BUSINESS ADMINISTRATION GRADUATE DEGREE IMPORTANCE
Relative to Personnel Transition From
Engineering to Management Membership

A thesis submitted in partial satisfaction of the
requirements for the degree of Master of Science in
Business Administration

by

James Otis Cardot

June, 1967
The thesis of James Otis/Cardot is approved:

Committee Chairman

San Fernando Valley State College
June, 1967
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ABSTRACT

BUSINESS ADMINISTRATION GRADUATE DEGREE IMPORTANCE

Relative to Personnel Transition From Engineering to Management Membership

by

James Otis Cardot

Master of Science in Business Administration

June, 1967

The objective of this thesis was to investigate the hypothesis that the attainment of a Master's Degree in Business Administration is more beneficial than attainment of an advanced engineering degree for the engineer who is assigned the responsibilities of management.

The primary source of data was 500 questionnaires returned by managers who had previously been trained or employed as engineers. Combined with these data findings were the results of other studies in similar areas of research.

The investigation reviewed the education, experience and training of the engineer. A comparison was then made between the background of the engineer and the management function to determine the adequacy of the engineer's preparation for the administrative and technical responsibilities assumed by him as manager. Determination of the educational needs of the technical manager was then made, followed by an analysis of the effects of participation in either a Master of Business Administration program or a graduate Engineering program.

The investigation did not prove, but did reveal positive indications that the proposed hypothesis was valid. It was found that neither the engineer's preparation for his profession, nor his work experience placed sufficient emphasis upon disciplines required of him as a manager. Technical requirements of the management position, however, had been relatively well-satisfied. It was also found that managers with an M.B.A. degree had relatively fewer educational needs pertaining to the management function, and they experienced less difficulty in making the transition into management.
As a result, they eventually were of greater value to their organization.
CHAPTER I
INTRODUCTION

The source of managers and executives has always been of concern to organizations, but in the last two decades, beginning with the post-World War II growth and sophistication of technology, the concern has taken on new dimensions and importance. As industries have grown in size and complexity, the ranks of management have also had to expand and mature to assure that adequate planning, direction and personnel leadership would be available. However, a problem has arisen with respect to the most appropriate training and education for the manager which will insure that he has the stature and capacity to accomplish adequately both present and future managerial duties. The manager or potential administrator must decide whether to increase his technical repertoire to keep pace with advancing engineering and scientific knowledge or whether he should place primary concentration on the "art of managing." Just as there is a clear division between the physical sciences which are governed by absolute, impartial theorems and laws accompanied by tangible proofs and the sociological arts, whose tenets are less structured than those of the physical sciences, there is likewise a difference of opinion among executives themselves as to the appropriate education for their own profession. The desirability of institutional training of any form is often a facet of the controversy, but the primary question under debate and of concern here is not the usefulness of higher education for the future executive but rather the kind of education which will be most beneficial.

A recent study by Scientific American, Inc. of the social and educational background of business executives revealed that between 1900 and 1964 the proportion of executives with higher education more than doubled, whereas the percentage of executives with degrees in science and engineering increased nearly five times - from 7 percent in 1900 to 20 percent in 1950 and then accelerated to 33 percent in 1964. In addition to the latter percentage, 5 percent can be added to account for those who did not have such formal training but came to the top of their companies through the technical chain of
command or through exercise of native talent as inventors and technical innovators. 1

The Problem

By and large, the scientist sees the manager as a bureaucrat, paper-shuffler, and parasite, an uncreative and unoriginal hack who serves as an obstacle in the way of creative people trying to do a job, and a person more interested in dollars and power than in knowledge and innovation. 2

In addition to assuming the unpleasant image of manager described by Mr. Sherman's quote, the engineer in transition to management is forced to move out of the area of his original profession and must also transfer his loyalty and perspective from that of his former profession to that of the company. In anticipation of the specific transitional problems that may arise and to better prepare for administrative positions, both companies and employees throughout every industry are investing increasing amounts of time and resources for advanced formal education. Hence, the problem which arises is that of determining, or at least indicating, the most advantageous area of advanced formal education which should be pursued by prospective members of management.

Beyond the general and somewhat obvious reason of providing a supply of well-equipped men to assume the duties and responsibilities of managing the nation's industrial firms, more basic reasons exist which are of special importance to the company and to the individual. First, the company which often finances training programs and advanced degree work and which possibly donates the employee's time for his continued education is interested in a maximum return on its investment. Second, the individual who contemplates a management career has the desire to be well prepared and is therefore interested in obtaining the knowledge and training


that will be most appropriate for the management function. And third, should the wrong or relatively inapplicable area of study be chosen, valuable time will have been lost in the career of the employee.

Hypothesis to be Tested

As a solution to the problem, the hypothesis is offered that the fulfillment of the requirements for a graduate degree in Business Administration (M.B.A. or equivalent) is a more beneficial area of advanced learning than attainment of an advanced engineering degree, excluding Industrial Engineering, for the engineer who is assigned the responsibilities of management and for the company that employs him.

The core of the hypothesis exists in the term "more beneficial." With respect to the engineer and the company, "more beneficial" is evidenced by:

1. The transition from engineer to manager being less time-consuming.
2. The engineer with advanced formal education in Business Administration having a greater appreciation for all aspects of his job and ultimately achieving greater satisfaction with his accomplishments.
3. The engineer with advanced formal education in Business Administration achieving a better performance record and advancing more rapidly through the ranks of management (assigned increasing amounts of responsibility sooner).
4. The engineer with advanced formal education in Business Administration having less obstacles and deficiencies to overcome while fulfilling the role of manager.

Advanced formal education in Business Administration includes not only the M.B.A. or traditional graduate degree at the master's level in Business Administration, but also encompasses the studies contained in the newly-emerging graduate programs referred to as Management, Industrial Management, and Management Engineering. Graduate study in Industrial Engineering is often more closely associated with the management function rather than with specialized technical knowledge and therefore has been placed in the category of
Business Administration.

The term "engineer" pertains to all persons engaged in chemical, civil, electrical, mechanical, metallurgical, and other types of engineering work at a level which requires a knowledge of, or training in engineering, physical, life, or mathematical sciences equivalent at least to that acquired through completion of a four year college course with a major in these fields.

The term "management" describes a level in the organization structure of a company which formally requires that its members coordinate people so that individual objectives are translated into group attainments.

Scope and Background of Study

Numerous studies have dealt with the advantages and disadvantages of education. Many of these have been concerned with the social and economic background of men in an attempt to ascertain correlations with their success or with their lack of success. Most of these studies have probed the nature of the executive function and have attempted to isolate favorable traits and characteristics conducive to becoming a top executive. Several studies, of which the earliest and most extensive was that conducted by F. W. Taussig and C. S. Joslyn, deal with the social origins of groups of business leaders, both early and contemporary. Very little study has been made, however, of the kind of education and training that individuals in management and executive positions have received and what effect it has had on gaining their respective positions.

Dr. Mabel Newcomer has pointed out that very little has been made known about the total business experience and training of those who reach the top executive positions or about changes which are taking place in regard to past experience and training. She has

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investigated three specific time periods relative to the training, experience and family backgrounds of the chief executives. Her studies encompass three "generations" of executives from 1898 to 1953, in order to answer certain questions and trace any changes in the kinds of men selected as the nature of the job has changed. These studies were recently updated to 1964 by Market Statistics, Inc. and Dr. Newcomer in conjunction with interest on the part of Scientific American, Inc.

Much of the basic data obtained by the original and updated Newcomer studies will be relied upon in this study and the methodology developed by Dr. Newcomer in the course of her research, data collection and data analysis will be adopted to the problem and questions of concern in the thesis.

All previous research in the area of the education, training and family background has not been isolated to specific fields of education, but has often been limited to a specific managerial level such as the chief executive and board chairman, as were selected in the Newcomer research. The scope of this thesis has not been limited to any particular level of management, but includes all members who fit the aforementioned definition of "management." Also, in contrast to other studies, the primary type of background being used as a reference basis is that of the engineer or equivalent as previously defined.

Because the number of engineers who do not possess a bachelor's degree in engineering is relatively small, and also due to their varied and often unidentifiable educational background, no attempt has been made to study or analyze these backgrounds relative to their applicability to the management function. Therefore, attention has been focused on the engineer who has a minimum of a Bachelor of Science degree in Engineering or equivalent.

There are many questions to be examined in determining the validity of the proposed hypothesis, as a relatively small amount of data exist concerning the careers of managers and executives with a technical undergraduate education. How effective is an engineering or scientific education in preparing an individual for the many
diverse activities throughout his professional career? Is there any observable objective relationship between types or extent of formal education and career progress? What has been the experience and what are the attitudes of managers and executives with respect to their technical education being an asset or a liability to their progress? In what respects has formal technical education been deficient in equipping individuals for their future role as leader, chief or director, and has their technical education provided for an increase in responsibility? Can graduate training in Business Administration be of help in filling in the weak areas of engineers in their transition to management? Or, spoken differently, in what should a specialist be trained in order to become a generalist?

It is not the objective of this thesis to provide complete and detailed answers to each, or to any, of the questions; nor is it necessarily the intention to objectively prove or disprove the central hypothesis upon which the study is based. However, through the search for meaningful and rational answers to such questions as have been mentioned, a concentrated effort has been made to discover major weaknesses that plague former engineers and technicians who are now responsible for the accumulative efforts of others, and to determine of what value formal graduate education in Business Administration is in correcting these deficiencies.

Method of Research and Analysis
And Source of Data

The method employed to test the validity of the hypothesis involved primarily the acquisition and analysis of empirical data obtained from members of all levels of management throughout the United States. Combined with these findings was knowledge acquired through other studies in similar areas of research. An analysis and cross-correlations of the acquired data in conjunction with graphical displays, exhibits, logical reasoning and personal interviews and discussions were used to structure, define and provide the appropriate perspective to the findings.

A four page questionnaire* consisting of four questions

* Contained in Appendix I.
concerning the company with which the respondent is employed and thirteen questions related to personal information was used to provide the bulk of data. A total of 900 questionnaires were sent to managers and executives, ranging from first-line supervisors to presidents, who had had a formal education in engineering or equivalent technical training. Seventeen of the questionnaires did not reach the addressees and were returned unopened. Therefore, the total number of questionnaires that were available for completion and return was 883. Of these 883, 58.8 percent, or 519 individuals responded to the survey. Nineteen of the returned questionnaires were unusable because they were largely incomplete for a variety of reasons ranging from lack of time to company policies which did not allow the answering of such questions. As a result, the usable sample size available for analysis was 500. Of the nineteen who responded but did not complete the questionnaire, three enclosed supplemental information of a more general and less personal nature or made valuable suggestions regarding sources of additional information in the area of interest. It is felt that the large response, especially when the highly personal nature of many of the questions is taken into consideration, is strongly indicative of a high degree of interest in the subject area being investigated.

The distribution concerning the type and size of the organizations with which the respondents were associated and the ages of the respondents is shown by Figure 1, 2, and 3 respectively.

A second source of original data consisted of personal interviews with engineers and other technically-trained men, supervisors and managers at various levels from second-line supervision to top management. Personal letters, company policy outlines, employment histories, generalized grouped information pertinent to management personnel and executive resumes were also of great value in ascertaining the validity of the questionnaire and providing information not available through the use of a questionnaire or referenced data.

*The tables referenced on each figure are found in Appendix II.
TYPES OF ORGANIZATIONS

All Respondents

Figure 1
SIZES OF ORGANIZATIONS
All Respondents

Average 30,225
Median 6,440

Figure 2

Total Number Employed (thousands)

Table 2
AGES OF RESPONDENTS

Figure 3

Table 3
The reference materials found most useful were a Scientific American sponsored study entitled The Big Business Executive / 1984, the American Society for Engineering Education study Education in Industry, the Engineers Joint Council report Assessment of the Goals of Engineering Education in the United States and Goals of Engineering Education Preliminary Report, published by the American Society for Engineering Education.

Qualifications and Limitations of Study

Natural abilities and initiative are unknown variables which play a significant role in the determination of answers to problems which may exist in conjunction with personal success, job difficulties and educational effectiveness. No matter how extensive and complete the data or how sophisticated the statistical analysis, the end result and conclusions can only be expressed in terms of general indicators and trends. The results cannot be taken as explicit answers to specific questions relative to what an individual should do in preparing for his job. The data, research and analysis that are brought forth in the examination of the validity of the thesis hypothesis are not intended, nor will they be presented as proof of unalterable facts, truisms, rules of thumb or conclusions that can be used by individuals, engineers, managers or companies in picking a course of action. Other than being at best only qualitative indicators, the results will often suggest areas where further study, research and empirical data is required to gain meaningful conclusions.

5The Big Business Executive / 1984.


One serious shortcoming of the present study is that the data has been taken at only one point in time and therefore does not lend itself to the projection of trends as readily as data taken at intervals over a period of time. Because an investigation with respect to time and different generations of managers is beyond the scope of this thesis, the results of the Newcomer and Scientific American, Inc. studies are weighed heavily in the conclusions. Also, while obtaining the data, care was taken to secure as much historical information as possible concerning the background of each respondent.

A second limitation of this type of study which seeks to make assessments based upon individual successes, failures, beliefs, likes, dislikes and so forth, is the interpretation and conception of what constitutes success or failure and upon what basis one may make an evaluation of individual growth and acceptance of increased responsibility. Often it will be found that a difference exists in one sample of data between what is believed to be right or even desired and the action subsequently taken by an individual. Allowances must be made for differences in the quality of graduate study in both Engineering and Business Administration. In order to minimize these variables in the study, particular educational programs will be used as a base of reference to focus and define individual subjective viewpoints.

**Thesis Format**

In Chapter II the educational background, experience and training of the engineer will be reviewed to establish the characteristics of the individual being studied. Data collected will be used to define the engineer's education and training, employment experience and his motivations, advancement history and his future as

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9 Mabel Newcomer, *The Big Business Executive*.

an engineer. In brief, the question will be asked, "What has been the typical history of the technical man who has made the transition into management?" Also included in this chapter will be a brief evaluation of the education and training presently being offered the undergraduate engineer from the aspect of preparing him for an eventual management position.

Chapter III will be devoted primarily to a description of the management function as it actually exists at the present time. The formal education and pre-managerial experience of the manager have been studied and compared with the way in which the manager obtains his position, his title, current job description, responsibilities, and probable future position. This analysis will provide an insight into how well the requirements and responsibilities of a managerial position are equated with the formal education that has been acquired by the engineer.

A management survey which was accomplished by the thesis questionnaire in order to indicate advanced formal education needs will be discussed in Chapter IV. A comparison will be made between the curriculums of an M.B.A. or equivalent degree and that of Master of Science degree in Engineering. The purpose of this comparison is to indicate which masters degree program appears to be the most appropriate in satisfying the formal educational needs of the technical manager.

Chapter V analyses the effects of participation in either an advanced Business Administration program or an advanced Engineering program. Thesis Questionnaire respondents who had attained an M.B.A. or equivalent degree were compared with those respondents who had earned a Master of Science degree in Engineering on the basis of completeness of required formal education and success in accomplishment of their job. Chapter V is supplemented by Chapter VI, which presents discussions and interviews that were held with engineers and managers. These discussions dealt with the same topics as were covered by the thesis questionnaire.

The thesis is summarized in Chapter VII and the validity of
the hypothesis is discussed. The significant findings of the study are reviewed and recommendations are offered with respect to future efforts in the determination of appropriate formal education for technical managers and the most prudent course of action to be chosen by the engineer following his bachelor's degree.
CHAPTER II
THE ENGINEER - EDUCATION, TRAINING AND ADVANCEMENT

It is the purpose of this chapter to define or describe the engineer: his education and training, the requirements of his engineering position, and the methods used by his employer to prepare him to carry out the responsibilities of an advanced position. Also presented are discussions concerning employment and advancement history of the engineer, his motivations, beliefs, desires, and his salary and status relative to other professions. To further aid in understanding the forces that act upon the engineer and cause him to either remain in engineering or move into management, an attempt has been made to gain some insight into the engineer's future as an engineer.

Previous Studies and Supplementary Data

One of the striking trends that is developing in American industry is the emergence of increasing numbers of business executives and managers qualified by formal education and occupational experience in science and engineering. The trend has been confirmed by three independent studies: Dr. Mabel Newcomer's classic work in the study of the business executive, \(^{11}\) the extension and updating of Dr. Newcomer's work in a study sponsored by *Scientific American*, \(^{12}\) and a study of 6,000 executives in American industry conducted at the Harvard Graduate School of Public Administration under that school's program of investigation in Science and Public Policy.

The Harvard Graduate School study found that, of those executives ranging in age from fifty-five to sixty-five, 36 percent had degrees in science or engineering. In the thirty-five to forty-five age group more than 50 percent had such degrees.

The *Scientific American* study found that, as of 1964, 38 percent of America's big business executives had technical

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backgrounds. Of the 38 percent, 33 percent held technical degrees and the remaining 5 percent consisted of executives who acquired their technical training on the job or through inventions and innovations which they brought to their organizations. An increase in the correlation of the professionalization of the business executive with qualification in science and technology is illustrated in Figure 4. This figure is based upon data obtained for the Scientific American study. Figure 5 from the same study shows the increasing professionalization of business executives by the changing character of their first full-time job. By 1964, more than half had begun their careers in professional functions; the most rapidly increasing number had begun as engineers.

Without question, the technically trained professionals are undertaking a larger and ever-increasing role in the administrative function of business organizations. Because evidence indicates that these professionals will soon constitute a majority of the business executives, special interest must be devoted to the engineer and his background relative to the duties and responsibilities of management. The immediate question is this: How well prepared is the engineer to assume his new managerial duties with confidence and aggressiveness? The most logical place to start in order to obtain an answer is in an investigation of the background of the engineer, followed by a comparison between these findings and the requirements for qualification as a competent business administrator.

The previous supplementary data concern both science and engineering. In the remainder of this study, however, attention will be focused on the engineer because, relative to the scientist, he exhibits a greater propensity to enter management. For example, Purdue University recently surveyed their post-World War II engineering and science graduates in an effort to obtain data regarding differences in migration from technical to administrative duties. 14

ACADEMIC DEGREES OF BUSINESS EXECUTIVES

Figure 4

Table 4
FIRST FULL-TIME JOB OF BUSINESS EXECUTIVES

Figure 5

Table 5
These differences are illustrated in Figures 6 and 7.

The Education and Training of Engineers

The majority who have been classified as engineers have obtained this status through completion of a college or university engineering curriculum, the most common of which consists of an eight semester or four year course that terminates with the awarding of a Bachelor of Science degree in a specific engineering area such as mechanical engineering, chemical engineering or electrical engineering. The minimum academic requirements for the bachelor's degree are essentially set by the educational institutions and by their regional accrediting associations.

Typical examples of undergraduate or pre-baccalaureate engineering curricular content are illustrated by Tables I, II, and III respectively for the University of California at Los Angeles, California Institute of Technology and San Fernando Valley State College. In each curriculum the primary objective is to provide general (theoretical) knowledge during the early years and concentration in specific areas during the latter years. A minimum amount of time is required for the social sciences, humanities and business administration specialities. This is not to find fault with the programs, but rather to point out that little time is available during a four year engineering course to provide for any more than basic general knowledge outside of the technical sphere. The similarity is found to exist in the programs of all accredited engineering schools, and there is no need to differentiate in this study between various universities or colleges which offer a bachelor's degree in engineering.

The future of formal education in engineering is also important because it is from the future engineer that future managers will emerge. An indication of what changes may be forthcoming in the engineering curriculum was revealed by observing the magnitude of the technical knowledge explosion and also by reviewing recommendations offered by the American Society of
TECHNICAL-ADMINISTRATIVE FUNCTION IN 1965
Purdue University Engineering Alumni

Percent

100
90
80
70
60
50
40
30
20
10
0

B.S. M.S. 1-5
B.S. M.S. Ph.D. 6-10
B.S. M.S. Ph.D. 11-15
B.S. M.S. Ph.D. 16-20

Years Since Baccalaureate

Figure 6

Table 6
Figure 7
### Table I

**Requirements for Bachelor of Science Degree in Engineering**

**University of California at Los Angeles**

**General Catalog 1965-66**

<table>
<thead>
<tr>
<th>Freshman Year</th>
<th>Sophomore Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math</td>
<td>Math</td>
</tr>
<tr>
<td>8 Units*</td>
<td>8 Units</td>
</tr>
<tr>
<td>Chemistry</td>
<td>Physics</td>
</tr>
<tr>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>Physics</td>
<td>Engr. Intro.</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Basic Engr.</td>
<td>Electives</td>
</tr>
<tr>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>Humanities</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Physical Educ.</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td><strong>Junior Year</strong></td>
<td><strong>Senior Year</strong></td>
</tr>
<tr>
<td>Engr. Specialties</td>
<td>Engr. Specialties</td>
</tr>
<tr>
<td>24 Units</td>
<td>8</td>
</tr>
<tr>
<td>Electives</td>
<td>Electives</td>
</tr>
<tr>
<td>12</td>
<td>24</td>
</tr>
</tbody>
</table>

**Elective Requirements**

- 18 Units Min. in Engr. Major
- 21 Units Humanities, Social Studies, and Fine Arts
- 9 Units Engr. Major and Humanities

48 Units in Total

*Units Based on Semester System*
TABLE II

REQUIREMENTS FOR BACHELOR OF SCIENCE DEGREE IN CHEMICAL ENGINEERING
CALIFORNIA INSTITUTE OF TECHNOLOGY
1966-1967 BULLETIN VOL. 75 NO. 3

<table>
<thead>
<tr>
<th>First Year</th>
<th>Second Year</th>
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<tbody>
<tr>
<td>Math</td>
<td>History</td>
</tr>
<tr>
<td>30 Units*</td>
<td>18 Units</td>
</tr>
<tr>
<td>Math</td>
<td>Math</td>
</tr>
<tr>
<td>Basic Engr.</td>
<td>Electricity</td>
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<tr>
<td>36</td>
<td>36</td>
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<tr>
<td>Chemistry</td>
<td>Chemistry</td>
</tr>
<tr>
<td>36</td>
<td>30</td>
</tr>
<tr>
<td>English and Lit.</td>
<td>Physical Educ.</td>
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<tr>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>History</td>
<td>Electives</td>
</tr>
<tr>
<td>5</td>
<td>27</td>
</tr>
<tr>
<td>Graphics</td>
<td>Electives</td>
</tr>
<tr>
<td>3</td>
<td>(Engr. &amp; Science)</td>
</tr>
<tr>
<td>Physical Educ.</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Third Year</th>
<th>Fourth Year</th>
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<tbody>
<tr>
<td>Literature</td>
<td>120</td>
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<tr>
<td>Elec. German</td>
<td>Electives (Major)</td>
</tr>
<tr>
<td>30</td>
<td>120</td>
</tr>
<tr>
<td>Quant. Analysis</td>
<td>Electives (Humanities)</td>
</tr>
<tr>
<td>10</td>
<td>27</td>
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<tr>
<td>Chemistry</td>
<td>Public Affairs</td>
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<td>43</td>
<td>6</td>
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<td>Oral Presentations</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Electives - (Major)</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td></td>
</tr>
</tbody>
</table>

**Business Courses Offered in Humanities Electives**

- Introduction to Industrial Relations
- Government Regulations
- International Economic Relations
- Econometrics
- Money, Income and Growth

*Units Based on Quarter System
TABLE III
REQUIREMENTS FOR BACHELOR OF SCIENCE DEGREE IN ENGINEERING
SAN FERNANDO VALLEY STATE COLLEGE
CATALOG 1965-1966

<table>
<thead>
<tr>
<th>Lower Division</th>
<th>Upper Division</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Core Requirements</td>
<td>Core Requirements</td>
</tr>
<tr>
<td>Engineering 5 Units*</td>
<td>Engineering Laboratory 3 Units</td>
</tr>
<tr>
<td>Chemistry 8</td>
<td>Mechanics 8</td>
</tr>
<tr>
<td>Economics 3</td>
<td>Elect. Engr. &amp; Electronics 8</td>
</tr>
<tr>
<td>Mathematics 16</td>
<td>Engineering Specialties 6</td>
</tr>
<tr>
<td>Physics 12</td>
<td>Engr. Economics &amp; Administration 3</td>
</tr>
</tbody>
</table>

Engineering Major 18 Units
Electives 5

*Units based on Semester System
Engineering Education (ASEE) following a study of the goals of engineering education.  

