses usually do not fulfill the objectives desired of the humanities and social science content.

(4d) Other courses, which are not predominantly mathematics, basic science, engineering science, engineering design, humanities or social sciences, may be considered by the institution as essential to some engineering programs. Portions of such courses may include subject matter that can be properly classified in one of the essential curricular areas, but this must be demonstrated in each case.
(4e) Appropriate laboratory experience which serves to combine elements of theory and practice must be an integral component of every engineering program. Every student in the program must develop a competence to conduct experimental work such as that expected of engineers in the discipline represented by the program. It is also necessary that each student have "hands-on" laboratory experience, particularly at the upper levels of the program. Instruction in safety procedures must be an integral component of students' laboratory experiences. ABET expects some coursework in the basic sciences to include or be complemented with laboratory work.

(4f) Appropriate computer based experience must be included in the program of each student. Students must demonstrate knowledge of the application and use of digital computation techniques to specific engineering problems. The program should include, for example, the use of computers for technical calculations, problem solving, data acquisition and processing, process control, computer-assisted design, and other functions and applications appropriate to the engineering discipline. Access to computational facilities must be sufficient to permit students and faculty to integrate computer work into coursework whenever appropriate throughout the academic program.

(4g) Competency in written communication in the English language is essential for the engineering graduate. Although specific coursework requirements serve as a foundation for such competency, the development and enhancement of writing skills must be demonstrated through student work in engineering courses as well as other studies. Oral communication skills in the English language must also be demonstrated within the curriculum by each engineering student.

(4h) An understanding of the ethical, social, and economic considerations in engineering practice is essential for a successful engineering career. Coursework may be provided for this purpose, but as a minimum it should be the responsibility of the engineering faculty to infuse professional concepts into all engineering coursework.

(4i) This section is not included because it covers advanced level (master's) requirements.
Appendix J

Demographic Analysis of Survey Population
Demographic data collected from the mailing list information are: (a) state where manager works, (b) company type, and (c) company size. Engineer degree data were collected with the questionnaire. A tabular compilation of these data is presented in Table 15. Nineteen states were represented by the 29 questionnaires sent. Two states were the destination of three questionnaires each, seven states were the destination of two questionnaires each, and nine states were the destination of one questionnaire each. Group means for the states are presented in order to show some correlation between the number of questionnaires sent and 1983 state employment (U.S. Department of Commerce, 1985, Table 657). Three questionnaires were sent to supervisors in states which had a group mean 1983 employment of 6,856,000 persons. Two questionnaires went to states which had a group mean employment of 3,744,000, and one questionnaire went to each state which had a group mean of 3,476,000.

Company type is presented in Table 15. Type was sorted into major industry categories and proportion of the sample was compared with 1980 proportion of the United States (U.S. Department of Commerce, 1985, Table 1336). Engineer degree is also presented in Table 15. Comparison of degree proportion of the 72 first-year engineers represented in the survey sample is compared with proportion of all employed engineers in the United States (U.S. Department of Commerce, 1985, Table 1004). Mechanical engineers comprised 61% of the sample, industrial engineers were 17%, electrical engineers were 7%,
civil engineers were 4%, and other was 11% of the 72 engineers. The 150 engineers represented by the cooperative education supervisor are not included.
Table 15
Demographic Analysis of Survey Population Data

<table>
<thead>
<tr>
<th>States represented</th>
<th>N</th>
<th>Employment 1983</th>
<th>Group mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>New York</td>
<td>3</td>
<td>8,062,000</td>
<td></td>
</tr>
<tr>
<td>Ohio</td>
<td>3</td>
<td>5,110,000</td>
<td>6,856,000</td>
</tr>
<tr>
<td>Alabama</td>
<td>2</td>
<td>1,761,000</td>
<td></td>
</tr>
<tr>
<td>California</td>
<td>2</td>
<td>12,333,000</td>
<td></td>
</tr>
<tr>
<td>Indiana</td>
<td>2</td>
<td>2,584,000</td>
<td></td>
</tr>
<tr>
<td>Kansas</td>
<td>2</td>
<td>1,186,000</td>
<td></td>
</tr>
<tr>
<td>Michigan</td>
<td>2</td>
<td>4,303,000</td>
<td></td>
</tr>
<tr>
<td>Wisconsin</td>
<td>2</td>
<td>2,435,000</td>
<td></td>
</tr>
<tr>
<td>Connecticut</td>
<td>2</td>
<td>1,608,000</td>
<td>3,744,000</td>
</tr>
<tr>
<td>Florida</td>
<td>1</td>
<td>4,903,000</td>
<td></td>
</tr>
<tr>
<td>Illinois</td>
<td>1</td>
<td>5,593,000</td>
<td></td>
</tr>
<tr>
<td>Maine</td>
<td>1</td>
<td>537,000</td>
<td></td>
</tr>
<tr>
<td>Massachusetts</td>
<td>1</td>
<td>2,987,000</td>
<td></td>
</tr>
<tr>
<td>Minnesota</td>
<td>1</td>
<td>2,174,000</td>
<td></td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>1</td>
<td>5,510,000</td>
<td></td>
</tr>
<tr>
<td>Rhode Island</td>
<td>1</td>
<td>477,000</td>
<td></td>
</tr>
<tr>
<td>South Carolina</td>
<td>1</td>
<td>1,476,000</td>
<td></td>
</tr>
<tr>
<td>Texas</td>
<td>1</td>
<td>7,629,000</td>
<td>3,476,000</td>
</tr>
</tbody>
</table>