The rapid growth of knowledge has been estimated by ASEE to be doubling every ten to twenty years and consequently has been putting a great demand on all of the professions, especially those closely associated with the sciences. Educational institution officials realize that it is becoming increasingly difficult to offer the added requirements of the engineering program which are necessary in order to keep pace with technological progress in the normal four year period. Attempts have been made to attract students into formal five year bachelor's programs in engineering but these curricula have, for the most part, disappeared and the ASEE believes that there is little likelihood of their return in the future.

The Goals of Engineering Education Preliminary Report, sponsored by the ASEE, recommended several changes to be considered for improving the quality of the engineering graduate. It was noted, however, that nowhere in the report was mention made of any need to expand or strengthen the engineer's knowledge in application of his technical skills or to improve his understanding of management and administration principles.

Supply of Engineers

A large supply of engineers is provided by schools that award two year associate engineering degrees and bachelor of arts degrees in engineering. Graduates from these formal programs are usually not classified as engineers upon receiving their B.S. or B.A. degrees, but become engineers only after additional education or

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16 Ibid., p. 27
on-the-job training. Also, many others who become engineers are former technicians who have been promoted into engineering positions following their participation in on-the-job training programs and additional formal class instruction.

Valid statistics indicating the actual number of men classified as engineers, but who have not completed a formal four year engineering course, do not exist. This may be attributed to the problems of occupational definition and identification. However, according to the National Science Foundation, more than 20 percent of the 615,000 engineers employed by American industry in 1959 did not have college degrees. It is known in general that this group is becoming increasingly smaller and thus increasingly unimportant, because of the emerging policy of both industry and government which requires that only individuals with a bachelor's degree in engineering be classified as engineers.

The number of bachelor's engineering degrees awarded by American educational institutions in this decade is provided by the United States Department of Labor, Bureau of Labor Statistics. In estimating the supply of engineers, the Bureau has calculated that, on the average, 34,700 engineering degrees will be awarded annually over the 1960-1970 decade. Only 85 percent of these degree holders will enter engineering, but for every 1,000 new graduates with engineering degrees who have entered the engineering profession in recent years, about 165 others have also entered who have a degree in some other field. In addition, taking into consideration the new entrants composed of former technicians and two-year college graduates, a total figure of 473,000 new entrants into engineering has been projected between 1960 and 1970.

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Engineering Training

A very important form of engineering education which is second only to the attainment of the initial engineering degree is on-the-job training. The education gained is by necessity narrow in scope and specific in nature, especially in the beginning years of employment after graduation. For the first five to seven years after obtaining his degree the engineer is confined to specific design, development and problem-solving assignments. The tasks initially utilize the very basic principles taught him during his formal education. For example, the new engineer may become involved in the development of fluid flow control devices. His formal education might have consisted of only a couple of classes in his subject and they were devoted to a basic understanding of the principles of operation, introduction to the appropriate equations for calculating flow rate, pressure drop and so forth, and possible a mention of the most common types and models in use. The fact that the young engineer is quite competent in technical details, possibly more so than his superiors, makes the assignment of this type of work most logical. During this time the engineer has little need for skills outside of his technical speciality. If additional formal education is felt to be needed, it is usually of a technical nature.

The young engineer, building upon his basic education, will realize eventually that he is gaining knowledge in subjects that goes beyond his classroom instruction. However, until the time when the engineer advances to a lead or principal position within his group, he is given little opportunity for on-the-job training which falls outside the scope of his technical speciality. With experience he will eventually find that no longer will he be expected to do the complete job himself, but that he must direct others to do the task. This in turn involves formulating future plans, estimating future manpower requirements, monitoring budgets of materials and funds, and formulating schedules. Of most importance, however, it must be remembered that he is still primarily technically-oriented and any on-the-job education and training which falls outside of or beyond his technical responsibilities is intermittent, and is quite likely
to exhibit no continuity toward attaining competence in a speciality outside that of engineering.

Independent Study and Education

A third type of engineering education which overlaps and is actually a part of on-the-job training, is self-education. In anticipation of increasing job requirements, the engineer, through his own initiative, finds many ways outside of classroom instruction to become better qualified for his present position and for future positions of increased responsibility. Consultation with other engineers with different specialities is the most common and can hardly be avoided in the daily routine of activities. This form of self-education may be classified as on-the-job training. However, the difference that self-education implies is that a deliberate attempt is made to seek specific knowledge, not that it may be of immediate help on a present project, but because it is felt that certain knowledge will be useful in the development of one’s technical capabilities.

Intentional involvement in various technical activities outside the organization is also a popular method of self-education. These activities consist of studying engineering or scientific periodicals and new engineering texts which have been updated to reflect the latest technological advances, attending local and national technical meetings on engineering subjects, writing and presentation of technical papers, and belonging to professional societies. The magnitude of participation in each of these technical activities has been surveyed by the ASEE and is shown in Figure 8. It is clear that graduate degree holders are more active technically and professionally than are the baccalaureate engineers. This fact is also reflected in a survey of Purdue engineering and science graduates. 21 It was found that a greater proportion of doctorate engineers and scientists held membership in more than one

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21 Engineering News (Purdue University), pp. 1-4.
PERCENT OF ENGINEERS WHO ENGAGED IN VARIOUS TECHNICAL ACTIVITIES DURING THE YEAR 1964

Subscribed to engineering or scientific periodicals

Purchased new books on engineering

Attended local technical meetings on engr. subjects

Attended national technical meetings on engr. subjects

Presented technical papers

Belong to one or more professional societies

Belong to three or more professional societies


Figure 8
professional society in their field. There were about as many engi-
neers with bachelor's degrees who had membership in one professional
society as there were with membership in none. Engineers and scien-
tists with master's degrees had a greater tendency to hold membership
in professional societies than those with bachelor's degrees but less
than those with doctorates.

It should be clear that the engineer has ample opportunity
for self-education in his professional field. Also, he has an im-
mediate opportunity to utilize the education in carrying out his job
assignment, which in turn instigates additional technical self-
education. Opportunities for self-education outside the engineer's
professional field are almost as readily available, but are clearly
secondary to technical self-education. Knowledge of the humanities
and social sciences is continually broadened through association with
other individuals and groups, and through participation in situations
that are encountered in one's daily life. This is not what is meant
by self-education in the strict sense of the word, however, because
it is not an intentional attempt to learn specific skills in an
overall plan to develop academic knowledge.

As the engineer performs his technical tasks, he eventually
realizes that it takes something other than engineering "know-how"
to satisfactorily complete a job and communicate the results in such
a way that they will be useful to others. He soon learns that
group dynamics and organizational diplomacy play a key roll in his
recognition as an important and respected member of his group. As
the engineer matures and assumes a principal technical position, he
finds that specific administrative skills become useful tools in
expressing himself and getting a number of jobs coordinated and
completed. Thus, the aggressive engineer has the desire to learn
specific administrative skills and does so largely through self-
education and experience.

Consultation with his supervisor and various management
personnel within his company is a readily available and constantly
used type of non-technical self-education that is conscientiously
sought by the engineer. Text books and periodicals are also of value
in providing the basic fundamentals and principles of administration skills. However, the total sources of non-technical information available to the engineer for his self-education are definitely limited compared to the technical sources. Supervisory personnel are restrained in the amount of organizational information they are allowed to discuss with the engineer. Management seminars and professional managerial organizations are also restricted to certain organizational levels of which the middle and lower-ranked engineers are not a part. Also, the engineer is not in a position to practice his self-taught skills in a continuing manner so that results are immediately available and the need for further administrative skills is readily apparent. At most, the engineer's self-taught managerial and administrative skills are acquired intermittently, are of secondary priority, and are largely of a trial-and-error nature.

Company-Sponsored Education

Courses taught away from the campuses of formal educational institutions are becoming increasingly popular with company organizations. Company-provided courses can be tailored to the specific demands of the industry and to the needs of individuals within the company. The classroom sessions usually are held on the company premises, which eliminates the transportation problem and enables the sessions to be held during working hours as well as after hours. Specific facilities are also often available to teach specialized skills that possibly are applicable only to that company. If the company offers a certificate program, arrangements are usually made with a university, college or adult occupational training center to supply qualified instructors and possibly to offer the basic prerequisite courses.

The engineer will find company-sponsored courses particularly suited to his profession because technical specialities are stressed and are designed to review or to extend the technical knowledge taught him during his formal education. As a typical example, North American Aviation, Inc. offers in their continued education program forty-three individual courses of which six are engineering courses, twenty-eight are mathematics and technical specialities and
two are concerned with management and business administration skills. The remaining seven are comprised of courses in language, writing, reading and speaking. In their certificate program, a total of seventy-two courses are offered with engineering, technical specialties and mathematics courses accounting for a total of sixty-eight courses. Two courses are offered in writing, one in speaking and one in the principles of management.

It becomes quite clear from this example of a company-sponsored educational program, which is typical of education programs of large organizations employing thousands of engineers, that continued education of the engineer in areas other than those which are technically oriented, is not encouraged. Management personnel who have the responsibility for employee training in four different large industrial firms were consistent in their reply that the company was primarily interested in improving the technical competence of the engineers. It was also believed that the engineer should devote his continued studies to advanced engineering subjects and that he should not be formally concerned, as an engineer, about management principles or specific administration skills.

In this review of education and training of the engineer, it was evident in every step that the technical skills were stressed as being of primary importance. Continued education in engineering must take precedence over all other subjects. Unless the engineer keeps abreast of the technological developments in his field of employment he will have lost his usefulness to his company as an engineer. The increasing demands placed upon the practicing engineer make it imperative that as long as he is in the profession he must continue his education in the engineering sciences and not allow himself to become reliant upon outmoded methods of problem solving.

Employment

In estimating the potential source of managers with technical backgrounds, and in determining how the total population of engineers was distributed throughout the United States with respect to type and size of organization, data made available by the U. S. government was evaluated.
The U. S. Department of Labor, Bureau of Labor Statistics, reported that as of 1961, over 40 percent of the engineers employed in industry were working in three major manufacturing industry groups: electrical equipment, transportation equipment (mostly in aircraft and parts), and machinery. The ratio of engineers to total employment varied considerably among individual industries, but on the average, engineers represented only about twenty-four out of every 1,000 employees in January, 1961. Engineering and architectural service establishments had the highest ratio with approximately 27 percent. In several manufacturing industries or industry groups, the total proportion of engineers to total employment was between 12 and 17 percent. These included ordnance, engineering and scientific instruments, communications equipment and aircraft. All of these industries, which are predominantly science-based, are heavily engaged in research and development; between 55 and 65 percent of the scientists and engineers working for them were engaged primarily in performing or administering R & D activities. The Bureau of Labor Statistics also reported that in most industries, engineers are concentrated in large establishments. A survey of distribution of engineers by size of establishment made in January, 1961 found that in nineteen of twenty-eight separate manufacturing industries and in three of twelve industries outside manufacturing, more than half of all the scientists and engineers worked in establishments with 1,000 or more employees. In manufacturing industries as a group, establishments with 1,000 or more employees had a substantially larger proportion of engineering employment than they had of total employment. Among smaller establishments - those with fewer than 55 employees - engineers accounted for approximately 36 percent of the total employed.

Comparing the number of engineers with total employment

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23 Ibid., p. 8.
gives further evidence that these personnel are employed predominantly in large establishments. In all industries combined, engineers in 1961 constituted 4 percent of the total work force in establishments with 1,000 or more employees. This compares with averages of 2.5 percent of all workers in organizations with 500-999 employees and 1.5 percent in establishments with fewer than 500 employees.

A 1965 Purdue University survey of employment settings for engineers indicated that the current place of employment tended to be private industry. Figure 9 presents the employment setting by degree level in engineering. Among the engineering graduates questioned by the Purdue Survey questionnaire, the majority of those in industry were in manufacturing rather than non-manufacturing settings; a large majority in education were employed in colleges and universities rather than secondary and elementary schools; and a large majority of alumni in government positions were with the federal government as opposed to state and local governments. For a majority of the Purdue engineering graduates, the principal field in which alumni were engaged at work in 1965 was the same as their field of study when attending Purdue. The data presented in Figure 10 indicates that the principal function corresponds with engineering and varies by degree level attained.

A similar survey was conducted by the University of Illinois School of Mechanical Engineering. Of 409 mechanical engineering graduates who returned their questionnaires, 316 were engaged in engineering work; 51 were in technical management; and 10 were in education. The remaining 32 were in other occupations of sales, law and purchasing.

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24 Engineering News, p. 3.
25 Ibid., p. 3.
1965 EMPLOYMENT SETTING FOR ENGINEERS
By Purdue Degree Level

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**Figure 9**

Table 8
PRINCIPAL FUNCTIONS OF ENGINEERING GRADUATES
By Purdue Degree Level

Figure 10
The Engineering Function

A typical question that arises when examining the engineering profession is, "What does the engineer do?" The answer is as complex as the field itself and results either in a number of ambiguous phrases or an endless tabulation of engineering tasks. As a compromise, two quotations that best express the goals and direction of engineering have been substituted.

A relatively concise expression of the distinguishing characteristics of engineering has been formulated by the Engineering Council for Professional Development as follows:

Engineering is the profession in which a 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.

The late Robert E. Doherty emphasized that engineering is an intensely human enterprise. He described engineering as:

... a genuine competence in the professional way of thought...
which embodies an analytical and creative power that is as effective in the social and human realm as that developed in engineering in the application of the physical sciences... when the engineers face a problem involving human and social elements either in relation to their regular professional work, or to their activity as citizens, or as individuals, they will deal effectively with the whole problem, not merely with the technical part.28

There are two types of engineering responsibility: technical responsibility and professional responsibility. The technical responsibility level of the engineer is closely correlated with his degree level, as evidenced by Figure 11.

The second type of responsibility applies to all engineers regardless of degree level. This responsibility is the personal

TECHNICAL RESPONSIBILITY LEVEL OF ENGINEERING GRADUATES
By Purdue Degree Level

Figure 11

Table 10
responsibility that is assumed by every competent and conscientious engineer when he performs his daily tasks. The importance of this type of responsibility is emphasized each time there is an unfortunate occurrence or disaster which has been brought about by a faulty design, a miscalculation or a production error. Unlike the work of the marginal accountant, banker or administrator whose errors are likely to cause, at worst, inefficiency, financial loss and embarrassment, the errors of irresponsible engineers, even at the very lowest level, can easily result in the collapse of dams, bridges and buildings, the loss of control and destruction of transporting vehicles or the loss of life and injury of many persons caused by faulty machinery, tools and appliances. The emphasis on personal responsibility in the engineer's daily effort has been recently increased and brought to the attention of the public by industry-wide programs that tout the necessity for "Zero Defects" and "Pride" in the job. It is the importance of this second type of responsibility that in this one respect prepares the engineer for assuming the responsibility that is placed upon management.

Motivation

An insight into the beliefs and desires of the engineer and the factors affecting his motivation may be gained through an examination of attitudes. The National Opinion Research Center asked some 34,000 graduate students representing more than 100 colleges and universities questions regarding their attitudes on several topics. Figure 12 illustrates the percent of engineering graduates who endorsed various statements concerning their attitudes toward people, opportunity, money, politics and self-appraisal. The responses to the statements appear to be idealistic in that the preference for money receives the second lowest consideration and that a career's worth is better measured by the creative opportunities it offers. The emphatic negative response regarding the desire to work with people also indicates an idealistic attitude toward

ATITUDES OF ENGINEERING GRADUATE STUDENTS

Percent Endorsing

100
90
80
70
60
50
40
30
20
10
0

prefer working with people
want chance for originality
want to make a lot of money
considers himself political liberal
thinks of himself as conventional person

Figure 12
individual achievement. The idealistic attitudes, it must be realized, in this sample are the reflections of young graduates with little or no engineering experience. Changes in these attitudes to more realistic views may be brought about by maturity and experience. Changes in attitude play a significant role in the transformation of the engineer to a manager.

Observation of the factors which affect motivation of practicing engineers reveals beliefs and desires similar to those indicated by young engineering graduates, but tempered by experience. A large amount of valuable and comprehensive data has been gathered in the course of a six-year study of motivation research conducted at Texas Instruments Incorporated. The study revealed that such matters as pay, supplemental benefits, company policy and administration, behavior of supervision, working conditions, and several other factors somewhat peripheral to the task, all traditionally perceived by management as motivators of engineers, were more potent as dissatisfiers. [High motivation did not result from their improvement, but dissatisfaction did result from their deterioration. The true motivators, for the most part, were found to be factors of achievement, recognition, responsibility, growth, advancement, and other matters associated with the self-actualization of the engineer on the job.] Job satisfaction and high production were associated with motivators, while disappointments and ineffectiveness were usually associated with dissatisfiers. Figure 13 shows the distribution of events or circumstances leading to favorable or unfavorable feelings for engineers. The length of the white bars on the upper side of the horizontal plane indicates the percentage of favorable sequences or events classified under each factor. Likewise, the lengths of the shaded bars on the under side of the plane indicate the frequency distribution of "unfavorable" sequences. The total length of the bars on each side of the plane equals 100 percent. The height of the bars represents duration of feelings.

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FACTORS AFFECTING MOTIVATION OF ENGINEERS


Figure 13
which reflect their relative importance to the engineer. Clearly, the most frequent motivator as well as the most frequent dissatisfier was achievement. Work itself is noted to be the most important motivator, whereas unfortunate experiences affecting responsibility were found to be the most important dissatisfiers.

**Advancement**

The lack of concern which the engineer appears to express with respect to pay is most fortunate, because if pay were of prime importance he would indeed be a part of an unhappy lot. Also, the engineer does not fare much better in advancing to positions of higher authority and responsibility. A poll of graduate engineers and of company executives conducted by the Engineers Joint Council (EJC) revealed that the average engineer, despite a high starting salary, climbs fast but not far. According to figures compiled by the EJC, the average engineer can hope to earn only about $13,000 a year. Even an engineer whose salary is in the top 10 percent earns only about $17,500 a year.

A ten-year analysis of engineers' salaries shows that even though the pay of engineers continues to rise rather rapidly, as would be expected because of the impact of engineering on national welfare and national defense, engineers are not doing nearly as well financially, as their colleagues who major in non-technical subjects. A further comparison of data from four sources (Engineering Manpower Commission, the National Science Foundation's National Register of

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Scientific and Technical Personnel, the Department of Labor's National Survey of Professional, Administrative, Technical and Clerical Pay, and Medical Economics) indicates the ranking of the engineer relative to other professions. The distribution of the professional median salaries as shown in Figure 14 places the engineer seventh behind medical doctors, middle managers, attorneys, chief accountants, personnel directors and physicists.

The role of salary as an incentive is controversial and as indicated by Figure 13, is not in itself particularly influential as either a motivator or dissatisfier. Analysis of motivating factors indicates that pay derives its importance primarily from the other factors it represents. In Figure 15A, "pay itself" accounts for only 11 percent of the reasons for satisfaction and is only one-fourth as important as the recognition it represents. Figure 15B shows that a disappointment in pay has more impact as an act of unfairness than it has as a loss of pay itself. A comparison of Figures 15A and 15B would also indicate that salary is less potent as a motivator than as a dissatisfier.

The salary level discrepancy that has traditionally existed between supervisory and non-supervisory personnel has not gone unnoticed. An attempt has been made to reduce the differences by employing what is known as the "dual-ladder" concept. The concept, in an attempt to show equal recognition for the engineers, holds that the engineer need not move into a supervisory position in order to enjoy substantial advances in salary. Despite the good intentions, however, Figure 16, showing a substantial gap between the two categories, illustrates the limitations of the concept.

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34 Ibid., quoting National Science Foundation, National Register of Scientific and Technical Personnel.
PROFESSIONAL MEDIAN SALARIES - 1964

Medical Doctors
Middle Managers
Attorneys
Chief Accountants
Personnel Directors
Physicists
Engineers
Chemists
Biologists
Earth Scientists
Psychologists
Job Analysts
Auditors

Figure 14

Table 12
MOTIVATION OF ENGINEERS BY PAY

Why Pay Is A Motivator

- 39% Recognition
- 11% Achievement
- 11% Possible Growth
- 11% Work Itself
- 6% Pay Itself
- 6% Security
- Other 5%

Why Pay Is A Dissatisfier

- 40% Unfairness
- 21% Pay Itself
- 15% Recognition
- 12% Failure
- Work Itself
- Insecurity
- Group Feeling
- Responsibility

Figure 15A

Figure 15B

Figure 15
MEDIAN SALARY SINCE BACCALAUREATE
All Engineering Activities

Figure 16
Work Environment

Last and probably least important to the engineer, but nevertheless a consideration, is his working environment. The engineer finds himself in the fortunate position of being intimately involved with the company's product. This factor alone is one of the primary forces that motivates the engineer to work tirelessly under almost any adverse circumstances. But, this same luxury of taking part in the research design, development and manufacture of a product places the engineer in the least comfortable working environment of any of his professional colleagues. The grime-covered battered desk on the shop floor and the open bays of aerospace and aircraft companies that seat engineers in groups by the half acre are the rule rather than the exception. It is only the consultant, the specialist or technical staff engineer who sometimes enjoys the comforts of privacy and an office. The environment itself as a motivator is somewhat analogous to pay itself, only to a much lesser extent. The environment itself can be endured, but it is the lack of prestige and professionalism that it represents that tends to make it a more potent dissatisfier.

The Engineer's Future

There are numerous crossroads that the engineer faces throughout his career. Each of the milestones calls for a reflection of the past and a projection into the future. At those crossroads where alternative opportunities are offered, a decision must be made to either "push on" in the profession or to alter the path of travel in hopes that a different route will be more fruitful. One of the alternatives that the competent and successful engineer usually encounters is the opportunity to enter management. During the course of making a decision, the engineer's projected future as a practicing engineer or as a manager are both carefully weighed in light of present attitudes and ambitions. Neither alternative is free of pitfalls and it is incumbent upon the engineer to fully evaluate all the advantages and disadvantages.
Professional Considerations

As he attempts a projection into his future as an engineer, many advantages will be seen. The engineer has no doubt become quite proficient and knowledgeable in his field and possibly an authority on a specific type of problem, system, or process. He has been educated specifically for his profession and receives great enjoyment and satisfaction from his accomplishments. The engineer knows that he will continually face challenges and be inspired by technological advances and new concepts of solving problems. With additional advance education, new responsibilities can be assumed and with them will come new horizons to be conquered. Continuing in engineering also means that the engineer can retain his loyalty to his profession without mixed emotions or political considerations; and in addition, it means a chance to see his original plans through to a satisfactory completion.

Conversely, with the passage of time and the accumulation of experience the engineer may find that he has modified the idealistic attitudes that he may have expressed as a young graduate. A review of his salary and advancement history will possibly divulge two familiar facts that he had often been told, but which he never believed or felt were important: that engineers climb fast but not far, and that the "dual concept" has serious limitations that for the most part make it unworkable. These factors that he once shrugged off as incidental at some time will seem more important. Also, the engineer may eventually find that his attitudes concerning individual accomplishment and his dislike for working with people have not been practical. The desire to direct and co-ordinate projects and work through others may possibly appeal to him and seem more important.

Advancement and Salary Considerations

One of the primary considerations of whether or not to stay with engineering involves a realistic evaluation of future advancements and salary increases. With respect to advancement, few precedents have been established that indicate his future positions in
engineering will keep pace with those available to him within management. When considering future salary increases there is data available that indicates a rather gloomy outlook.\textsuperscript{37} For example, starting salaries are actually increasing more rapidly than salaries for experienced engineers. This fact is shown plainly by Figure 17. The starting engineer of 1964 received a salary that was 61 percent higher than that of his counterpart in 1953. The largest increases since 1953 have occurred among engineers with eight and ten years of experience. As can be seen, in 1964 the engineer with eight years of experience was earning 85.5 percent more than the engineer, who, in 1953 had eight years of experience. An indication of how the older engineer has done over the eleven years preceding 1964 is given by typical increases in Figure 18. Engineer A, who graduated in 1953, earned 182 percent more in 1964 than in his first year of work. Engineer D, an older man with twenty-five years of experience by 1953, has not enjoyed comparable increases during the same eleven year period. His salary has increased from $8,500 to $14,000 in 1964 - a 66 percent gain. On the positive side, however, assuming that engineering will continue to have an important role in civilian and military affairs and that the field will not become over-crowded, the engineer can safely expect his salary to continue to rise - but at a more moderate rate than it has in the past.

When the engineer looks at the management alternative he sees a much more appealing future in terms of salary, advancement and prestige. In looking beyond this glossy cover, however, the engineer encounters many questions that have reason to concern him. His original work, at least the details of it, will have to be left for someone else to accomplish. It will mean giving up a successful profession for one in which there is a fear of failure and thus a resulting loss of prestige and self-respect. Many engineers may be troubled over the possible loss of their "nice guy" image and the forfeiture of the social group to which they belong. Also, there is

\textsuperscript{37}Professional Income of Engineers, p. 13.
ENGINEERING SALARY LEVEL INCREASES
1953 - 1964

Figure 17

Table 14
TYPICAL ENGINEERING SALARY INCREASES
1953 - 1963

Thousands of Dollars

Years Since Baccalaureate

Source: Professional Income of Engr's., p. 13

Figure 18
the realization by the engineer that he has been accustomed to basing his decisions on theorems and laws governing physical behavior. Should he make a transition to supervision he must rely on human nature and deal in intangibles with each individual problem being a special case. Becoming a member of management brings with it a fear of the loss of direct control over the work, and the meticulous engineer senses the difficulty in accepting the solutions of others to problems which he has solved in the past.

If the engineer, after careful consideration of all factors, feels he does not want to make the transition into management, his future course of action is clear-cut. The continued need for advanced education in the field of engineering and particularly in the engineer's specialty is a necessity. It has been proven that the professional engineer, in order to better assure himself of a responsible position in his field, is committed to life-long education in the engineering sciences.

Despite the preference for engineering, there are two strong forces that more often than not compel the engineer into making the transition to a management position: the desire to move up within his company and the persuasion by his company to accept a supervisory responsibility. When an engineer is offered a management position, it is not only an opportunity to advance in the organization, but it is more importantly a recognition of the outstanding job he has done as an engineer. A rejection of the alleged advancement goes against the rationality of the individual, as it is a refutation of the company's respect and admiration, and it also carried the implication that there is an unwillingness to bear a heavier responsibility for the well-being of the establishment.

Assuming that the engineer does make the decision to enter management and that it is the organization's desire that he do so, the question that is the subject of this thesis is then encountered: "What is the most advantageous area of advanced formal education that should be pursued so that an efficient and beneficial transition from engineering to management functions can be effected?"
In this chapter the background of the engineer has been reviewed and discussed in an effort to establish a "base-line" or known value on which to investigate the proposed hypothesis. The education, training and attitudes of the engineer will prove most important in evaluating his future educational needs as a member of management. With a resume of the typical engineer in mind, the following chapter will investigate the qualifications and responsibilities of the manager so that the difference between an engineering background and the management task become evident.
CHAPTER III
THE MANAGEMENT FUNCTION

The basic concept of management is often muddled by the confusion that is attached to the meaning of the word. The term "management" may have a specific connotation, such as a reference to a class of rulers in a society, or it may be a very general definition of rational behavior, as when a man's affairs are well managed. Neither connotation, however, represents the concept of management being referred to when company or governmental organizations are being discussed. The term as it is used herein refers to those men who act as administrators or executives of industrial firms, unions, military organizations, churches, educational institutions or governments. Another difficulty which arises is that persons who are called managers do not always manage, and it is obvious that many persons who are not called managers are really a part of the management process. The meaningful definition of management, therefore, deals with the kind of activity, rather than the kind of person involved in the activity.

It is the intent of this section, therefore, to discuss different kinds of managerial activities and then to compare them with the engineering background previously discussed. Because the hypothesis under discussion is the transition of engineers into management positions, it is logical to assume that these positions will be technically oriented, at least for the initial management position. Speaking in other terms, the engineer does not suddenly find himself a supervisor in personnel or labor relations; rather, his duties will probably involve supervision of other engineers or technical personnel who are performing tasks he once carried out himself, or which are of a similar nature. Therefore, a fair analysis of the educational needs of the engineer who is making the transition to management can only be obtained by evaluating the requirements of the technically-oriented management functions. This consideration will be accommodated by dividing the activities of the manager into administrative requirements and technical requirements.
The activities to be discussed will be based primarily on the results of the thesis questionnaire, current management periodicals and personal interviews with management personnel.

Prior to delving into specific managerial activities, preliminary discussion is necessary concerning the concept of management - its theory and its functions. Also, in order to place the managerial activities in proper perspective, there is need to mention the changes in the principal occupational experience of business executives and the levels of management being discussed.

The Concept of Management

Extensive controversy exists, particularly with respect to the theory of management, regarding the nature of the duties of the manager. Educators and students of management concepts have formulated many general definitions and phrases in an attempt to condense into simple, understandable terms the basic job that the manager must accomplish. Peter F. Drucker defines management as "... the direction of the resources and the efforts of the business toward opportunities for economically significant results. The bulk of time, work, attention, and money first goes to 'problems' rather than to opportunities." Drucker believes that the business enterprise is not a phenomenon of nature, but one of society and that the major problem the manager must solve is to be able to distinguish between effectiveness and efficiency. Drucker states:

It is this fundamental confusion that stands between doing the right thing and doing things right. There is nothing quite so useless as doing with great efficiency that which should not have been done at all. Yet, everything we do concentrates on efficiency... The end products of the manager's work are decision and action, rather than knowledge and insight... The first duty of the manager is to strive for the best possible economic results from the resources currently employed or available.\(^\text{39}\)


\(^{39}\) Ibid., p. 54.
R. A. Gordon sees the manager as a professional executive doing a "management" job; co-ordinating his firm's activities, approving decisions that flow up to him from his subordinates, but doing less and less initiation. 40

Seymour Tilles feels that the primary job of the manager lies in the area of his relationship with individuals over whom he does not exercise direct control. 41 Tilles has the conviction that management is an art and always remain an art because the practitioner of management must go beyond the limits of theoretical knowledge if he is to be effective. Tilles states that, "As soon as the manager begins to think 'scientifically', he has already made an abstraction from reality. This abstraction may be made on any of the specialties but it is only a part of reality. The manager must see and understand the whole situation." 42

These statements are not without value in comprehending the trend of thought with respect to management theory. However, they are of little help in analyzing specific tasks that managers face, or in determining the requirements that constitute management capability. A deeper observation of the manager's job is therefore required in order to be of use in this study.

The first step in analyzing the task of managing is to categorize those functions that distinguish managing from specific tasks such as accounting, engineering, manufacturing, purchasing, and so forth. These operational tasks differ from one company or business to another and from one industry to another, but the functions of a manager are universal and common to all organized human activity. In David Granick's book, The Red Executive, it is

42 Ibid., p. 81.
shown that the manager in Russia's Communist society has basically the same function and encounters the same problems as does his capitalistic counterpart. 43

There has been wide disagreement among scholars and practitioners of management as to how the functions of the manager are divided, but a pattern has been slowly emerging. This pattern has been formalized by Harold Koontz and Cyril O'Donnell, who have classified the managerial activities into five functions of planning, staffing, organizing, directing, and controlling. 44 Koontz and O'Donnell emphasize that it is not always possible in practice to slice all managerial activities neatly into these categories, since the functions tend to overlap; however, it is agreed that these classifications are helpful in analyzing the functions. No attempt will be made to probe into the depths of each of the function categories because a complete and detailed discussion is readily available in the referred text. 45 In order to assure that the meaning of each of the terms is understood, however, a definition of each is appropriate.

Planning is the function of selecting the objectives of the organized human activity and the policies, programs, and procedures for achieving these objectives. Staffing encompasses those activities that are essential in manning the positions provided by the organization structure. Organizing involves the determination and enumeration of the structure of activities and authority required to accomplish the objectives of the enterprise. Direction relates to the guidance and supervision of subordinates. Control is the process whereby the results of activities are monitored and corrections and

45 Ibid.
additional direction initiated to compel events to conform to plans.

The Management Position

The prevailing view of the way in which managerial and executive positions were attained in the 1920's and 1930's was expressed by Taussig and Joslyn in the following statement:

"... To the extent that business leaders of the present generation are drawn from the big business class, inbreeding may be said to characterize the group responsible for the control and direction of American business... There is reason to believe that the representation of this class among business leaders is tending to increase as time goes on."

However, the facts gathered as of 1964 by the Scientific American study do not support the conclusion of Taussig and Joslyn. There has been an increasing social mobility that has brought men from the lower and middle classes to the top. As indicated by Figure 19, top executives in industry have been coming in increasing numbers from families in modest circumstances. This mobility has been the result of the prolongation of formal education through college and even into graduate schools, which now supply the primary qualifications for advancement to top executive responsibility.

Figure 20 shows that the entrepreneur and capitalist who played a major role in the organizing of large corporate enterprises at the turn of the century has practically disappeared from the top ranks of industrial management. The place of the entrepreneur and capitalist has been taken by career executives, especially by professional men, among whom engineers are the most rapidly growing group. The trends are emphasized by comparison of the occupational experience of the older (seven or more years in present position) and younger (less than seven years in present position) men.

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FAMILY BACKGROUND OF BUSINESS EXECUTIVES

Figure 19

Table 15
PRINCIPAL OCCUPATIONAL EXPERIENCE OF BUSINESS EXECUTIVES

Figure 20

Table 16
The thesis questionnaire, supporting the notion that there is an increasing tendency for the manager to come from the ranks of professional men, indicated that the majority of respondents had been promoted into their present position. Of the 497 who responded to the question of how they obtained their present position, 363 or 73 percent, indicated that they had been elected or promoted. Only 30 (approximately 6 percent) indicated that they had attained their position through inheritance or had purchased or started the companies in which they were top executives. The total responses are shown in Figure 21. Also, the thesis questionnaire revealed that in excess of 90 percent of the 500 respondents had worked their way into management through a previous series of promotions in their specific profession or specialty.

The levels of administrative and technical managerial activities to be discussed range from the duties of first-line supervision to those of the chief executive. The primary emphasis, however, will be placed upon middle management. The occupational positions of the respondents to the thesis questionnaire have been categorized into four levels. The first and largest level consists of board chairmen, presidents, executive vice-presidents, senior vice-presidents and vice-presidents. The second level is composed of directors, general managers and associates reporting to the vice-president. The third level is made up of managers, chief engineers, department heads, group leaders and superintendents. The fourth level is reserved for all others: supervisors, administrators, senior project engineers, project engineers, staff assistants, consultants, and specialists, all with supervisory responsibilities. Figure 22 show the percentage of the thesis questionnaire respondents in each of the four levels. Because people in first-line supervision (fourth level) and lower middle management (third level) are the ones who are most likely to be affected by transition problems as they make the change from engineering to management status, interviews and observations concerning activities and responsibilities were restricted to these two levels.
METHOD OF OBTAINING PRESENT POSITION
All Respondents

Figure 21
PRESENT JOB LEVELS
All Respondents

Percent

50
45
40
35
30
25
20
15
10
5
0

First Level
Second Level
Third Level
Fourth Level

First Level
Chair of Board
President
Exec. Vice Pres.
Sr. Vice Pres.
Vice Pres.

Second Level
Director
Gen. Manager
Associate

Third Level
Manager
Chief Engr.
Dept. Head
Group Leader
Superintendent

Fourth Level
Sr. Proj. Engr.
Proj. Engr.
Supervisor
Administrator
Staff Asst.
Consultant
Specialist

Figure 22

Table 18
Managerial Administrative Requirements

The administrative functions that have been categorized into five classifications by Koontz and O'Donnell apply to all levels of management as well as to all human organizations. This point was emphasized previously; however, the scope of each of the functions increases with the level of responsibility. At the highest level the scope of responsibilities is broad and all-encompassing. The chief executives and vice-presidents are primarily concerned with discovering, developing, defining and evaluating the goals of the organization and the alternative policies that will lead toward the goals. Next, the executives make certain the organization is made aware of and adopts the policies as they were intended. The effectiveness of the policies is then scrutinized and subsequently, appropriate steps are taken to change policies when they are judged to be less effective than planned. Each of the lesser executives and managers down to the first-line supervisors is given the responsibility of a proportionately smaller part of the overall organizational plan.

It should be recognized that, in the typical organization, "management" does not connote rigid control and that an organization will be managed best by permitting maximum freedom of decision among its members. This lack of direct control immediately brings about the basic prerequisite to becoming an effective and efficient manager: the ability to work through other people. Dealing with people requires an understanding of the basic forces within society and human nature, and recognition of the weaknesses and deficiencies in each system. A member of management, to be successful, must develop the capacity to use the methods of the humanist in approaching business issues, especially in developing sensitivity to human aspirations, and have an imaginative awareness of the value of elements in subordinate self-respect and dignity. An understanding of human relations and administrative practices is therefore thought to be one of the most important, if not the most important attribute that a manager at any level can acquire.
Interwoven with the need to be able to delegate responsibility is the complementary necessity for skill in basic forms of communication. This skill is a two-dimensional quality working for the manager in both an upward and a downward direction. Lower and middle level managers must be able to justify their actions and report their progress and accomplishments to superiors through the use of both written and oral communication. This is most important, for example, at the time of outlining the manpower, material and budget requirements for the future operation of a manager's department or group. The top executives, likewise, have the responsibility to convey the company's progress and position to both the stockholders and the public. Recent examples of need for such communication have been seen in the attacks upon industries with respect to fair-product labelling, air pollution, and auto safety. Each of the controversies has made it necessary for top company officials to present to the public a justification of the activities and policies of their company. In the downward direction, the lack of effective communication with subordinates would not be tolerable. Activities are initiated in a human organization by communicating requirements downward to the "working" levels through formal channels. These channels consist of verbal and written directives prepared and presented by management.

Decision-making is a major activity of the manager in an established organization. In order to make the correct decisions the majority of the time, innumerable evaluating capacities are required. The manager or executive must first know what kinds of information are needed in order to obtain a realistic description of the progress of various activities. This job, in turn, requires that the appropriate measurement criteria are selected and that the format is understandable as well as meaningful. Economics, finance, capital budgeting and accounting are just a few of the administrative disciplines that must be understood by the manager, not only in the selection of the proper information, but also in the evaluation of the information. The manager must decide such things as the amount
which the firm should spend on the development of new products; whether a particular component should be purchased or made; whether a less costly method of manufacturing Part A or Part B exists; and whether there is justification for the fact that the assembly department is more efficient than the machining department. For each of these decisions there will be an array of positive and negative factors that must be separated from the most significant points.

In an effort to solve, or at least to understand the solution to the many problematical decisions that a manager encounters, the practical application of game theory, queuing theory, shortest-route techniques, and cost analysis is necessary. In addition, his accuracy and efficiency of decision-making are increased through the application of knowledge of statistics, probability and auditing processes. Also, an understanding of the potential uses for automatic data processing procedures is of value to the manager who has the opportunity to base his decisions on quantitative data.

As business relationships between government and industry increase, an awareness of various costing methods, acceptable inventory techniques and financial reporting procedures is necessary. Government business also necessitates a knowledge of proposal preparation, (complete with man, money and material forecast) detailed time schedule estimates such as the recently developed PERT and CPM networks, and numerous marketing techniques which help attract and retain various governmental department.

A complete comprehension of all the administrative methods cannot be expected of the manager, but it is important for him to master the underlying principles of at least one broad area of business policy and to gain an appreciation of the contributions which a given specialty can make to managerial policy making. An executive, for instance, might become proficient in the application of various social science principles to business affairs and thus be able to draw upon these subjects in whatever manner might be desirable in specific business situations. As he carries out his
daily responsibilities, this manager may theorize that the firm is a social system and thereby he develops a large body of knowledge concerning the manager's job in the social system. Or, the manager may visualize his group or department as a data processing system and decision network. From this theory the manager endeavors to accumulate a considerable amount of empirical information about the manager's role in decision making. Should a manager be financially inclined, he might find it beneficial to draw the analogy that the firm is a system of funds flow. A store of knowledge will then be compiled regarding the manager's use of financial resources. It should be cautioned, however, that in making use of such methods, the executive or manager may become enchanted with his particular theory of the manager's job and attempt to apply the theory where it is not applicable.

A very common and realistic theory of overall project or program management is that which approaches the job from a system viewpoint. The basic notion of the system is that it is a set of interrelated parts. In performing his duties, the manager divides whatever responsibility he has into four basic tasks: he first defines the project as a system, but does not necessarily confine the system to the project under his control. The manager, then, establishes the system objectives wherein other system interrelationships are identified and performance criteria are established. Next, he creates the necessary subordinate or sub-systems necessary to handle required details. Last, the manager seeks to systematically integrate the activities of each sub-system within the system and to coordinate his system with other interrelated systems.