Total 29
Table 15—Continued

<table>
<thead>
<tr>
<th>Manufacturing company type</th>
<th>N</th>
<th>%</th>
<th>% National 1980</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor vehicles and equipment</td>
<td>7</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td>Other transportation equipment</td>
<td>3</td>
<td>6%</td>
<td></td>
</tr>
<tr>
<td>Machinery except electrical</td>
<td>4</td>
<td>13%</td>
<td></td>
</tr>
<tr>
<td>Electric and electronic equipment</td>
<td>4</td>
<td>9%</td>
<td></td>
</tr>
<tr>
<td>Fabricated metal products</td>
<td>1</td>
<td>8%</td>
<td></td>
</tr>
<tr>
<td>Food and kindred products</td>
<td>1</td>
<td>8%</td>
<td></td>
</tr>
<tr>
<td>Furniture and fixtures</td>
<td>1</td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>28</td>
<td>97%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Engineering (nonmanufacturing)                | 1 | not available |

<table>
<thead>
<tr>
<th>Engineer degree</th>
<th>N</th>
<th>%</th>
<th>% national 1982</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical engineer</td>
<td>44</td>
<td>61%</td>
<td>19%</td>
</tr>
<tr>
<td>Industrial Engineer</td>
<td>12</td>
<td>17%</td>
<td>Included in other</td>
</tr>
<tr>
<td>Electrical engineer</td>
<td>5</td>
<td>7%</td>
<td>28%</td>
</tr>
<tr>
<td>Civil engineer</td>
<td>3</td>
<td>4%</td>
<td>9%</td>
</tr>
<tr>
<td>Other engineer</td>
<td>8</td>
<td>11%</td>
<td>44%</td>
</tr>
<tr>
<td>Total</td>
<td>72</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>
Appendix K

Engineering Supervisor Survey Data With Means and Standard Deviations
Engineering Supervisor Survey Data With Means and Standard Deviations

<table>
<thead>
<tr>
<th>Survey Number</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Years sup.</td>
<td>10</td>
<td>6</td>
<td>2</td>
<td>19</td>
<td>10</td>
<td>4</td>
<td>7</td>
<td>2</td>
<td>15</td>
<td>24</td>
<td>5</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>2. First year</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>6</td>
<td>3</td>
<td>8</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>3. Span</td>
<td>3</td>
<td>4</td>
<td>7</td>
<td>9</td>
<td>4</td>
<td>15</td>
<td>3</td>
<td>13</td>
<td>13</td>
<td>6</td>
<td>10</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>4. Degree</td>
<td>0</td>
<td>ME</td>
<td>MFG</td>
<td>IE</td>
<td>2ME</td>
<td>2ME</td>
<td>EE</td>
<td>3ME</td>
<td>8OT</td>
<td>OT</td>
<td>2ME</td>
<td>2IE</td>
<td>EE</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Importance to job performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. Writing skills</td>
</tr>
<tr>
<td>Oral skills</td>
</tr>
<tr>
<td>Finance</td>
</tr>
<tr>
<td>Human relations</td>
</tr>
<tr>
<td>Professionalism</td>
</tr>
<tr>
<td>Ethics</td>
</tr>
<tr>
<td>Social resp.</td>
</tr>
<tr>
<td>Learning ability</td>
</tr>
<tr>
<td>Cont. education</td>
</tr>
<tr>
<td>Sum</td>
</tr>
<tr>
<td>N</td>
</tr>
<tr>
<td>Mean</td>
</tr>
<tr>
<td>Survey Number</td>
</tr>
<tr>
<td>---------------</td>
</tr>
<tr>
<td><strong>First year BSE performance</strong></td>
</tr>
<tr>
<td>6. Writing skills</td>
</tr>
<tr>
<td>Oral skills</td>
</tr>
<tr>
<td>Finance</td>
</tr>
<tr>
<td>Human relations</td>
</tr>
<tr>
<td>Professionalism</td>
</tr>
<tr>
<td>Ethics</td>
</tr>
<tr>
<td>Social resp.</td>
</tr>
<tr>
<td>Learning ability</td>
</tr>
<tr>
<td>Cont. education</td>
</tr>
<tr>
<td><strong>Sum</strong></td>
</tr>
<tr>
<td><strong>N</strong></td>
</tr>
<tr>
<td><strong>Mean</strong></td>
</tr>
</tbody>
</table>
### Survey number (Note: 17 is omitted from 1, 2, and 3 means and standard deviations)

<table>
<thead>
<tr>
<th></th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>19</th>
<th>20</th>
<th>21</th>
<th>22</th>
<th>23</th>
<th>24</th>
<th>25</th>
<th>N</th>
<th>Mean</th>
<th>R</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Years sup.</td>
<td>4</td>
<td>8</td>
<td>12</td>
<td>8</td>
<td>2</td>
<td>6</td>
<td>5</td>
<td>20</td>
<td>8</td>
<td>2</td>
<td>6</td>
<td>14</td>
<td>24</td>
<td>8.79</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. First year</td>
<td>6</td>
<td>4</td>
<td>12</td>
<td>151</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>6</td>
<td>1</td>
<td>2</td>
<td>7</td>
<td>4</td>
<td>24</td>
<td>3.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Span</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>2</td>
<td>5</td>
<td>12</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>8</td>
<td>2</td>
<td>24</td>
<td>5.42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Degree</td>
<td></td>
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**Note.**  
1. Abbreviations in category 4 are: MFG—manufacturing engineer, ME—mechanical engineer, IE—industrial engineer, EE—electrical engineer, OT—other, and UN—unknown.  
2. X indicates no response.  
3. R is rank of 9 skills.
BIBLIOGRAPHY


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Pyko, K. (1986). *Aging conference addresses issues facing older engineers.* The Institute, 10(6), 1, 6.