In addition to the many administrative skills that have been mentioned, a member of supervision must have personal traits that make him amenable to the position. Correlation of personality characteristics with success has been a preoccupation of personnel administrators and students of the principles of management, but this effort has not proven to be always particularly reliable information. The use of data processing equipment, however, will
probably bring about more success in matching the requirements of a job to the personality of the individual. Both employment placement organizations and individual companies are building up large files of personnel data in an effort to make better selections when job openings appear. Specifications for middle and top management jobs are focusing increasingly on precise personal characteristics. To list these personal characteristics individually and to describe the way in which they are successfully acquired or their relative importance would be meaningless because only the accumulative effect is significant. For example, a manager may be discourteous to his subordinates but, because he is adventurous, entrepreneurial and dynamic, he will generate fierce loyalties and thereby be an effective leader who gets the job done correctly and on time. In general, however, personal traits of the successful manager are most often characterized by: an instinctive acceptance of responsibility; physical and nervous energy; emotional balance; outgoing personality; diplomacy; perseverance and integrity.

Managerial Technical Requirements

In making an evaluation of the importance of technical knowledge to the manager who has made the transition from engineering to a supervisory position, a description of the manager's job is of interest. The thesis questionnaire responses were divided into four categories: (1) management of primarily technical projects and the supervision of engineers and scientists; (2) management of non-technical projects and non-technical personnel; (3) general management of overall company operations including technical activities; and (4) others. The latter category consisted of staff assistants, consultants, specialists, and principal engineers who are considered to be part of management but are primarily engaged in engineering work. The percentage in each category (Figure 23) shows that 52.4 percent, or 262 of the 500 respondents manage technical projects and/or supervise engineers and scientists, whereas, only 15.4 are considered as non-technical management. The need for technical knowledge is apparent. Figure 23 also verifies the previous
MANAGEMENT FUNCTION
All Respondents

Percent

55
50
45
40
35
30
25
20
15
10
5
0

Technical
Non-
Technical
General
Management
Other

Figure 23

Table 19
assumption that engineers who move to management positions are engaged primarily in the technical, rather than the non-technical aspects of the company.

A second indication of the importance of scientific and technical training at the managerial level has been indicated by the Scientific American study of the business executive. The question asked was: "How helpful is your scientific, technical or professional training in your position?" Figure 24 shows that, of the 518 executives who replied, 85 percent gave high ratings to their education as preparation for their present responsibilities. Those with technical education found their training to be "very" and "absolutely" helpful in somewhat larger percentages than did those with non-technical educations.

When engineers are moved into management positions, it is expected that their technical abilities, which have been proven in previous responsibilities, will be useful in the direction of the organization toward goals that reflect the rapid expansion of scientific knowledge. There are numerous examples of matured single-product companies which, through employment of research and development, have regained their vitality by diversification into a variety of goods. As a result, an increasing number of engineers who have been responsible for the creation of the new products are being brought into management. A typical example is the Borden Company, which had long been established solely in the food products industry. In 1954 their chemical division accounted for less than 1 percent of Borden sales. By 1966, Borden chemical division sales were up to 22 percent of company sales. Over the twelve year period, the company has diversified through technical developments and acquisitions into petro-chemical products, fabric coating, vinyl films, adhesives, resins, pressure sensitive tapes, inks, thermoplastics, and aerosol spray paints. The emphasis upon technically-oriented products

48 Ibid., p. 18.
BUSINESS EXECUTIVES EVALUATION OF EDUCATION

Figure 24

Table 20
required a management which offered a fresh approach and, of
greatest importance, which would provide an insight into "the products
of the day." The need for this new type of management resulted,
for the first time, in the election of an operating executive who did
not have a background of experience in the food products industry.
Borden's recently-elected president is a chemical engineer who built
his reputation in the expanding Borden chemical division. His analy-
tical approach to problems and his chemical engineering background
provide the combination which the company hopes will result in
future benefits.

Other indicators of the increased need for technical capa-
bilities at the management level are the numerous seminars and
training programs which are being offered to the executive. U.C.L.A.
has instituted a six-week course on "Modern Engineering for the
Engineering Executive." It is the purpose of this program to develop
a deeper understanding of the nature and forces of our changing
technology, and to amplify and up-date the knowledge of men in
senior executive or administrative positions in engineering. The
subject material is divided into three sections: Mathematical tech-
niques; integrated applications, such as the study of plasmas, com-
puters and technical theories; and basic science, which includes,
among many subjects, relativity, electromastics, molecular structures
and chemical reactions. The purpose is to teach principles rather
than specifics and thus enable the participants to gain insight
into and new perspective on the changing industrial problems of today.

Many companies are attempting to avert technical obsolescence
among their executives by arranging engineering seminars and course
work which is attended during working hours. Other companies are
sending their key executives back to school on full-time programs.
Included in these university programs are large doses of technical
learning. Massachusetts Institute of Technology, for instance, has
made a concentrated effort to increase interchange between campus
and corporation.50 "MIT's New Breed of Engineers," Business Week, January 18,
1964, pp. 54 - 58.
and the ten-week senior executive program are given the opportunity to gain insight into the importance of scientific developments and are encouraged to improve their technical capabilities to the fullest extent.

Generally speaking, there is little question regarding the advantages and importance of having a technically competent manager in a scientifically-oriented organization. Specifically, the amount and kinds of technical knowledge required is dependent upon the responsibilities of the manager. For those managers who are at the higher levels in an organization, the requirements are broadly based, and thus very little detailed knowledge is required in the area of engineering methods. Conversely, the first-line supervisors and lower level managers are expected to be intimately familiar with specific engineering disciplines to insure proper evaluation of the work of their engineers and scientists and to be able to define and direct the technical tasks of their particular project.

The degree to which specific engineering techniques must permeate to the higher levels of management is also dependent upon the type of organization. Organizations, such as research laboratories, whose existence depends upon a certain type of technical skill, will undoubtedly have numerous members in management who could do many of the specialty tasks required of their engineers. Engineers and scientists at North American Aviation’s Science Center, in addition to performing all the necessary managerial duties required of a division, are also expected to carry out basic research studies, write technical books and papers, and perform experimentation in the laboratory.

If a manager in an industrial organization has been an efficient and capable leader, he will have made certain that a competent technical staff exists to perform engineering work. Also, if the manager has acquired the ability to work through people, there will be little necessity for him to become involved in engineering detail. It is axiomatic that as the manager climbs higher on the administrative ladder, the actual work that he himself must do diminishes, provided he has courage, a trust in his subordinates, and
delegates authority so that he doesn’t have to deal personally with everybody and every job. If the manager of the engineering department, for example, has to concern himself with heat transfer calculations, stress analysis, and thermodynamics principles, it is the fault of his leadership ability.

The future technical requirements that will be placed upon the manager are becoming more demanding with the rapid technological change and the growing engineering responsibilities in industry and government. The emphasis now being placed on increasing the manager’s technical capabilities, however, will be placed to a greater extent upon the development of the potential ability and insight in the individual and less upon the transfer of generally prescribed content in standardized engineering courses. As is true of all advanced education, the problem will not be in the retention of specific engineering facts taught in a precise curriculum, but will concentrate upon growth in and understanding of the method or process of transferring the knowledge into sound judgments and rational decisions.

Comparison - Engineering Background vs. Managerial Functions

In Chapter II the education, training, employment experience, and typical characteristics of the engineer were discussed. Also, several supplementary studies were reviewed to better define attitudes and motivations of the typical engineer. A comparison between these factors and the management functions which have been discussed in this chapter will aid in the formation of general conclusions regarding the fundamental discrepancies that exist.

The possession of technical education and training and the development of problem-solving abilities are assets which will aid the engineer who has accepted a management position. This technical background strengthens the individual’s capacity to think for himself, to relate basic skills and general knowledge to specific business decisions, and to approach particular problems in an imaginative, intellectual manner. However, attitudes and philosophies that he may have acquired during his engineering studies and experiences could
work to his disadvantage as a manager. Engineering as a profession stresses the merits of originality and creativity and thereby strengthens individualistic attitudes. As previously shown, the engineering graduate student has a marked preference for working with things rather than with people. Management, however, is characterized as a cooperative job that demands talent in dealing with people. The attitude differences that exist between the professions of engineering and management are indicated by Figure 25 which shows the business graduate students' attitudes as well as those of engineering graduate students.

It can be concluded that the engineer is relatively well-qualified to deal with technical requirements upon his transition into management, but whether or not there remain significant gaps in managerial knowledge which will later impede him in his efforts to become an effective and dynamic manager is a question yet to be answered.

In comparing the engineer's background with the administrative requirements of a managerial position, little evidence is found to indicate that the engineer's background provides adequate preparation for managerial duties. During the course of the engineer's undergraduate education there has been neither time nor purpose to teach him the principles of management and the concepts of accounting, finance, economics, capital budgeting and personnel functions. Also, his employment experience has not given him an opportunity to explore the disciplines and capabilities that are required of a manager. It could not be stated conclusively at this point in the study, but it was suspected that the engineer lacked the required knowledge in the techniques and disciplines of business administration.

The comparisons made from the discussion in Chapter II and III indicate administrative requirement deficiencies as being the more prevalent. However, the comparisons are only an indication of the potential strengths and weaknesses of an engineer in a managerial position. The question concerning the most appropriate continued
ATTITUDES OF GRADUATE STUDENTS
Engineering & Business

Percent Endorsing

- Engineering
- Business

Figure 25

Table 21
advanced formal education cannot be answered by merely comparing general background information to general job requirements. The answer can only be attempted after reviewing the relative importance of the deficiencies. Additional data will be required in order to determine the significance of a lack of advanced technical knowledge versus a lack of administrative knowledge. It is the purpose of the next two chapters to review and analyze such data as has been obtained by the thesis questionnaire and several supplementary surveys. Chapter IV will ascertain how technical managers rate the relative importance of the formal education that they had, and what, if any, formal technical or administrative training they lack or feel would be helpful in the future.
CHAPTER IV
MANAGEMENT SURVEY

An Indication of Advanced Formal Education Needs

In the course of determining the advanced formal educational needs of managers who had at one time been members of the engineering profession, the educational backgrounds of the 500 respondents were first examined, categorized and summarized. Second, the respondents' ratings of selected subject material with respect to its importance in the performance of their present duties were analyzed. Third, educational subject material which the respondents indicated they lacked with respect to its need during their job history was considered. Fourth, an analysis was made of transition difficulties that the respondents experienced upon accepting managerial positions. Last, observations were made concerning (1) the formal education which respondents believed would be the most beneficial to them in the future and (2) the formal education and skills which the respondents believed would be increasingly important to the job they held at the time the survey was made.

The educational requirements for a master's degree in business and in engineering were then reviewed after educational needs had been established. This was done to clarify the type of subject material offered by each program and to indicate which program best satisfied the educational needs of technical managers.

One of the two supplementary studies to which references will be made is the work of a Joint Feedback Committee formed by the Engineering College Administrative Council (ECAC) and the Relations with Industry (RWI) Division of the American Society for Engineering Education (ASEE). 51

The second supplementary study used as reference material was the familiar 1964 *Scientific American* study of business executives.  

**Educational Backgrounds**

The respondents held a total of 500 undergraduate degrees and 171 graduate degrees. Sixteen of the respondents had no college degrees and 209, including the sixteen with no degrees, had had no graduate level formal education. The undergraduate degrees consisted of 475 Bachelor of Science and twenty-five Bachelor of Arts and Associate Bachelor degrees. Of the 475 Bachelor of Science degrees, 418 were in the field of engineering. The distribution of the total undergraduate degrees is shown in Figure 26.

The 171 graduate degrees consisted of 147 Master of Science degrees and twenty-four Doctorate degrees. Fifty-four of the 147 master’s level degrees were M.B.A. or equivalent; seventy-seven were in engineering and the remaining sixteen were in non-technical curricula. The distribution of the total graduate degrees is shown in Figure 27.

Table IV shows how the technical and administrative master’s degrees and the doctorate degrees were distributed among individual respondents. The table also shows the number of individuals who indicated formal graduate level study in Business Administration or technical subjects.

In evaluating educational backgrounds the military service of the respondents was also considered. Figure 28 indicates that 61 percent of respondents served in the armed forces. The difference in the average time served between officer and enlisted groups reflects the minimum required time for each type of service.

**Formal Education Rating**

The thesis questionnaire asked the respondents to rate eight areas of formal education with respect to its importance in the performance of their present duties. The areas to be rated were:

---

UNDERGRADUATE DEGREE MAJORS
All Respondents

Bachelor of Science

Mechanical Engr.

Electrical Engr.

Chemical Engr.

Civil Engr.

General Science

Aeronautical Engr.

Business Adm.

General Engr.

Metallurgical Engr.

Mathematics

Agricultural Engr.

Industrial Engr.

Bachelor of Arts & Assoc. Bach.

Figure 26

Table 22
GRADUATE DEGREE MAJORS

Master of Science
M.B.A. or Equiv.
Electrical Engr.
Mechanical Engr.
General Engr.
Chemical Engr.
Aeronautical Engr.
Civil Engr.
Technical Misc.
Metallurgical Engr.
Non-Technical Misc.
Ph.D.
Engineering
Science
Non-Technical

Figure 27

Table 23
Figure 28

Table 24

MILITARY SERVICE
All Respondents

Percent

No Military Service
Officers
Enlistees
(a) Engineering and Scientific; (b) Economics and Finance; (c) Human Relations - Personnel; (d) Mathematics; (e) Specific technologies (stress analysis, heat transfer, etc.); (f) Accounting; (g) Business Administration (management skills); and (h) Industrial Engineering. The rating was on a "1 to 5" scale with "1" signifying that which was very important and "5" that which was unimportant.

<table>
<thead>
<tr>
<th>TABLE IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>DISTRIBUTION OF GRADUATE DEGREES BY RESPONDENTS</td>
</tr>
<tr>
<td>Graduate Degree Or Advanced Education</td>
</tr>
<tr>
<td>-----------------------------------------</td>
</tr>
<tr>
<td>M.S. Engineering</td>
</tr>
<tr>
<td>M.B.A. or equivalent</td>
</tr>
<tr>
<td>M.S. Engineering &amp; Ph.D.</td>
</tr>
<tr>
<td>M.B.A. or equivalent &amp; Ph.D.</td>
</tr>
<tr>
<td>M.S. Engineering &amp; M.B.A. or equivalent</td>
</tr>
<tr>
<td>M.S. Engineering, M.B.A. or equivalent &amp; Ph.D.</td>
</tr>
<tr>
<td>Business Administration graduate study</td>
</tr>
<tr>
<td>Technical graduate study</td>
</tr>
<tr>
<td>Business Administration &amp; technical graduate study</td>
</tr>
</tbody>
</table>

In calculating an average overall rating for each of the areas of formal education so that the most important area would reflect the highest numerical rating, points were assigned inversely to the numbers used to indicate relative importance. The average rating for each of the areas of formal education for all of the 500 respondents is shown by Figure 29.

When one considers the fact that the respondents are predominantly involved with engineering projects, it is interesting to note that the specific business administration skills of economics and finance, and accounting were indicated as being more important than specific technical subjects.
FORMAL EDUCATION IMPORTANCE
All Respondents

Importance Rating
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0


Figure 29
Table 25
Subject Material Lacking

It was noted that the data gathered by the Joint Feedback Committee in their survey of engineering graduates revealed that the most frequently selected needed subjects were in areas in which the engineer had attached a high degree of importance. When the data from the thesis questionnaire was tabulated, it was also found that the areas of formal education which had been rated high in importance were the same areas most frequently indicated as those in which subject material was lacking.

The thesis questionnaire requested the respondents to list subject material lacking in their past formal education with respect to its need during job history. No limit was put on the number of subjects that could be listed and consequently the total number of subjects exceeds the number of respondents. The subject material that was indicated as lacking was divided into ten education areas, with eight of them being the same as those areas rated in importance. The two additional areas were liberal arts, which included communications skills, general knowledge, history, literature and so forth, and computer technology.

Figure 30 shows the indicated "subject material lacking" percentage distribution between the ten areas of formal education. A total of 575 subjects were indicated as lacking with respect to need during job history.

There appear to be no contradictions between the responses to "education importance" and "subject material lacking." The similarity in the selection of Business Administration and human relations as the first and second rankings for each question tend to validate the data. The low needs with regard to the "Engineering and Scientific" category as compared to its higher importance rating previously noted can be logically explained when considering educational backgrounds. The majority of respondents had been trained and employed in the engineering profession; therefore, it would not

---

American Society for Engineering Education, Education In Industry.
EDUCATION SUBJECT MATERIAL LACKING
All Respondents

Percent

0  5  10  15  20  25  30  35


Figure 30

Table 26
be expected that they would be deficient in technical subjects relative to other areas in which they were untrained or inexperienced. However, engineering and scientific subjects should be of importance to technical managers and evidence from the questionnaire responses indicated that this was, in fact, the case.

The Scientific American survey of business executives obtained data which indicated deficiencies in education similar to those previously noted by the thesis questionnaire responses. 54 The question posed to the business executives was, "Is there any formal scientific, technical or professional training you lack which you feel would have been especially helpful in your position?" This supplementary data concerning gaps in the education of business executives is shown in Figure 31 for both technical and non-technical respondents. Of the 272 executives who answered, more than half of the 108 with technical backgrounds expressed the wish that they had had more training in the business skills traditionally associated with the management function. Of 164 executives who had non-technical backgrounds, 57 percent expressed the wish that they had had more subject material in the sciences and engineering - again, confirmation that it would not be expected that specific education to which individuals had been exposed would be lacking relative to other subject material in which education had not been obtained.

A third source of data which indicated the type of subject material lacking with respect to its need during job history was obtained from the Joint ECAC - RNI Feedback Committee study of engineering graduates. 55 Even though only 413 of the 4,057 respondents were in management positions, the results of the study are felt to be relevant to this thesis.

55 American Society for Engineering Education, Education In Industry.
GAPS IN THE EDUCATION OF BUSINESS EXECUTIVES 1964

Percent

100
90
80
70
60
50
40
30
20
10
0

All Executives
Technical
Non-Technical

All Other
Law
Accounting
Economics
Business Admin.
Science
Engineering

Figure 31

Table 27
Table V shows the ten subjects, ranked in descending order of greatest need, which were chosen by respondents as those in which the most training was needed. The ten subjects were selected from 113 listed courses.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Subject</th>
<th>Percent</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Management Practices</td>
<td>65.4</td>
<td>2660</td>
</tr>
<tr>
<td>2</td>
<td>Technical Writing</td>
<td>64.0</td>
<td>2601</td>
</tr>
<tr>
<td>3</td>
<td>Probability and Statistics</td>
<td>60.2</td>
<td>2449</td>
</tr>
<tr>
<td>4</td>
<td>Public Speaking</td>
<td>59.8</td>
<td>2430</td>
</tr>
<tr>
<td>5</td>
<td>Creative Thinking</td>
<td>56.9</td>
<td>2315</td>
</tr>
<tr>
<td>6</td>
<td>Working With Individuals</td>
<td>56.6</td>
<td>2301</td>
</tr>
<tr>
<td>7</td>
<td>Working With Groups</td>
<td>55.1</td>
<td>2238</td>
</tr>
<tr>
<td>8</td>
<td>Speed Writing</td>
<td>53.6</td>
<td>2178</td>
</tr>
<tr>
<td>9</td>
<td>Talking With People</td>
<td>53.4</td>
<td>2171</td>
</tr>
<tr>
<td>10</td>
<td>Business Practices (Marketing, Finance, Economics)</td>
<td>50.8</td>
<td>2064</td>
</tr>
</tbody>
</table>

The data obtained by the Joint Feedback Committee was also analysed by means of grouping it according to engineering bachelor degree specialty. It was found that there were very real differences in technical training needs for engineers from different backgrounds; but, when reviewing data presented from each of ten different engineering fields, it was found that the subjects of "Management Practices," "Talking with People," "Speed Reading," "Technical Writing," "Creative Thinking," and "Business Practices" were consistently in the top fifteen subjects elected by nine of the groups. The data therefore showed a remarkable consistency in response to non-technical subjects presented in the Feedback Committee questionnaire.
In summary, the data obtained through the thesis questionnaire and the two supplemental studies are in agreement. There is clear evidence with respect to managers who have received an engineering degree or who have a technical background, that the greatest need for formal education is in the area of Business Administration. Also, it is apparent from the data that engineering and scientific education, especially specific technical subject material, are the areas in which there are the fewest deficiencies.

**Transition Difficulties**

One of the criteria for judging the most appropriate advanced formal education for the engineer who is assigned the responsibilities of management, is whether or not the course of study is directed toward resolution of transitional problems. In order to determine the nature of the more important transitional problems that have been encountered in actual experience, the thesis questionnaire asked, "If at any time during your full-time employment history you switched from engineering to management, what do you consider was the most difficult task(s) relative to effecting the transition?"

A total of 64.6 percent of the 500 respondents returning the questionnaire indicated that they had experienced specific difficulties upon moving into a management position. In analyzing the responses, the indicated difficulties were divided into eight categories: (1) Human Relations and subordinate motivation; (2) Delegation of work; (3) Specific Business Administration skills; (4) Management Principles; (5) Decision-making; (6) Technical skills; (7) Communication, political and legal problems; and (8) Accomplishment of job details and all other problems. The eighth category consisted of responses such as "learning job function," "getting used to longer hours and travel away from home," "meetings," "scheduling my time," and "paperwork," which was the most common response. The distribution of the total responses among the eight categories is shown in Figure 32. Of the specific Business Administration skills, finance and economics were the most often mentioned areas of difficulty.
TRANSITION DIFFICULTIES
All Respondents

Percent

35
30
25
20
15
10
5
0

Human Relations
Delegation of Work
Bus. Adm. Skills
Mgmt. Principles
Decision Making
Tech. Skills
Communi. Political
Accomplishment of Job

Figure 32

Table 28
The wide difference between the number of difficulties that were encountered in the area of Business Administration as compared to engineering and technical skills indicates that either the preparation of the engineer for a management position is definitely unbalanced or that the management function requires relatively few technical skills. In actuality, however, based upon the previous comparison between an engineering background and the management function, the cause of the predominance of administrative difficulties in transition to management is a result of both training and job requirements.

**Future Graduate Education Preferences**

A cross-check was made on the rating of past formal education importance and on the subject material that had been indicated as lacking. This was done by asking the respondents, if they were to work toward a graduate degree, what programs of formal education, in their opinion, would be most beneficial to their future. One or more programs were to be listed in order of importance. A high correlation in their response with previous indications concerning education was obtained.

The responses were divided into six educational programs plus an additional category for "no further education required." The programs consisted of Personnel and Human Relations, Engineering and Scientific, Business Administration, Industrial Engineering, Computer Technology and Mathematics, and Liberal Arts, Law and others. The Engineering and Scientific, and Business Administration programs were sub-categorized into General Engineering and Specific Technologies, and Management Principles and Specific Administrative skills, respectively. Figure 33 shows the percentage distribution of the first preference for all respondents and also for 209 respondents who had had no graduate education in either Business Administration or Engineering and Science. There was no difference in the overall results between the two samples.

A second choice graduate degree program was selected by approximately one-half or 47.4 percent of the respondents who had
FUTURE FORMAL GRADUATE EDUCATION
First Preference

Figure 33 Table 29


All Respondents
No Graduate Study
had no graduate study. The distribution is shown by Figure 34.

The predominant preference for a Business Administration graduate degree for both the first and second choices indicated a discrepancy in the data. However, upon examining the data more closely, it was noted that many of the respondents who indicated a preference for "management" on the first choice also listed specific business administration skills for the second choices. A comparison of Figure 33 and Figure 34 shows that the predominant first choice is more accurately "management," whereas the predominant second choice is "specific business administration skills."

To summarize, it appeared that the typical technical manager, in making a choice between graduate business education and graduate engineering education, would select: first, management principles; second, specific business administration skills; third, general engineering; and fourth, specific technical skills.

Future Education or Skills Required by Position

In conjunction with the previous analysis of preferred graduate education for the individual, it was also important to determine the formal education or skills which the technical manager felt would be of increasing importance (over the next ten years) in the adequate accomplishment of the tasks that will be required for the job he now holds.

The thesis questionnaire requested respondents to list one or more items in order of importance. In the returns, a total of 428 of the 500 respondents listed items which they believed would be of increasing importance to their present job. In making the analysis, each of the items listed was placed in one of seven groups: "human relations," "general engineering and technical knowledge," "specific engineering and technical skills," "management principles," "specific business administration skills," "experience and personal qualifications," and "mathematics, statistics and computer technology."
FUTURE FORMAL GRADUATE EDUCATION
Respondents With No Graduate Study
Second Preference

Figure 34

Table 30
The percentage distribution of education or skills of first importance is shown in Figure 35 for all respondents. Future job requirements listed second as being increasingly important are shown by Figure 36.

A comparison of Figure 35 and 36 with Figures 33 and 34 reveals a 100 percent correlation with respect to the order of ranking between the preference and need for business administration education and that of engineering education. The formal graduate education believed to be most beneficial in the future to the individual, and the formal graduate education thought to be increasingly important to the job was "management principles," which was followed by "specific business administration skills." Third and fourth in importance for both questions were "general engineering education" and "specific technical skills."

Master's Degree Requirements

In order that there may be a clear understanding of the contents and objectives of a master's program, discussion is warranted in this area prior to investigating the results of alternative choices of study. First, the various M.B.A. or equivalent programs will be presented; second, the typical content of a master of science program in engineering will be discussed.

M.B.A. or Equivalent Programs

Traditionally, the master's programs in business have consisted of three types. The first is the integrated two-year program which assumes no previous preparation in business subjects and which requires a substantial core of graduate level courses. Programs of this type are offered chiefly by graduate schools and tend to fall into one of two sub-groups: (1) those that emphasize the development of administrative skills, particularly through the use of cases; and (2) those that place more emphasis on subject matter and the underlying disciplines. Both of these sub-groups are

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FORMAL EDUCATION OR SKILLS INCREASINGLY REQUIRED BY PRESENT POSITION IN NEXT 10 YEARS

All Respondents
First Importance

<table>
<thead>
<tr>
<th>Category</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mgmt. Experience, Personal Qual.</td>
<td>35</td>
</tr>
<tr>
<td>Math., Stat., Computer Tech.</td>
<td>30</td>
</tr>
<tr>
<td>Bus. Adm. Principles</td>
<td>25</td>
</tr>
<tr>
<td>Specific Engr &amp; Tech.</td>
<td>20</td>
</tr>
<tr>
<td>Specific Skills</td>
<td>15</td>
</tr>
<tr>
<td>Gen'l. Engr &amp; Tech.</td>
<td>10</td>
</tr>
<tr>
<td>Human Relations</td>
<td>5</td>
</tr>
</tbody>
</table>

Figure 35

Table 31
FORMAL EDUCATION OR SKILLS INCREASINGLY REQUIRED BY PRESENT POSITION IN NEXT 10 YEARS

All Respondents
Second importance

Percent

35
30
25
20
15
10
5
0

Human Relations
Gen'l. Engr. & Tech.
Specific Engr. & Tech.
Specific Bus. Adm. Skills
Mgmt. Experience, Personal Qual.

Figure 36

Table 32
management-centered programs and relate the student's work to manageri
dal decision making. Given this orientation, the various speciali-
ties such as accounting, finance and marketing are studied, not as self-contained bodies of knowledge, but rather as supporting branches of the broader field of management. As of 1959 there were no more than ten schools whose master's programs in business were thus oriented. Development of the case method approach has been credited to the Harvard Business School, which first offered the program in 1908. This decision to have instruction "as far as practicable" take the form of classroom discussion of specific problems was prompted by the example of the Harvard Law School. The second sub-group, which is best exemplified by the programs offered at Chicago University, Massachusetts Institute of Technology and Carnegie Institute of Technology, stresses "scientific decision-making" in the approach to business training. Such programs place emphasis on the study of mathematics, statistics, economics and psychology.

The management-centered schools have concentrated on criti-
cal policy decisions of the firm and have placed strong emphasis on dealing with concrete problems from a variety of viewpoints. The student is required to engage in independent analysis; he must exercise a certain degree of ingenuity and judgment in his work; he must be prepared to meet questions and criticism on written and oral presentations; he gains some feeling for complexities and diffi-
culties of decision-making in a business setting and he gains some appreciation of the interrelationship between business processes within the firm and between the firm and its external environment.

The second type of master's program is the "hybrid" program which requires from one to two years of study, depending on the

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student's background. These programs fall into two groups: (1) two-year programs with a substantial core curriculum divided into two parts, the first of which may be omitted for the student who has previously studied corresponding undergraduate courses. These programs tend to emphasize preparation for general management careers and, in general, do not emphasize specialized subject matter. (2) This group offers modifications of the conventional one-year program. Students who have not studied the necessary prerequisites spend one year attaining such course credits in special graduate sections. Under such programs, the second year, which is relatively free of core requirements, is devoted chiefly to a field of specialization and to electives.

The last type consists of one-year programs based on a set of undergraduate prerequisites. Students who have not taken the necessary prerequisite courses must gain these credits in undergraduate courses. Such programs usually tend to have little or no required core curriculum, emphasize specialized subject matter, and are geared to the needs of specialists, accountants, researchers, or teachers, rather than to the needs of future administrators. This remains the most common type of master's program. A small minority of schools do require the study of a substantial core curriculum which emphasizes preparation for general management careers.

In the cross-analysis of the thesis questionnaire data, no attempt has been made to separate the three types of master's programs in Business Administration because of the unavailability of descriptive information and the lack of details which must be considered in order to determine significant differences. Also, the small amount of data that pertains to Industrial Engineering advanced education was included with the M.B.A. data. The analysis of Industrial Engineering was not treated separately because it was found that these programs were most closely aligned with, and could

58 Gordon and Howell, p. 249.
59 Ibid. p. 250.
not be distinguished from, many courses in Business Administration.

Also included with the M.B.A. degree data were the master's
degrees in business offered by a number of engineering schools.
These programs bear titles such as Industrial Administration, In-
dustrial Management, and Engineering Administration. Unlike their
undergraduate counterparts, they require practically no formal work
in engineering and in essence attempt to meet the same needs as
other graduate business programs.

The two-year program in Industrial Administration tends to
be quite similar to those in the better graduate schools of busi-
ness. There is a substantial core of required work in the funda-
mental business subjects; the development of management skills is
emphasized, and the narrower aspects of engineering are largely ig-
nored. Carnegie Institute of Technology and Massachusetts Institute
of Technology offer the best-known examples of two-year master's
programs in Industrial Administration.

Other types of advanced programs in Industrial Administration
do exist and they vary over a wide range. Some have no core require-
ments, but rather are "tailor made" for individual students; others
have core requirements, but vary in their orientation to engineering.
In some programs, the core requirements depend on the student's
undergraduate background; other programs are of a specialized
nature, such as the Operations Research program offered by Case
Institute.

A more specific description of the type of material to
which graduate students in various Business Administration courses
are exposed is illustrated by Table VI.

The pattern of almost all programs leading to a master's
degree in Business Administration includes core subject require-
ments in accounting, statistics, economics, marketing, finance,

60Ibid., p. 251.
### TABLE VI

NUMBER OF MASTER'S PROGRAMS REQUIRING GRADUATE COURSES IN THE VARIOUS CORE FIELDS IN SAMPLES OF FOUR TYPES OF BUSINESS SCHOOLS*

<table>
<thead>
<tr>
<th>Field</th>
<th>Eight Exclusively Graduate Schools</th>
<th>Fifty-four Mixed Grad.-Under-Grad. Schools</th>
<th>Five Engineering Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accounting</td>
<td>6</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>Statistics</td>
<td>5</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Integrated &quot;controls&quot; subjects</td>
<td>1</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Managerial economics</td>
<td>2</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>Applied macroeconomics</td>
<td>1</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Other economics</td>
<td>3</td>
<td>13</td>
<td>2</td>
</tr>
<tr>
<td>Organization administration</td>
<td>4</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Human relations—personnel</td>
<td>4</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>Management Principles</td>
<td>1</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Finance</td>
<td>6</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>Marketing</td>
<td>6</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>Production</td>
<td>6</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>Industrial relations</td>
<td>0</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Legal, political, social framework</td>
<td>4</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>Business policy</td>
<td>4</td>
<td>13</td>
<td>1</td>
</tr>
</tbody>
</table>

business law, personnel, and production. The upper-level graduate courses which are taken following the completion of the core requirements emphasize the managerial uses of these tools; i.e., stress is placed on the process of analysis and interpretation wherein the core courses tend to be weak. More recently, added emphasis has been placed on quantitative tools and the newer kinds of computer techniques for managerial problem-solving. Mathematical sophistication is becoming evident in many of the solutions to business problems that heretofore have lent themselves only to subjective decisions based upon the experience of the manager.

In a speech given before the American Management Association of New York in 1956, Dean Stanley E. Teel of Harvard University expressed his views regarding important changes in future graduate business programs. It will be noted that some of the changes suggested in the following excerpt from Dean Teel's speech are presently being put into practice.

I believe that all of us would readily agree that top management is a mixture of art and science. My own view is that it is overwhelmingly more art than science, but that the element of science will increase notably during the next generation. To be brash indeed and put out specific numbers to provoke discussion, I would say that today top business management is 90 percent art and 10 percent science and that in another generation a tremendous increase in attention to scientific aspects might make the ratio 80 percent art and 20 percent science. Obviously what I have in mind particularly here is the growing attention on the one hand to mathematical - statistical theories and on the other hand to the electronic data processing equipment which may make those new mathematical - statistical theories and methods

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Master of Science in Engineering Programs

A master's degree program in engineering is most easily and accurately described as being an extension in depth and specialization of the subjects taken during the undergraduate program. The material that is offered extends over a wide range from pure science, and especially what is known as engineering science, to technology, depending upon the particular field of engineering which is chosen. With the exception of the Industrial Engineering program, which has been discussed previously, all of the major fields of advanced engineering and Chemical Engineering concentrate exclusively on courses which are highly specialized in their respective area of interest. The purpose of these courses is not to provide a broad background or to present general material concerning engineering, but rather to offer detailed knowledge and to develop special skills so that the engineer is kept current with technological advances in his specialty and has the proper tools to solve complex engineering problems.

The basic core requirements in the master's program in engineering emphasize thorough training in the quantitative problem-solving techniques of mathematics. The graduate foundation in mathematics includes, as a minimum, the study of differential equations, numerical analysis, advanced calculus, statistics, and probability. 63

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The more advanced mathematical needs differ among the several professional specializations. The physical sciences are also heavily stressed. Courses in chemistry and physics are offered to provide explanations of the behavior of nature and to build a strong foundation which is necessary for understanding the engineering sciences. Logically, fields of specialization such as Chemical Engineering, Nuclear Engineering and Agricultural Engineering place primary emphasis on the physical sciences.

Following training in the core subjects, the engineering graduate student concentrates upon specific engineering sciences which encompass the basic physical sciences and embrace the principles of engineering. The engineering sciences cover a wide area of technical knowledge which cut across most fields of engineering. Therefore, it is not possible for the student to take all of the engineering sciences; rather, he must choose between engineering curricula such as: mechanics; electrical science, electric and magnetic fields, circuits, and electronics; thermodynamics and statistical mechanics; material science; information science, communication processes, logic and computing devices, systems concepts; or transfer and rate processes, such as heat and mass transfer, or some phase of fluid mechanics. In addition to these subject areas, entirely new fields of engineering have developed from the engineering sciences such as those termed "communication science," "space science," "environmental science," and "bio-engineering."

Within the major area of concentration, the graduate engineering program provides for and requires the development of abilities in engineering problem synthesis, analysis, design and research, and laboratory procedures. The final courses are characterized by fairly sophisticated research or engineering system design problems which, it is hoped, will encourage creative thinking. The learning experiences of the entire curriculum are so planned that innovation is encouraged and the engineering techniques are optimized.

Graduate programs in engineering often allow selection of
several electives. However, the choices are limited to alternatives within the areas of engineering with the thought that associated spectrums of technical knowledge will be explored. Because engineering is a "learning" profession, in which the education process must be continuous and comprehensive in order to stay afloat on the rising tide of technical advancement, there is no time remaining within the master's program in engineering for formal course work outside the major field of study.

Summary and Preliminary Conclusions

The principal finding of the thesis questionnaire was that technical managers in general felt that they need more education in both technical and non-technical areas, although their first needs appeared to be, by a wide margin, subjects which emphasize first, the principles of management and second, which teach specific business administration skills.

Previous formal education in Business Administration and engineering was of almost equal importance in the performance of present job duties. The high importance rating of past engineering education is not surprising considering the fact that the respondents are technical managers, former engineers, and are involved primarily with technical projects. This data does not deny that technical education plays an important part in the success of an engineer in a management position; however, it reveals the importance of areas in education that have not been traditionally associated with the needs of engineers. The high degree of importance which the technical manager attached to human relations, economics, finance and accounting, and the relatively low importance he attached to specific technological skills in indicative of the change in personal attitudes and academic emphasis that accompanies the transition from engineer to manager.

The increasing need that the manager or executive has for Business Administration education was initially revealed by an analysis of the subject material which he felt had been lacking during
his employment history. The thesis questionnaire indicated a need for general business education which was approximately six times that indicated for general engineering and technical subject matter. Also, the need for specific Business Administration subjects was about five times greater than the indicated need for specific technical skills.

A second indicator of the most appropriate graduate education for the manager and for the potential manager was the transition difficulties brought out by the thesis questionnaire. Difficulties relating to technical skills were almost non-existent. On the other hand, transition problems stemming from Business Administration difficulties consisting of both managerial skills and specific administrative skills accounted for over 40 percent of the responses. This data leaves little doubt regarding the conclusion that an M.B.A. or equivalent degree would seem to be the most appropriate for the individual in facilitating his transition from engineering into management.

Two additional indicators of the most beneficial type of advanced formal education were the opinions held by managers and executives regarding the type of graduate degree which they believed would be most beneficial in their future and also the education or skills which they believed will be increasingly important to the positions they now hold. Taking cognizance of both the individual and the job, the opinion that Business Administration education and skills would be the most beneficial, as well as being increasingly important, far exceeded all other considerations.

The opinion that future graduate education in engineering would be of primary benefit and increasingly important to the job was expressed by less than 10 percent of those who responded.

Considering degree requirements, indications point toward Business Administration as being the area of advanced education
which would prove most appropriate for the engineer who is assigned the responsibilities of management. However, it must be emphasized at this time that the data that has been presented thus far is an indication, and only an indication, of the most appropriate area of advanced formal education. The proof that these indicators are correct and that fulfillment of the requirements for a graduate degree in Business Administration are more beneficial has yet to be presented and discussed.

The purpose of the next chapter will be to present the analysis of the thesis questionnaire data divided by academic background. The cross-analysis endeavors to ascertain if differences in formal graduate education have been reflected in the performance of the technical manager and in his attainments of positions and salary.
CHAPTER V

ACADEMIC BACKGROUND ANALYSIS AND RESULTS

To facilitate the analysis of academic backgrounds, the thesis questionnaire data was first categorized into five separate academic groupings. The backgrounds of those respondents with M.B.A. or equivalent degrees and with M.S. Engineering degrees were then analyzed to determine differences that could mask subsequent comparisons of educational benefits. Next, attitudes toward educational background and its importance were surveyed and compared, followed by an effort to determine whether there was a notable difference between the five categories concerning subject material lacking relevant to its need during job history. The respondents' opinions — as well as differences of opinion — concerning their assessment of the relative benefit of graduate degrees and the future requirements of their jobs were compared in light of their chosen course of advanced education. Differences in transitional difficulties between groups having advanced degrees were evaluated and last, an indication of relative job performance value was approximated by noting advancement history, position in the organization and annual salary versus age.

It is acknowledged that there are a multitude of variables responsible for the success or failure of an individual and that these variables often obscure the effects of education. The information that was obtained by the thesis questionnaire did not offer conclusive proof that an M.B.A. or equivalent degree is the most beneficial; however, after analyzing the data and rationally weighing and balancing existing circumstances, a logical conclusion was reached.

Academic Grouping of Thesis Questionnaire Data

The five groups consisted of those respondents who had:
(1) an M.B.A. or equivalent graduate degree; (2) an M.S. in Engineering degree; (3) participated in Business Administration graduate level formal study; (4) participated in technical graduate level formal study; and (5) no Business Administration or technical graduate level formal study. The majority of cross-analyses and comparisons were made between the first two groups — the graduate Business
Administration versus the graduate Engineering degree. The remaining categories supplied supplementary data.

The first group was made up of fifty-four respondents. Two of the respondents had doctorate degrees in addition to their M.B.A. degrees. One was in Industrial Engineering and the other in Nuclear Engineering. The undergraduate academic backgrounds of the respondents with M.B.A. or equivalent degrees are shown in Figure 37.

The second group consisted of seventy-five respondents. Fourteen of these respondents also had, in addition to their M.S. degree in Engineering, a doctorate degree. Two respondents had both Business Administration and Engineering graduate degrees and they have been placed in both the first and second groups. One of these respondents also had a doctorate degree. The undergraduate academic background and graduate technical specialties are shown in Figure 38 and Figure 39 respectively.

Ninety-one of the 500 respondents had taken graduate level courses in Business Administration and eighty-two had taken graduate level courses in technical subjects. Fifteen of these respondents had taken advanced courses in both Business Administration and Engineering. Group three of the analysis was therefore made up of the seventy-six respondents who had taken only advanced Business Administration courses but had not earned an advanced degree, and group four consisted of the sixty-seven respondents who had taken only advanced technical courses, but who also had not obtained an advanced degree. Group five consisted of 209 respondents who had not participated in either advanced business or advanced engineering study.

Isolation and Analysis of Non-academic Variables

In the process of determining the relative benefits which may be attributed to obtaining a Master’s degree in Business as opposed to obtaining a Master’s in an engineering field, it was first necessary to isolate and analyze factors not directly associated with comparisons of educational value. These variables consisted of the type, size, location and age of the organizations.
UNDERGRADUATE DEGREE MAJORS
Respondents With Master’s Degrees in Business Administration

Bachelor of Science
  - Mechanical Engr.
  - Electrical Engr.
  - Chemical Engr.
  - Civil Engr.
  - General Engr.
  - Aeronautical Engr.
  - Metallurgical Engr.

Associate Bachelor
  - Engineering
  - Non-Technical

Bachelor Business Adm.

Figure 37

Table 33
UNDERGRADUATE DEGREE MAJORS
Respondents with Master's Degrees in Engineering

Bachelor of Science
- Electrical Engr.
- Mechanical Engr.
- Chemical Engr.
- Civil Engr.
- Aeronautical Engr.
- General Education
- Metallurgical Engr.
- General Engr.
- Agricultural Engr.
- Economics
- Associate Bach. Engr.

Figure 38
MASTER of SCIENCE-ENGINEERING
AREAS of TECHNICAL SPECIALITY

Electrical Engr.
Mechanical Engr.
General Engr.
Chemical Engr.
Aeronautical Engr.
Civil Engr.
Other Specialties
Metallurgical Engr.

Figure 39

Table 35
with which the respondents were associated; the age of the respondents; their length of service with the organizations and time in present positions; the respondents' military backgrounds and facts concerning financial aid and the continuity of formal education.

Type of Organization

The type of organization with which respondents in the two groups with graduate level degrees were associated was first determined and evaluated. Figure 40 compares the employing organizations of M.B.A. graduates and M.S. Engineering graduates with those of all respondents.

The higher percentage of M.S. Engineering graduates relative to M.B.A. graduates in both the "Electronic and Aerospace" and "R & D" categories is indicative of the emphasis placed on technical knowledge and skills by these firms. Also, it is in these organizations that advanced technology is growing the most rapidly.

There is a tendency for the engineer working in aerospace organizations to be better compensated than his counterpart in other industries, especially in the "14 to 20 years of experience" group. However, a comparison of median annual salaries of graduates in aerospace companies with median annual salaries for graduates in all industries (Figure 41) revealed that the average difference was less than $1,000 per year. The rapid growth of the aerospace industry, on the other hand, will possibly provide the M.S. Engineering respondents better opportunities for advancement.

It was concluded that there was no evidence to indicate that the respondent would benefit greatly or be significantly hampered because of the type of organization for which he worked.

Size, Location and Age of Organization

When an examination was made of the size, location, and age of the companies for which the M.B.A. and M.S. Engineering graduates worked, it was found that no differences existed between the two groups which might be expected to bias the data. The data is
TYPES OF ORGANIZATIONS

Percent

<table>
<thead>
<tr>
<th>Types of Organizations</th>
<th>All Respondents</th>
<th>MBA Graduates</th>
<th>M.S. Engr. Graduates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indust.</td>
<td>60</td>
<td>50</td>
<td>0</td>
</tr>
<tr>
<td>Public Utility</td>
<td>10</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>Gov't.</td>
<td>20</td>
<td>30</td>
<td>40</td>
</tr>
<tr>
<td>Transportation</td>
<td>10</td>
<td>50</td>
<td>0</td>
</tr>
<tr>
<td>R. &amp; D.</td>
<td>10</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Electronic, Aerospace</td>
<td>30</td>
<td>40</td>
<td>30</td>
</tr>
<tr>
<td>Other</td>
<td>10</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Figure 40

Table 36
MEDIAN SALARY SINCE BACCALAUREATE

All Graduates

Dollars/Year

$15,000

Aerospace

All Industries

Years Since Baccalaureate

Figure 41

Table 37
shown in Table VII.

<table>
<thead>
<tr>
<th>TABLE VII</th>
<th>All Respondents</th>
<th>M.B.A. Graduates</th>
<th>M.S. Engr. Graduates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Number Employed</td>
<td>30,225</td>
<td>55,198</td>
<td>49,878</td>
</tr>
<tr>
<td>Relative Size</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large</td>
<td>50.3%</td>
<td>59.3%</td>
<td>57.3%</td>
</tr>
<tr>
<td>Medium</td>
<td>35.3%</td>
<td>27.8%</td>
<td>32.0%</td>
</tr>
<tr>
<td>Small</td>
<td>14.4%</td>
<td>12.9%</td>
<td>10.7%</td>
</tr>
<tr>
<td>Location</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>East Coast</td>
<td>46.4%</td>
<td>37.0%</td>
<td>53.3%</td>
</tr>
<tr>
<td>Midwest</td>
<td>64.2%</td>
<td>61.0%</td>
<td>53.3%</td>
</tr>
<tr>
<td>Rocky Mountain</td>
<td>10.2%</td>
<td>16.7%</td>
<td>14.7%</td>
</tr>
<tr>
<td>West Coast</td>
<td>35.2%</td>
<td>42.5%</td>
<td>42.7%</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than 12 yrs. old</td>
<td>12.2%</td>
<td>18.5%</td>
<td>18.6%</td>
</tr>
<tr>
<td>Twelve or more yrs. old</td>
<td>87.8%</td>
<td>81.5%</td>
<td>81.4%</td>
</tr>
</tbody>
</table>

Age of Respondents, Length of Service with Company and Time in Present Position

The age distribution for M.B.A. graduates and M.S. Engineering graduates compared with the age distribution of all respondents is shown in Figure 42. There are no significant differences between the two groups.

The average M.B.A. graduate had been with his employer for 11.7 years. The range was from one year to twenty-eight years, with a median length of service of twelve years. In comparison, the M.S. Engineering graduate had served an average of 14.1 years with his present company. The range of time for this group was from one year to thirty-eight years. The median length of employment was also
AGES OF RESPONDENTS

Figure 42
twelve years. The average number of years that all respondents had served their company was 14.5 years.

It was found that the two groups of data were nearly identical with respect to average length of time that respondents had been assigned to their present positions. The M.B.A. graduates had spent an average of 3.2 years in their present respective positions whereas the M.S. Engineering graduates had accumulated an average of 3.4 years in each of their present positions.

From this analysis it was concluded that, because of the similarity in data between the M.B.A. group and the M.S. Engineering group, neither the average age, the length of time with the present company, nor the time assigned to the present position needed to be considered in the remainder of the comparative analysis. Each of these factors played an important part in the evaluation of progress of an individual respondent, but when the average progress of the two groups was being considered, these factors were self-canceling.

Military Service

Figure 43 compares the military experience of M.B.A. graduates with that of M.S. Engineering graduates. For comparison, the military experience of all respondents is also shown. The similarity in the average number of years served as officers, and particularly as enlistees, by respondents in all three groups reflected the minimum service requirements imposed by the U.S. government. The fact that the average number of years served by those who had been enlisted was within .1 to .4 years of the minimum required time of two years indicated that those respondents were not willing to spend any more time than necessary in the service. The average number of years served by officers was higher than the minimum required time because of the presence of military career men in all groups.

The wide variety of duties and experiences which are available in the military service were felt to be the dominant military factors in influencing subsequent careers. However, data was not obtained concerning these details of military experience; but, based
MILITARY SERVICE

Figure 43

Table 39
on the data that was obtained, there was no reason to suspect a lack of balance in military experience, on the average, between the M.B.A. group and the M.S. Engineering group.

Financial Aid and Continuity of Formal Education

There was no basis on which to compare the institutions granting the M.B.A. degrees with those granting the M.S. Engineering degrees because of the lack of a common denominator. However, for the purpose of interest only, the institutions from which the respondents obtained their master's degrees are shown in Tables VIII and IX. It was expected that the significant differences which do exist in the universities and colleges offering master's programs in Business and Engineering would be reflected in the quality of education received by the respondents. Differences in the programs offered by the various institutions are therefore a part of the comparison and analysis of the value and the appropriateness of the M.B.A. degree as opposed to the M.S. Engineering degree.

In response to the thesis questionnaire inquiry regarding the financial aid obtained from the family toward formal education prior to first full-time employment, 19.8 percent of all respondents indicated that they had received more than one-half of the expenses. The percentage of the respondents with master's degrees who had received more than half their expenses was substantially higher. Of those respondents who held M.B.A. degrees and M.S. Engineering degrees, 35.2 percent and 41.4 percent respectively had received more than half their expenses. It was not proven, but the difference in financial aid between all respondents and those with advanced degrees most likely reflected the fact that the additional time and school work required by the master's degree puts greater financial strain on the student. Hence, he must depend more upon his family for extra help than does the student who obtains only a bachelor's degree. The six percent difference between the two groups with master's degrees is possibly explained by the continuity of formal education.
# TABLE VIII

**INSTITUTIONS OF GRADUATE BUSINESS ADMINISTRATION STUDY**

<table>
<thead>
<tr>
<th>Institution</th>
<th>Number of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harvard University</td>
<td>9</td>
</tr>
<tr>
<td>University of Chicago</td>
<td>5</td>
</tr>
<tr>
<td>Massachusetts Institute of Technology</td>
<td>4</td>
</tr>
<tr>
<td>Stanford University</td>
<td>4</td>
</tr>
<tr>
<td>Purdue University</td>
<td>3</td>
</tr>
<tr>
<td>Indiana University</td>
<td>2</td>
</tr>
<tr>
<td>Temple University</td>
<td>2</td>
</tr>
<tr>
<td>University of California at Los Angeles</td>
<td>2</td>
</tr>
<tr>
<td>Western Reserve University</td>
<td>2</td>
</tr>
<tr>
<td>American International College</td>
<td>1</td>
</tr>
<tr>
<td>Boston College</td>
<td>1</td>
</tr>
<tr>
<td>Drexel Institute of Technology</td>
<td>1</td>
</tr>
<tr>
<td>George Washington University</td>
<td>1</td>
</tr>
<tr>
<td>Illinois Institute of Technology</td>
<td>1</td>
</tr>
<tr>
<td>Northwestern University</td>
<td>1</td>
</tr>
<tr>
<td>Rollins College</td>
<td>1</td>
</tr>
<tr>
<td>San Fernando Valley State College</td>
<td>1</td>
</tr>
<tr>
<td>Southern Methodist University</td>
<td>1</td>
</tr>
<tr>
<td>St. Bonaventure University</td>
<td>1</td>
</tr>
<tr>
<td>University of Akron</td>
<td>1</td>
</tr>
<tr>
<td>University of Buffalo</td>
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</tr>
<tr>
<td>University of Colorado</td>
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<tr>
<td>University of Delaware</td>
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<tr>
<td>University of Michigan</td>
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<td>University of Missouri</td>
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<td>University of Pennsylvania</td>
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<tr>
<td>University of Pittsburgh</td>
<td>1</td>
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<tr>
<td>University of Southern California</td>
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</tr>
<tr>
<td>University of Washington</td>
<td>1</td>
</tr>
<tr>
<td>University of Wisconsin</td>
<td>1</td>
</tr>
</tbody>
</table>
### TABLE IX

**INSTITUTIONS OF GRADUATE ENGINEERING STUDY**

<table>
<thead>
<tr>
<th>Institution</th>
<th>Number of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purdue University</td>
<td>18</td>
</tr>
<tr>
<td>Massachusetts Institute of Technology</td>
<td>10</td>
</tr>
<tr>
<td>California Institute of Technology</td>
<td>4</td>
</tr>
<tr>
<td>Case Institute of Technology</td>
<td>4</td>
</tr>
<tr>
<td>University of Illinois</td>
<td>3</td>
</tr>
<tr>
<td>Cornell University</td>
<td>2</td>
</tr>
<tr>
<td>Illinois Institute of Technology</td>
<td>2</td>
</tr>
<tr>
<td>John Hopkins University</td>
<td>2</td>
</tr>
<tr>
<td>Northwestern University</td>
<td>2</td>
</tr>
<tr>
<td>Ohio State University</td>
<td>2</td>
</tr>
<tr>
<td>University of California at Los Angeles</td>
<td>2</td>
</tr>
<tr>
<td>City College of New York</td>
<td>1</td>
</tr>
<tr>
<td>Columbia University</td>
<td>1</td>
</tr>
<tr>
<td>Chrysler Institute of Technology</td>
<td>1</td>
</tr>
<tr>
<td>Drexel Institute of Technology</td>
<td>1</td>
</tr>
<tr>
<td>Georgia Institute of Technology</td>
<td>1</td>
</tr>
<tr>
<td>New York University</td>
<td>1</td>
</tr>
<tr>
<td>Polytechnic Institute of Brooklyn</td>
<td>1</td>
</tr>
<tr>
<td>Rensselaer Polytechnic Institute</td>
<td>1</td>
</tr>
<tr>
<td>Rice University</td>
<td>1</td>
</tr>
<tr>
<td>Stanford University</td>
<td>1</td>
</tr>
<tr>
<td>Syracuse University</td>
<td>1</td>
</tr>
<tr>
<td>University of California</td>
<td>1</td>
</tr>
<tr>
<td>University of Colorado</td>
<td>1</td>
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<tr>
<td>University of Connecticut</td>
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</tr>
<tr>
<td>University of Kansas</td>
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<tr>
<td>University of Kentucky</td>
<td>1</td>
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<tr>
<td>University of New Hampshire</td>
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<td>University of Pittsburgh</td>
<td>1</td>
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<tr>
<td>University of Southern California</td>
<td>1</td>
</tr>
<tr>
<td>University of Washington</td>
<td>1</td>
</tr>
<tr>
<td>University of Wisconsin</td>
<td>1</td>
</tr>
<tr>
<td>Virginia Polytechnic Institute</td>
<td>1</td>
</tr>
<tr>
<td>No information</td>
<td>2</td>
</tr>
</tbody>
</table>
The average elapsed time between high school graduation and receipt of the bachelor's degree and between receipt of the bachelor's degree and earning of the master's degree, for both the group of respondents with M.B.A. degrees and the group with M.S. Engineering degrees was 5.3 years and 5.7 years. Considering the fact that the minimum possible time normally is four years, these values are reasonable and show no difference in continuity in formal education at this point between the two groups. However, there is a significant difference in the average elapsed time between obtaining the bachelor's degree and obtaining the master's degree. The M.B.A. graduates had an elapsed time of 10.3 years between the two college degrees, whereas the M.S. Engineering graduates obtained their master's degree only 4.9 years, on the average, after obtaining their baccalaureate degree. This observation was one of the more important findings of the study and was found to have wide implications in the remainder of the analysis. It may now be seen that part of the answer to the question concerning the 6 percent difference in education financial aid between the two groups lies in the fact that there was obviously a difference in earnings over the period between the attainment of the two college degrees. The M.S. Engineering graduate continued his formal education with little or no time for intervening employment, whereas the M.B.A. graduate worked for an average of possibly eight to nine years before getting his M.B.A. degree.

In the process of summarizing the isolation and analysis of non-academic variables, it was found that only one consideration entered into the subsequent comparative analysis of the M.B.A. and M.S. Engineering degrees. There were no appreciable differences between the two groups of respondents - M.B.A. graduates and M.S. Engineering graduates - regarding type of organization, average company size, location and age, average respondent age, average length of service with the company, length of time in present position, or military experience. The one significant difference that was noted and which was taken into consideration in the subsequent
analysis was the point in the engineer's career at which either an M.B.A. or an M.S. degree in Engineering was obtained.

Comparative Analysis of Advanced Formal Education Value

The thesis questionnaire data which pertained to attitudes concerning past education, to employment experience, to opinions regarding future required education and skills, and to advancements in responsibilities and earnings were compared between academic groupings and then analyzed. The responses to the questions in these areas revealed indications of the relative value of advanced business and advanced engineering education and of the benefits derived therefrom.

Formal Education Importance

The type of advanced formal education which had been selected by the respondents should be reflected in the importance which they attached to various areas of education. For example, if the data were valid, it would be expected that respondents who had a Master's degree in Engineering would attach a relatively greater importance to the area of "Engineering and Scientific" education than would other respondents. To determine if this assumption were true or if there were any deviations that might have tended to bias an evaluation of the value of master's degree programs, the data was grouped according to academic background and each educational area was then analyzed.

Figure 44 shows the relative importance rating that M.B.A. graduates and M.S. Engineering graduates attached to different areas of education. These ratings are compared with those of all respondents. The method of calculating the ratings and the areas of education examined are the same as discussed in Chapter IV.

It was interesting to note that the rating given to "Specific Technologies" by the engineering group was lower than the ratings which the same group gave "Economics and Finance," "Human Relations," and "Business Administration." Hence, the content of a master's program in engineering does not appear to be consistent with the
FORMAL EDUCATION IMPORTANCE

<table>
<thead>
<tr>
<th>Importance Rating</th>
<th>All Respondents</th>
<th>MBA. Graduates</th>
<th>M.S. Engr. Graduates</th>
</tr>
</thead>
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<tr>
<td>45</td>
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<td>40</td>
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</tr>
<tr>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 44

Table 40
importance attached to the "Specific Technologies" area of education by technical managers who hold Master's Degrees in Engineering.

A supplementary independent analysis was made in an attempt to verify the previously presented data. This was done by comparing the combined education area importance ratings of those respondents who had indicated they had taken advanced business courses only, but who had not been granted an M.B.A. or equivalent degree with those ratings of respondents who had taken advanced technical courses only, but who had not been granted a Master's degree in Engineering (group 3 versus group 4). The comparative ratings, as shown by Figure 45, exhibited different absolute rating numbers than did Figure 44, but the qualitative characteristics were identical. "Specific Technologies" was again given a relatively low rating, not only by group three, but also, ironically, by those in group four - the group whose respondents had taken courses in specific technologies.

To provide a final, general overall observation of the importance of past formal education, the respondents were asked to indicate whether they felt that formal education following a bachelor's degree has, or would have, helped them in attaining their present employment status. Figure 46 shows the percentage distribution of the responses.

As a result of the analysis of these comparisons concerning formal education importance, it was concluded that, except for the one discrepancy noted, the attitudes of the respondents were consistent with the action they had taken to continue their formal education. There was no evidence that indicated distortion of subsequent comparative analyses.

Subject Material Lacking

Subject material which respondents felt had been lacking in past formal education with respect to its need during job history was compared according to academic background. The groups compared
FORMAL EDUCATION IMPORTANCE

- All Respondents
- Bus. Adm. Grad. Study
- Engr. Grad. Study

Figure 45

Table 41
GRADUATE EDUCATION VALUE

Percent

- All Respondents
- MBA Graduates
- M.S. Engr. Graduates

Yes  No  Possibly  Don't Know

Figure 46

Table 42
were: M.B.A. graduates; M.S. Engineering graduates; and those respondents who had had no graduate level study in either business or technical courses. Figure 47 shows the percentage distribution of subject material indicated as lacking by each group. The data for all respondents is again shown for comparative purposes. The ten areas into which the subject material has been divided were discussed in Chapter IV.

The fact that every area directly involving education in Business Administration was indicated as an area of deficiency the least number of times by M.B.A. degree holders relative to "all respondents," the "M.S. Engineering" group and the "no graduate studies" group points out two important facts. First, business courses are generally important to all technical managers regardless of academic background; and second, the knowledge that has been gained by respondents who hold a Master's degree in Business Administration has been of value to them in satisfying their educational need during job history. These same two points were not always found to be true in the case of M.S. Engineering graduates.

When the group of M.S. Engineering graduates was compared with the group of M.B.A. graduates in the area of "Technical subject material lacking," it was found that the M.S. Engineering group always indicated fewer deficiencies. However, the same was not true when the M.S. Engineering group was compared with all respondents and with those respondents who had no advanced technical or business education. Only in the area of "Specific Technologies" did the M.S. Engineering group indicate that their educational needs were fewer than did all other groups.

Three assumptions can be drawn from these discrepancies. First, those respondents who have taken master's programs in engineering have, by so doing, recognized additional technical education needs; second, the knowledge that they received during their master's program was insufficient in relation to their needs; or third, advanced technical education was not needed by all respondents. With regard to the first assumption, it is unlikely, acknowledging that
Figure 47

Table 43
an M.S. Engineering program is mainly an extension in detail of the B.S. program, that a manager's cognizance of the technical requirements of his job will be increased as a result of attaining a Master's degree in Engineering. Regarding the second assumption, there is little doubt that the knowledge gained in technical courses is of value in satisfying many of the technical educational needs of the manager. There are many engineering areas offered for graduate work, and there should be little problem matching specific programs with definite technical needs. The conclusion reached was that the third assumption was the predominant reason for the discrepancies noted in the data. Advanced technical education is not generally needed by engineers in management positions, a fact which has been previously discussed. However, there are managers who, possibly by virtue of having a Master's degree in Engineering, have accepted highly technical managerial positions and therefore have the need for a strong technical background. It is not difficult to visualize that these managers feel they will never have a technical background which is as strong as they would like it to be.

The high relative needs of M.B.A.'s in the areas of "Communications, Liberal Arts, and Law" and "Computer Technology" indicate the possibility that these are high need areas as well as areas of deficiency in the M.B.A. curriculum. In the area of Industrial Engineering, the response was too sparse to be of value in the analysis. Therefore, no commentary is offered.

Future Education and Training Requirements

A study was made of the differences in opinions between the M.B.A. and M.S. Engineering groups with respect to the formal education or skills which they thought would be increasingly required by their present position over the next ten years. Opinions regarding items of first and of second importance were compared.

Figure 48 shows the percentage of members in each of the two master's degree groups in relation to all respondents, concerning the education or skills which they thought should be considered first
FORMAL EDUCATION OR SKILLS INCREASINGLY REQUIRED
BY PRESENT POSITION IN NEXT 10 YEARS

First Importance

- All Respondents
- MBA. Graduates
- M.S. Engr. Graduates

Figure 48

Table 44
as factors which will be increasingly important to their present job. The formal education or skill that was chosen second by members of the same groups is shown by Figure 49.

The analysis of these opinions concerning formal education and skills that will be increasingly important over the next ten years revealed two facts: first, those managers who have completed a master's program in Business Administration place mathematics, statistics and computer technology as first selections for subjects of increasing importance to the job they are now doing. This is not to say that business administration skills are not the most important now or in the future; but, it is an indication of the sophistication that will be increasingly demanded of management due to technological advances. Second, the importance that was attached to future engineering and scientific knowledge by managers with Master's degrees in Engineering also reveals the increasing technological advances of our society. But, in addition, the more than equal attention that was given by them to future required formal education in Business Administration strongly implies that there is presently a lack in this area.

Transition Difficulties

An investigation of transition difficulties determined that advanced formal study in Business Administration made the transition from engineer to manager easier than it otherwise might have been had the education not been obtained. The investigation and analysis consisted of a comparison of the transition difficulties noted by the M.B.A. graduates with those experienced by the M.S. Engineering graduates and also of observations for each group of the length of time required before transition was considered complete.

A higher percentage of M.S. Engineering graduates indicated transition difficulties than did M.B.A. graduates. As previously noted, 64.6 percent of all respondents stated some transition difficulty. In comparison, 59.3 percent of the M.B.A.'s indicated difficulties and 65.3 percent of the M.S. Engineering graduates noted
FORMAL EDUCATION OR SKILLS INCREASINGLY REQUIRED
BY PRESENT POSITION IN NEXT 10 YEARS

Second Importance

- All Respondents
- MBA Graduates
- M.S. Engr. Graduates

Human Relations
General Engr-Tech. Knowledge
Specific Engr-Tech. Skills
Specific Bus. Adm. Skills
Mgmt. Principles
Experience, Personal Qualifications
Math, Stat, Computer Tech.

Figure 49

Table 45
problems associated with their transitions into management.

A cursory observation of the distribution of responses would lead one to believe that the respondents who had Master's degrees in Business experienced more difficulties in the area of management than did M.S. Engineering graduates. A similar observation also would seem to be true in respect to delegation of work. However, upon examining the data in more detail it was noted that sixteen of the thirty-two M.B.A.'s who had reported transition difficulties had received their graduate business degrees after they had made the transition into management. Therefore, in order to get a more realistic indication of the effects of an M.B.A. degree upon transition difficulties, the sixteen were eliminated, leaving an adjusted sample size of thirty-eight M.B.A.'s. When analyzing the adjusted figures, it was found that only about 42 percent of the M.B.A.'s had reported transition difficulties as compared with approximately 65 percent of the M.S. Engineering graduates. The responses for each group are shown in Figure 50, distributed by percentage among the seven areas of difficulty that have been previously discussed. The distribution of problems per person ratios between the eight categories of transitional difficulties for both groups is shown in Figure 51. For purposes of comparison, data for all respondents is also shown.

On the average, M.B.A. graduates indicated that twenty months had been required before transition from engineer to manager could have been considered complete. In comparison, the M.S. Engineering graduates indicated that an average of 25.5 months had been required. The average time for all respondents was found to have been 22.5 months. The median transition time for both the M.B.A.'s and the M.S. Engineering graduates was twenty-four months. However, when examining the questionnaires which had not indicated a specific time period, it was noted that 14.5 percent of the M.S. Engineering graduates had reported in various ways that transition would never be complete. Only 5.5 percent of the M.B.A.'s had the same sentiments concerning transition time.
TRANITION DIFFICULTIES
Percent

<table>
<thead>
<tr>
<th>Percent</th>
<th>All Respondents</th>
<th>MBA Graduates</th>
<th>M.S. Engr. Graduates</th>
</tr>
</thead>
<tbody>
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</tr>
</tbody>
</table>

Figure 50

Table 46
TRANSITION DIFFICULTIES
Problems per Respondent

- All Respondents
- MBA. Graduates
- MS. Engr. Graduates

Figure 51

Human Relations
Delegate Work
BusAdm. Skills
Mgmt. Principles
Decision Making
Tech. Skills
Communi., Political
Accomp. of Job

Prob/Resp.
When looking at the overall picture revealed by the respondents concerning transition into management from engineering, it appears that an M.B.A. degree is the more beneficial post-baccalaureate formal education. Because of the limited amount of data, an accurate statement cannot be made regarding how much more valuable the M.B.A. is with respect to transition compared with the M.S. in Engineering degree. However, if the overall ratio of transition difficulties to the number of respondents is an indication, an approximation of about 25 percent would be in order.

Relative Job Classifications and Annual Salary

The position one has attained in his company or organization and the monetary compensation he is awarded constitute an accumulative measurement which represents relative professional success. It can be argued that money and position do not necessarily point out a good man, but, nevertheless, these are the most commonly used indicators of personal achievement in modern society. Also, these same factors visualized as goals play a paramount role in motivation of workers, both laborers and managers. For example, it was discussed earlier in Chapter II that improved opportunities in both advancement and salary were important motivators which persuaded the engineer to become a member of management. Assuming, therefore, that position and salary are the primary awards used in all profit-oriented organizations in recognition of good work, an analysis was made of the job classifications and salary of the two groups with advanced degrees. The objective of the analysis again was to find evidence that would indicate the relative value of an M.B.A. or equivalent degree as opposed to an M.S. degree in Engineering.

The four classifications into which managerial positions were grouped has been discussed but are again shown in Figure 52, along with the percentage distribution of M.B.A. and M.S. Engineering graduates in each classification.

It appeared as though the respondents with M.B.A. degrees
PRESENT JOB LEVELS

Percent

First Level
Second Level
Third Level
Fourth Level

All Respondents
MBA. Graduates
M.S. Engr. Graduates

First Level
Chair. of Board
President
Exec. Vice Pres.
Sr. Vice Pres.
Vice Pres.

Second Level
Director
Gen. Manager
Associate

Third Level
Manager
Chief Engr.
Dept. Head
Group Leader
Superintendent

Fourth Level
Sr. Proj. Engr.
Proj. Engr.
Supervisor
Administrator
Staff Asst.
Consultant
Specialist

Figure 52

Table 48
have not succeeded as well in attaining high ranking positions in their organizations as have their counterparts who hold Masters degrees in Engineering. These results, however, do not reflect only the differences in master's degree program. It was previously noted that fourteen of the seventy-five respondents with M.S. Engineering degrees also held doctorate degrees. After a re-examination of the Distribution of the M.S. Engineering group, it was found that the Ph.D.'s weighted the top classifications more heavily than the lower ones. In the first classification, where 36 percent of the M.S. Engineering positions were located, 6.7 percent of the positions were those of respondents with doctorate degrees. M.S. Engineering graduates with doctorates also accounted for 5.3 percent of the positions in both the second and third classifications. Only 1.3 percent of the M.S. Engineering positions ranked in the fourth classification were those of respondents with doctorate degrees.

Although there was little doubt about the placement of jobs in the first as opposed to the fourth classification, the division of jobs into adjacent classifications was not as clear. Therefore, a second factor which had to be considered when analyzing the present positions of the respondents was the correct interpretation of their answers. Job titles are not standardized; sometimes the same title may apply to different job classifications, a situation which may even exist within a single company. In order to minimize job classification errors because of title ambiguities, other data in the respondent's questionnaire was weighed before making the final placement decision. In this analysis, factors noted were the positions held prior to the current position, the current job description and the desired or most likely future position. Considering also that the four job classifications were relatively broad, it is not likely that there are gross misrepresentations which would influence the data to the extent that a different result would be reached. However, it was acknowledged that a degree of subjectivity was attached to the analysis of job classification, and therefore it was not weighted heavily in the final conclusion of
the overall study. A more objective evaluation of professional success and personal attainment was felt to be that associated with the analysis of annual salary.

The questionnaire respondents were asked to check one of fourteen salary ranges. Of the 500 useful questionnaires returned, 461 completed the question. A histogram of the number of respondents that checked each of the salary ranges is shown in Figure 53. The distribution was found to be typical, with the average salary being $29,600 and the median salary lying within the $21,000 to $25,000 range. The positive skewness of the distribution is magnified by a change of salary range. This was done as a compromise because it was desired to keep the number of ranges to be checked at a minimum but yet cover the full scale from less than $10,000 to more than $100,000 while maintaining emphasis on those salaries below $40,000. Calculations relative to average salaries for this and for subsequent analyses were based on the assumption that the mean salary of each respondent was at the midpoint of the salary range checked.

The annual salaries of the M.B.A. graduates and the M.S. Engineering graduates were first compared on the basis of average and median salaries for each group. It is apparent from Figure 54, which shows the salary histograms for both M.B.A.;s and M.S. Engineers, that those managers with M.S. Engineering degrees earn higher salaries, on the average. The average annual salary of the M.B.A. group was $28,310 with a median salary in the range of $16,000 to $20,000 per year, whereas the average annual salary of the M.S. Engineering group was $32,193 with a median salary in the $21,000 to $25,000 per year range. However, when those respondents with doctorates were separated from the M.S. Engineering group, the average annual salary was noted to be $29,866. The average annual salary of the Ph.D.'s in the M.S. Engineering group was $41,500. The average salaries of the two groups now compare more favorably, but the M.S. Engineering group still has the upper salary by an average of about $1,500 per year.

In partial explanation of this difference, the time at which
Figure 53

Table 49
ANNUAL SALARY

Figure 54

Table 50

<table>
<thead>
<tr>
<th>MBA. Graduates</th>
<th>M.S. Engr. Graduates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>20</td>
</tr>
<tr>
<td>Annual Salary</td>
<td>(thousands)</td>
</tr>
</tbody>
</table>

$10 15 20 25 30 35 40 50 60 70 80 90 100$
the advanced degrees for each group were obtained must be considered. It may be recalled that the M.S.A. graduates earned their degrees, on the average of less than five years after being awarded a bachelor's degree. Median annual salaries earned by M.S. degree holders who were rated as engineering supervisory personnel were compared with those salaries earned by bachelor's degree graduates who held similar positions of employment. The comparison revealed, as shown by Figure 55, that there was an average difference of $2,475 per year over the one-to-ten year period since the earning of the baccalaureate degree. It is not assumed, nor is it true that upon obtaining a master's degree there is an accompanying sudden increase in salary. Therefore, the median salary difference between the two levels of degrees can be expected to be reflected in the average salaries of two groups who received their graduate degrees at different intervals after their bachelor's degrees.

In order to further investigate differences in salaries between the M.B.A. graduate group and the M.S. Engineering graduate group, comparisons were made on the basis of age. Figure 56 shows the average annual salary of all respondents, the M.B.A. group and the M.S. Engineering group for nine age categories. From the twenty-five to thirty age bracket through the forty-one to forty-five year age bracket, the M.B.A.'s fall behind the M.S. Engineering group. This result would be expected, based upon the difference in time of attaining the two advanced degrees and the Engineers Joint Council data previously discussed. In the forty-six to fifty year age bracket and continuing through the fifty-six to sixty year age bracket, the managers with M.B.A.'s exceed in salary their counterparts with M.S. Engineering degrees.

A similar comparison between the two groups was found for

---

MEDIAN SALARY SINCE BACCALAUREATE
All Industries

Dollars/Year

$15,000

12,500

10,000

7,500

0

0 4 8 12 16 20 24 28 32 36 40

Years Since Baccalaureate

M.S. Graduates

All Graduates

Figure 55

Table 51
AVERAGE ANNUAL SALARY
By Age Group

Average Salary (thousands)

$50

45

40

35

30

25

20

15

10

5

0

All Respondents
MBA. Graduates
MS. Engr. Graduates

Respondents' Ages

Figure 56

Table 52
increasing lengths of time after the baccalaureate degree (Figure 57).

The total analysis of salary comparisons reveals that managers with an M.B.A. degree have, on the average, progressed further in salary over the long term than those managers with M.S. Engineering degrees. However, it was also evident that a delay in obtaining their M.B.A. degree was to their detriment for a period of time after attaining their advanced degree which was about as long as the time interval between their bachelor's and master's degree. A delay of ten years was, in other words, reflected in salary for an additional ten years after the M.B.A. degree holders obtained their master's degree. Therefore, by observing only the overall average salary of managers with an M.B.A. as compared with managers with an M.B. Engineering degree, the performance of the M.B.A. graduates appeared to be relatively poorer.

Summary and Conclusion

When the backgrounds of M.B.A. graduates and M.S. Engineering graduates were compared, there was found to be one difference that required consideration during subsequent analyses. The difference was in the respective lengths of time between the baccalaureate degree and the master's degree. The M.S. Engineering degree was obtained, on the average, within five years after the bachelor's degree, whereas the M.B.A. was not obtained for an average of about ten years.

The importance attached to various areas of formal education was generally consistent with the choice of advanced education. The one noted exception was that managers with M.S. Engineering degrees felt that economics, finance, humanities and business administration were more important than specific technological courses. There was positive indication that the M.B.A. program had reduced the need for education in business administration, which had been previously indicated as being the most important academic interest to all supervisory personnel. Completion of the Master's program in Engineering reduced the technical education needs of managers relative to the M.B.A. graduates but did not necessarily do so relative to all respondents. There was no evidence of reduction in the needs for
AVERAGE ANNUAL SALARY
Since Baccalaureate Degree

Average Salary (thousands)

- MBA. Graduates
- M.S. Engr. Graduates
- MS. Engr. Graduates less Ph.D. Average Salaries

Years Since Baccalaureate

Figure 57 Table 53
managerial skills and specific business administration disciplines as a result of the attainment of a Master's degree in Engineering.

The M.B.A. degree proved to be more beneficial than the M.S. Engineering degree when considering transition from engineering to management. This was evident both in terms of the type and the number of difficulties encountered, and also in the time required before transition was considered complete.

The positions and average salary level that had been attained by managers with an M.B.A. degree relative to those which were attained by managers with an M.S. Engineering degree were not as high. Managers with an M.B.A. or equivalent degree had the characteristic of being "late starters" because of the lack of an advanced degree in the early years of their career. However, when differences in the time at which the advanced degree was obtained were taken into consideration, managers with an M.B.A. degree had the higher average rate of salary rise and also, on the average, eventually attained a higher salary level.

In conclusion, the analysis of the thesis questionnaire data supports the validity of the thesis hypothesis. For every criterion selected as an indicator, with the exception of the level of position within the organization, the M.B.A. or equivalent degree proved to be more beneficial to the technical manager than a Master of Science degree in Engineering. In regard to the one exception, it was noted that titles are often misleading and therefore this criterion could not be weighed too heavily in the final analysis. It is acknowledged that, because of the limited amount of data and its restriction to a single period of time, conclusive proof of the proposed hypothesis, beyond any doubt, was not established. However, the tendencies are clearly evident.

The factual data which were collected by the questionnaire were supplemented by discussions and personal interviews. It is the purpose of the following chapter to summarize this supporting information.
CHAPTER VI
SUPPLEMENTARY DISCUSSIONS AND INTERVIEWS

The opinions of approximately 175 persons regarding the thesis subject were gained during discussions which were held concurrently with the gathering and analysis of material for this study. In addition, twenty-five planned interviews were conducted during which all the thesis questionnaire subjects, with the exception of annual salary, were discussed.

A summary of relevant information gained from the supplementary discussions and interviews will be given in the following text. This material has been categorized according to the position and academic background of the respondent. Comments and responses elicited from both managers who hold M.B.A. or equivalent degrees and those who hold Master of Science degrees in Engineering will be discussed.

During the course of these discussions and interviews detailed notes were not taken; however, important points were subsequently recorded for future reference. Three letters received with thesis questionnaire returns were also considered in the discussion material. The primary purpose for obtaining the supplementary information was to cross-check the reliability of the questionnaire data. It was also felt that these discussions and interviews would be an aid in determining whether the questionnaire would successfully elicit the true nature of the respondents' opinions regarding the questionnaire topics. Quantitative analysis of the information obtained in interviews was not attempted, nor was an effort made to draw separate conclusions outside of the questionnaire subjects.

Managers

The majority of managers contacted were involved with either first or second line supervision and thus were still closely associated with technical programs and projects. All managers interviewed had
been employed as engineers at some time prior to their transition into management. Some had attained bachelor's degrees in engineering, while others had gained the position of engineer by virtue of on-the-job experience. Organizations represented by the managers included government-sponsored, aircraft, aerospace, industrial and specialized product manufacturers, and laboratory or research services.

Not all managers agreed that advanced formal education in business administration was worth while. Without exception, however, all managers admitted the need for additional skills in managerial practices. Those who did not agree that formal education was necessary despite their needs, rationalized the discrepancy by replying that the kind of skill which they were lacking could not be taught, but could be gained only through on-the-job experience. The belief that the curricula offered by schools of business administration are too specialized and do not offer generalized training in management principles was also expressed. During the course of these discussions, it became evident that the manager's concepts of curriculum content of the M.B.A. programs was often considerably distorted. For example, four managers who were particularly opposed to formal business administration education held the impression that the course content was based upon bookkeeping, typing and other specific clerical duties.

The problems which were mentioned most frequently as being the most difficult to solve were those referred to as "people problems." None of the managers could say that they had successfully solved the problem of how to motivate subordinates. Maintaining discipline, particularly when non-technical or junior-level workers were involved, was another human relations problem mentioned by the managers. The unpredictability of human behavior was felt to be a constant factor which must be dealt with by men in management; yet the engineering background offered the technical managers little or no past experience in solving such problems.

When managers were asked about specific business administration or technical disciplines that were lacking with respect to
their need during job history, the most common answer was related to management principles. Second was a variety of specific business subjects, among which economics and finance were the most common. Only in the several cases in which managers were directly involved with technical problems in research work were there indications that specific technical subject material was lacking. If technical handicaps were mentioned, it was also noted that they were soon alleviated by taking formal courses in the subject, reading, and independent study. However, solutions to management problems were not always so readily available. Administrative problems which had arisen were frequently felt to be a present handicap at the time of the discussion and solutions did not always seem apparent.

The responses given to questions concerning problems which may have been met during the period of transition from engineer to manager were similar in nature to those mentioned relative to subject material lacking. Deficiencies in engineering or scientific knowledge did not present transition problems to any of the managers who were interviewed. Rather, as was found to be true of the questionnaire respondents, the area of management principles was the one causing most difficulty. The answer most frequently given concerning the duration of the transition period was "forever." Very few managers would even attempt to estimate a specific length of time. This hesitancy on the part of the men interviewed to give a definite answer to this question cast doubt upon the validity of the results obtained from the same question in the questionnaire. It is believed that possibly the correct answer could never be determined. At the other extreme, approximately one-quarter of the managers felt there was no problem in transition and that the time period was immediate. In each of the latter interviews the opinion was expressed that the transition had been accomplished mentally long before the actual change in employment status was made. In addition, these managers expressed the opinion that this mental transition or preparedness was a prerequisite to becoming a member of management.

When discussing the future advanced education of their
subordinates, managers stressed one point above all others: All emphasized that technical competence was by far the most important consideration. An engineer, even though he possessed an intuitive grasp of administrative problems, could not expect to be promoted to a management position unless he excelled in the technical area of knowledge. Managers considered that their own advancement into management had taken place under such circumstances. They believed that they excelled technically and that without this outstanding technical skill they would not have been promoted, regardless of how competent they may have been in administrative disciplines.

Managers With Advanced Degrees

Discussion with managers who held M.B.A. degrees and those who held Master of Science degrees in Engineering were compared to determine differences in attitudes toward their job or in difficulties which had been encountered.

It was found that managers who held M.B.A. or equivalent degrees had pursued this course of formal education from five to ten years, and in some instances as much as fifteen to twenty years, after they had obtained their bachelor's degrees. The reason given for this delay was most frequently expressed as "no desire." As young engineers recently graduated from college, these managers felt there would be little need for the type of subject material offered by business administration programs. Hence, they had no desire to study in this area of advanced education. There was a consensus of opinions among the managers that only with the passage of time did administrative problems become important to them. When they realized the fact that at some future date they would be required to deal with management problems, if they had not already had to do so, the managers were sufficiently motivated to enter an M.B.A. program. Those managers who had earned their M.B.A. less than four years after they had received their baccalaureate degree had planned their careers somewhat differently than had the others. To these people, the engineering education was considered as a means of becoming a member of management, which was their ultimate goal, whereas with other managers, the bachelor engineering degree had been a means of reaching
the goal of holding a position as an engineer.

Discussions with supervisory personnel who held master's degrees in engineering revealed that the majority of this group had embarked upon their advanced studies immediately after completion of the bachelor's program. At the time, this seemed to them to be the logical course of action — the "capstone" or culmination of their undergraduate work. The minority portion of this group — those who had earned their M.S. in Engineering later in their career — gave numerous reasons for the delay. Some stated that they had had no intention of taking a graduate program until it had been forced upon them, either by the demands of their work or by their supervisors. Several managers mentioned that they had finally earned a graduate engineering degree because the possession of such a degree had been a requirement for job advancement.

When managers with advanced degrees were asked if the additional education had been beneficial to them, different answers, depending upon the academic background of the respondent, were received. Managers who had earned M.B.A. or equivalent degrees felt that the education had helped them in their daily work as managers. They expressed the belief that their advancement in earnings and their present position were, to a great extent, dependent upon skills and knowledge attained during the course of the program. However, they also felt that their M.B.A. degree did not help (or would not have helped) in being promoted into management.

Managers who held an M.S. degree in Engineering revealed a substantially different attitude toward the value of their advanced education. Those who had earned their master's degree prior to becoming members of management attributed their promotion to possession of the degree. However, they also felt that the knowledge and skills gained as a result of taking an advanced degree had been of most benefit to them as engineers, rather than as members of management. Less than 10 percent of these managers felt that the course content of the M.S. Engineering program had been of great value to them in their position as managers. One manager who recently obtained a M.S. in
Mechanical Engineering degree after being employed as a manager for ten years stated that, not only would he never make use of the detailed technical skills that he had learned, but that he had never intended to do so. When asked the reason for his efforts, he was very positive in his answers that it looks good on the record and that nowadays one needs the degree to open doors to other companies and other positions. Most managers who held graduate engineering degrees did express the opinion that the advanced education gave them better insight into technical problems which they encountered. The reason for this, however, was not attributed to the specific course work but rather to the improvement in their approach to and handling of problems.

Summary

The information gained from discussions with managers was in harmony with data obtained from the questionnaire. The only area of the questionnaire upon which doubt of validity was cast by the results of the discussions was that concerning required transition time. These discussions with members of management did aid in making sounder interpretations of the thesis questionnaire data. This was particularly true with respect to the differences in time which were required to attain the advanced degree and also regarding the actual reasons for entering a master's program.

Numerous discussions were also conducted with non-supervisory personnel, working in technical positions. The opinions and attitudes expressed were roughly equivalent to those expressed by the managers. Since these discussions were not directly related to the thesis subject, but were conducted as an aid in the writing of Chapter II, reiteration is unnecessary. The only difference noted in discussions between the manager and engineer was that the engineer appears to be more aware of the problems of management and the need for formal education in business administration than the manager felt he was at the time he was an engineer. This change is possibly a reflection of the increasingly active role which the engineer is taking in management - an observation which precipitated this study.
CHAPTER VII

FINAL SUMMATION OF HYPOTHESIS VALIDITY

During the investigation, analysis and writing of this thesis, much evidence was found which indicated the need among managers for broad and general formal education in the disciplines of business administration as opposed to specific technical training. The essence of Peter F. Drucker's thoughts concerning education were frequently borne out.

The man who only acquires functional skills, and only learns specific business or engineering subjects, is not being prepared to be a manager. All he is being prepared for is to get his first job. 65

A statement by Clarence Randall, former president and chairman of the board of Inland Steel Company, summarizes the sentiments of managers and executives. Mr. Randall stated:

Standing as I do on the plateau of retirement and looking over my shoulder at my life, I can see with startling clarity that the greatest asset I have had in business from the point of view of personal preparation was the general education that I received at Harvard. I have no shadow of a doubt that the early selection of a specialty would have been a long-time limitation in my life, even though for a few years I might have earned more money. 66

The thesis study was successful in determining, not necessarily with positive proof, but with a strong indication, whether or not the proposed hypothesis was valid. In addition to the validity


of the hypothesis, both the significant findings of the study and the resulting recommendations will be subsequently summarized.

It is acknowledged that the small sample of data accumulated relative to the size and importance of the problem did not necessarily yield normative information. However, positive indications that the hypothesis is valid were discovered, particularly when the time of obtaining a Master’s degree in Business Administration was taken into consideration. The study did provide both qualitative and quantitative evidence of relationships among attitudes, academic backgrounds and careers in management which contribute to the overall objective of the subject question.

Significant Findings of the Study

A significant deficiency in the engineer’s formal education was revealed by a comparison of the educational and employment background of the engineer with the requirements demanded by the managerial functions. Neither the engineer’s preparation for his profession nor his work experience placed emphasis upon disciplines required of him as a manager. Conversely, the technical requirements of the management position appeared to be relatively well-satisfied by past formal technical training and experience. A survey of the advanced formal education importance and needs of managers supported the conclusions drawn from the comparison. Managers rated the importance of their past formal education in subjects relating to business administration as being equal to, or in most cases, above those concerning technical material. Furthermore, deficiencies noted in their formal education and difficulties which they encountered during their transition from engineer to manager pointed toward a need for additional training requirements in business administration. Little or no evidence was noted which would indicate that managers were deficient in technical ability, particularly in the area of specific technologies. Future graduate education preferences and opinions regarding the knowledge or skills which would be increasingly required by their position in the organization were also in agreement.
with the hypothesis. In both cases the managers indicated first, the need for improving management skills and second, the need for acquiring knowledge of specific administrative disciplines.

A comparison of Master's degree requirements in business administration and in engineering resulted in the conclusion that the educational needs of managers would be met more satisfactorily by an M.B.A. or equivalent degree. Subsequent investigation revealed this to be true. Managers with an M.B.A. had relatively fewer educational needs in business administration and they had less difficulty in making the transition into management than did those managers who held a Master's degree in Engineering. As a result of being relatively better prepared for the job of management, the M.B.A. graduates appeared to eventually attain a higher salary level. The attainment of a higher position within the organization was not evident, however. Several reasons for this latter situation may be given. First, position titles on job descriptions can often be ambiguous and thereby misleading when actual circumstances are being determined. An equally important reason was the fact that the advanced degrees had been obtained at different periods of time following the earning of the baccalaureate degree. A delay in the completion of a master's program in business relative to the time of completion of an advanced engineering degree was noted to have adversely affected salary. The same situation could have had a similar effect on advancement in employment status.

Interviews and discussions with technical management personnel supplemented the findings of the thesis questionnaire. Contradictory information was not encountered. On the contrary, the sentiments of managers concerning the importance of business education were stressed even more adamantly than they were as revealed by the thesis questionnaire.

Recommendations

Recommendations resulting from this study fall into two classifications: (1) those pertaining to future efforts in the determination of appropriate education for managers and executives, and
(2) those pertaining to the most prudent course of action to be chosen by the Engineer.

Expansion of a study such as has been presented herein to cover an extended period of time and to include a larger sample of data would be necessary to offer more conclusive proof that a Master's degree in Business Administration offers a more beneficial area of advanced learning than does the advanced engineering degree for the engineer who is assigned the responsibilities of management.

The relative importance of business education should be quite evident, but, of greatest importance would be a determination of specific subject material which, either because of its presence or absence in the advanced business curriculum, has had the greatest impact on the careers of managers. This thesis study certainly did not definitely conclude, but did imply, that business courses must not be descriptions of business practices, but rather must be oriented toward decision-making. In addition to placing emphasis on general management principles, it appears that there is an increasing need for use of more quantitative methods of evaluating alternatives. Operations research and computer technology will probably be found to be two of the most important analytical problem-solving tools.

A second companion study using material such as is presented herein as a pilot is also in order. Included would be a survey comparable in magnitude to that which was conducted by the Joint ECAC-RWl Feedback Committee on Engineering Education which would sample opinions of a large number of managers and executives from various educational backgrounds.67

With regard to the second category of recommendation, there are two circumstances to be considered. First was the finding brought out by the thesis survey that the delaying of advanced education after receiving the bachelor's degree adversely affected

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advancement in salary and, quite possibly, in position. However, encouraging enrollment in an M.B.A. or equivalent program upon obtaining the undergraduate degree may not be a satisfactory solution. The attitudes of the young engineering graduates will probably not be attuned to those required for concentrated and conscientious study of administrative principles. Also, there will be present neither the feeling of need for such knowledge which is necessary to motivate the young engineer, nor the background of experience which would enable him to focus his attention on the most troublesome areas of management.

The second consideration was also evident from an analysis of questionnaire results. The fact that the random sample accumulated seventy-five respondents who held advanced engineering degrees, but only fifty-four respondents with advanced business degrees was not surprising. It was an indication of the hiring and promotion policies which presently exist. The desirability of a general business rather than a specialized education has been stressed by the Newcomer and *Scientific American* studies, and by this thesis study. But despite the indications of these studies, the proportion of individuals who hold specialized advanced degrees is very high and seems to be increasing. There is evidence that the increase is due to the fact that specialists are chosen for specialized jobs. The policy thereafter is to select as managers, with little or no thought given to the question of their formal administrative training, men from within the company who have excelled in their specialty. This procedure hence leads to a predominance of specialists in management.

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some of whom do not understand what is expected of them as managers. The wrong men, having made the shift but not the successful transition, are often left to flounder in a morass of difficulties they have never been prepared to adequately overcome. Training for general administration is rare and the demand for general administrators who are just out of college is practically unheard of.

Considering the effects of delaying advanced education and the emphasis which is placed upon specialists by industry, the alternative course of action for the engineer is quite clear. It will be to his advantage first to prepare himself well for his initial profession by obtaining a master's degree in engineering before, or soon after commencing his working career, and second, to prepare himself for his ultimate profession as manager by obtaining a Master's degree in Business when his attitudes and experience are amenable to the transition.
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OTHER SOURCES


APPENDIX I

QUESTIONNAIRE COVER LETTER

and

QUESTIONNAIRE
I am conducting a study pertaining to management and education for the completion of a masters degree in business administration at San Fernando Valley State College.

One of the questions of interest in the study is, "Do employees have the proper formal education for the work assigned them?". Often it is realized that employees do not have sufficient education, but then to remedy the situation, the problem of what kind of additional formal education will be most appropriate, must be resolved.

It is the purpose of the enclosed questionnaire to gather information from members of management concerning their personal education and advancement, and to obtain their opinions with respect to additional education which they believe would aid them in their job.

Completion and return of the questionnaire at your earliest convenience will be sincerely appreciated.

Yours very truly,

James O. Cardot

Enclosure
## I. Company Data

1. Type of Company (Check one)
   - Industrial - Manufacturing
   - Public Utility
   - Government
   - Transportation
   - Research and Development
   - Electronic & Aerospace
   - Other (specify)

2. Size of Company
   - Relative to other companies within the industry (or industries) in which your company participates, do you feel your company is: (Check one)
     - Large
     - Medium
     - Small
   - Approximate total number employed

3. Location of Major Plant or Facilities (Check all applicable).
   - East Coast
   - Midwest
   - Rocky Mountain
   - West Coast

4. Age of Company (Check one)
   - Twelve or less years old
   - Greater than twelve years old

## II. Personal Data

1. Age (Check one)
   - less than 25
   - 25 to 30
   - 31 to 35
   - 36 to 40
   - 41 to 45
   - 46 to 50
   - 51 to 55
   - 56 to 60
   - 61 to 65
   - Over 65
2. Formal Education
   a. Year graduated from high school
   b. Degrees

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<thead>
<tr>
<th>Degrees</th>
<th>Major (specialty, if any)</th>
<th>Year Attained</th>
<th>Institution</th>
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<td>1.</td>
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<tr>
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<td>3.</td>
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<td>4.</td>
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</table>

c. Other educational institutions attended or attending

<table>
<thead>
<tr>
<th>Nature of Studies</th>
<th>Years Attended</th>
<th>Institution</th>
</tr>
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<td>4.</td>
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</tbody>
</table>

d. Financial aid obtained from family toward formal education prior to first full-time employment. (Check one)

1. More than one-half  
2. One-half or less

3. Active military service
   Yes [ ]  No [ ]
   If yes, number of years; Rank at time of discharge

4. Employment History
   a. Family influence in obtaining first full-time job (check one)

   Instrumental [ ]  Some Influence [ ]  No Influence [ ]

   b. Positions held prior to current position (full-time employment only)

<table>
<thead>
<tr>
<th>Name of Position</th>
<th>Year to Year</th>
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<td>3.</td>
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<td>4.</td>
<td></td>
</tr>
</tbody>
</table>

c. Number of years with present company
d. Position when starting with company ______________________________

e. Present job title ______________________________

f. Year present position obtained ____________

g. How obtained (Check one)
   Promoted □ Inherited □
   Tests □ Elected □
   Appointed □ Other ____________

5. Current job description

6. Desired or most likely future position

7. Rate each of the following areas of formal education with respect to its importance in the performance of your present duties. (Very important = 1; average importance = 3; unimportant = 5)

   a. Engineering and scientific □ □ □ □ □
   b. Economics and finance □ □ □ □ □
   c. Human relations - personnel □ □ □ □ □
   d. Mathematics □ □ □ □ □
   e. Specific technologies (stress analysis, heat transfer, etc.) □ □ □ □ □
   f. Accounting □ □ □ □ □
   g. Business administration- (Management skills) □ □ □ □ □
   h. Industrial engineering □ □ □ □ □

8. In past formal education, what subject material was lacking with respect to its need during job history?

   a. Is the lack presently a handicap? Yes □ No □
   b. If not, how was the deficiency overcome? ______________________________
9. If you were to work toward a graduate degree, what programs of formal education do you think would be most beneficial to your future? (List one or more in order of importance)

a. 

b. 

c. 

10. What formal education or skills do you think will be increasingly important over the next 10 years to adequately accomplish the tasks that will be required for the job you now hold? (List one or more in order of importance)

a. 

b. 

c. 

11. If at any time during your full-time employment history you switched from engineering to management, what do you consider was the most difficult task(s) relative to effecting the transition?

______________________________

a. Estimate length of time in months required to consider transition complete? ________________

12. Annual salary (check one)

<table>
<thead>
<tr>
<th>Salary Range</th>
<th>Box</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than $10,000</td>
<td>✜</td>
</tr>
<tr>
<td>$11,000 to $15,000</td>
<td>✜</td>
</tr>
<tr>
<td>16,000 to 20,000</td>
<td>✜</td>
</tr>
<tr>
<td>21,000 to 25,000</td>
<td>✜</td>
</tr>
<tr>
<td>26,000 to 30,000</td>
<td>✜</td>
</tr>
<tr>
<td>31,000 to 35,000</td>
<td>✜</td>
</tr>
<tr>
<td>36,000 to 40,000</td>
<td>✜</td>
</tr>
<tr>
<td>$41,000 to $50,000</td>
<td>✜</td>
</tr>
<tr>
<td>51,000 to 60,000</td>
<td>✜</td>
</tr>
<tr>
<td>61,000 to 70,000</td>
<td>✜</td>
</tr>
<tr>
<td>71,000 to 80,000</td>
<td>✜</td>
</tr>
<tr>
<td>81,000 to 90,000</td>
<td>✜</td>
</tr>
<tr>
<td>91,000 to 100,000</td>
<td>✜</td>
</tr>
<tr>
<td>more than 100,000</td>
<td>✜</td>
</tr>
</tbody>
</table>

13. Do you feel that formal education following a Bachelor's Degree has, or would have, helped you in attaining your present employment status? (Check one)

a. Yes ❏

b. No ❏

c. Possibly ❏

d. Don't Know ❏
The Figures presented in the preceding pages of this thesis are based upon the data set forth in the Tables that follow.
### TABLE 1

**TYPES OF ORGANIZATIONS**

**ALL RESPONDENTS**

<table>
<thead>
<tr>
<th>Organization</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial</td>
<td>299</td>
<td>59.8</td>
</tr>
<tr>
<td>Public Utility</td>
<td>15</td>
<td>3.0</td>
</tr>
<tr>
<td>Government</td>
<td>23</td>
<td>4.6</td>
</tr>
<tr>
<td>Transportation</td>
<td>7</td>
<td>1.4</td>
</tr>
<tr>
<td>Research &amp; Development</td>
<td>31</td>
<td>6.2</td>
</tr>
<tr>
<td>Electronics &amp; Aerospace</td>
<td>74</td>
<td>14.8</td>
</tr>
<tr>
<td>Other</td>
<td>51</td>
<td>10.2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>500</td>
<td>100.0</td>
</tr>
</tbody>
</table>

*Source: Questionnaire*
<table>
<thead>
<tr>
<th>Number Employed</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 50</td>
<td>25</td>
<td>5.6</td>
</tr>
<tr>
<td>50 to 99</td>
<td>21</td>
<td>4.6</td>
</tr>
<tr>
<td>100 to 999</td>
<td>97</td>
<td>21.5</td>
</tr>
<tr>
<td>1,000 to 9,999</td>
<td>129</td>
<td>28.5</td>
</tr>
<tr>
<td>10,000 to 19,999</td>
<td>47</td>
<td>10.4</td>
</tr>
<tr>
<td>20,000 to 29,999</td>
<td>33</td>
<td>7.3</td>
</tr>
<tr>
<td>30,000 to 39,999</td>
<td>22</td>
<td>4.9</td>
</tr>
<tr>
<td>40,000 to 49,999</td>
<td>11</td>
<td>2.4</td>
</tr>
<tr>
<td>50,000 to 59,999</td>
<td>11</td>
<td>2.4</td>
</tr>
<tr>
<td>60,000 to 69,999</td>
<td>2</td>
<td>0.4</td>
</tr>
<tr>
<td>70,000 to 79,999</td>
<td>3</td>
<td>0.7</td>
</tr>
</tbody>
</table>
### TABLE 2 - CONTINUED

<table>
<thead>
<tr>
<th>Number Employed</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>80,000 to 89,999</td>
<td>7</td>
<td>1.5</td>
</tr>
<tr>
<td>90,000 to 99,999</td>
<td>3</td>
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<tr>
<td>100,000 to 249,999</td>
<td>31</td>
<td>6.9</td>
</tr>
<tr>
<td>250,000 to 499,999</td>
<td>3</td>
<td>0.7</td>
</tr>
<tr>
<td>500,000 to 749,999</td>
<td>6</td>
<td>1.3</td>
</tr>
<tr>
<td>750,000 to 1,000,000</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>More than 1,000,000</td>
<td>1</td>
<td>0.2</td>
</tr>
<tr>
<td>Total</td>
<td>452</td>
<td>100.0</td>
</tr>
</tbody>
</table>

No information: 48

Source: Questionnaire
### TABLE 3

**AGES OF ALL RESPONDENTS**

<table>
<thead>
<tr>
<th>Ages</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 25</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>25 to 30</td>
<td>10</td>
<td>2.0</td>
</tr>
<tr>
<td>31 to 35</td>
<td>49</td>
<td>9.8</td>
</tr>
<tr>
<td>36 to 40</td>
<td>84</td>
<td>16.9</td>
</tr>
<tr>
<td>41 to 45</td>
<td>118</td>
<td>23.6</td>
</tr>
<tr>
<td>46 to 50</td>
<td>93</td>
<td>18.7</td>
</tr>
<tr>
<td>51 to 55</td>
<td>62</td>
<td>12.4</td>
</tr>
<tr>
<td>56 to 60</td>
<td>47</td>
<td>9.4</td>
</tr>
<tr>
<td>61 to 65</td>
<td>22</td>
<td>4.4</td>
</tr>
<tr>
<td>More than 65</td>
<td>14</td>
<td>2.8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>499</td>
<td>100.0</td>
</tr>
<tr>
<td>No information</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

**Source:** Questionnaire
TABLE 4

ACADEMIC DEGREES OF BUSINESS EXECUTIVES*

<table>
<thead>
<tr>
<th>Academic Degrees</th>
<th>1900</th>
<th>1925</th>
<th>1950</th>
<th>1964</th>
</tr>
</thead>
<tbody>
<tr>
<td>Some College Education</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With or Without Degrees</td>
<td>39.3</td>
<td>51.5</td>
<td>75.6</td>
<td>90.6</td>
</tr>
<tr>
<td>With College Degrees</td>
<td>28.3</td>
<td>40.2</td>
<td>62.1</td>
<td>74.3</td>
</tr>
<tr>
<td>With Law Degree</td>
<td>8.4</td>
<td>12.0</td>
<td>11.9</td>
<td>11.2</td>
</tr>
<tr>
<td>With Technical Degree</td>
<td>6.8</td>
<td>13.2</td>
<td>20.0</td>
<td>32.8</td>
</tr>
</tbody>
</table>

### TABLE 5

**FIRST FULL-TIME JOB OF BUSINESS EXECUTIVES**

<table>
<thead>
<tr>
<th>Position</th>
<th>Number of Executives</th>
<th>Percentage of Executives</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1900</td>
<td>1925</td>
</tr>
<tr>
<td>Independent businessman</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>Business Executive</td>
<td>16</td>
<td>21</td>
</tr>
<tr>
<td>Clerical &amp; Minor Administrative</td>
<td>104</td>
<td>96</td>
</tr>
<tr>
<td>Skilled Labor</td>
<td>25</td>
<td>36</td>
</tr>
<tr>
<td>Unskilled Labor</td>
<td>19</td>
<td>23</td>
</tr>
<tr>
<td>Errand Boy</td>
<td>20</td>
<td>24</td>
</tr>
<tr>
<td>Salesman</td>
<td>35</td>
<td>19</td>
</tr>
<tr>
<td>Engineer</td>
<td>23</td>
<td>38</td>
</tr>
<tr>
<td>Lawyer</td>
<td>28</td>
<td>33</td>
</tr>
<tr>
<td>Position</td>
<td>Number of Executives</td>
<td>Percentage of Executives</td>
</tr>
<tr>
<td>---------------------</td>
<td>----------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td></td>
<td>1900</td>
<td>1925</td>
</tr>
<tr>
<td>Accountant</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Other Professions</td>
<td>18</td>
<td>11</td>
</tr>
<tr>
<td>Total</td>
<td>298</td>
<td>311</td>
</tr>
<tr>
<td>No information</td>
<td>18</td>
<td>19</td>
</tr>
</tbody>
</table>

### TABLE 6

#### TECHNICAL-ADMINISTRATIVE FUNCTION IN 1965 BY YEAR SINCE B.S. DEGREE

**PURDUE UNIVERSITY ENGINEERING ALUMNI**

**Percentage Distribution**

<table>
<thead>
<tr>
<th>Years Since Baccalaureate</th>
<th>1-5</th>
<th>6-10</th>
<th>11-15</th>
<th>16-20</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Function</strong></td>
<td>B.S.</td>
<td>M.S.</td>
<td>B.S.</td>
<td>M.S.</td>
</tr>
<tr>
<td>Administrative</td>
<td>18</td>
<td>15</td>
<td>21</td>
<td>9</td>
</tr>
<tr>
<td>Half Administrative</td>
<td>22</td>
<td>12</td>
<td>28</td>
<td>17</td>
</tr>
<tr>
<td>Technical</td>
<td>60</td>
<td>73</td>
<td>51</td>
<td>74</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

**TABLE 7**

<table>
<thead>
<tr>
<th>Percentage Distribution Since Baccalaureate</th>
<th>15</th>
<th>15</th>
<th>15</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>B.S. B.M.S. B.S. M.S. M.S. Ph.D. Ph.D.</td>
<td>12</td>
<td>14</td>
<td>14</td>
<td>14</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>B.S.</td>
<td>M.S.</td>
<td>B.S.</td>
<td>M.S.</td>
<td>B.S.</td>
<td>M.S.</td>
</tr>
<tr>
<td>1-5</td>
<td>1-5</td>
<td>1-5</td>
<td>1-5</td>
<td>1-5</td>
<td>1-5</td>
</tr>
<tr>
<td>6-10</td>
<td>6-10</td>
<td>6-10</td>
<td>6-10</td>
<td>6-10</td>
<td>6-10</td>
</tr>
<tr>
<td>16-20</td>
<td>16-20</td>
<td>16-20</td>
<td>16-20</td>
<td>16-20</td>
<td>16-20</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Employment Setting</th>
<th>B.S.</th>
<th>M.S.</th>
<th>Ph.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private Industry</td>
<td>79</td>
<td>62</td>
<td>48</td>
</tr>
<tr>
<td>Education</td>
<td>4</td>
<td>19</td>
<td>42</td>
</tr>
<tr>
<td>Government</td>
<td>13</td>
<td>16</td>
<td>3</td>
</tr>
<tr>
<td>Other</td>
<td>4</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
<td><strong>100</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Principal Functions</th>
<th>B.S.</th>
<th>M.S.</th>
<th>Ph.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research</td>
<td>9</td>
<td>13</td>
<td>26</td>
</tr>
<tr>
<td>Design</td>
<td>12</td>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td>Development</td>
<td>16</td>
<td>18</td>
<td>12</td>
</tr>
<tr>
<td>Teaching</td>
<td>3</td>
<td>15</td>
<td>29</td>
</tr>
<tr>
<td>Technical Management</td>
<td>13</td>
<td>16</td>
<td>21</td>
</tr>
<tr>
<td>Sales &amp; Service</td>
<td>10</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Other</td>
<td>37</td>
<td>25</td>
<td>9</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

### TABLE 10

**TECHNICAL RESPONSIBILITY LEVEL OF ENGINEERING GRADUATES BY PURDUE UNIVERSITY DEGREE LEVEL**

<table>
<thead>
<tr>
<th>Technical Responsibility</th>
<th>B.S.</th>
<th>M.S.</th>
<th>Ph.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple Standardized Tasks</td>
<td>28</td>
<td>21</td>
<td>3</td>
</tr>
<tr>
<td>Complex Tasks</td>
<td>49</td>
<td>44</td>
<td>25</td>
</tr>
<tr>
<td>Pioneering Tasks</td>
<td>23</td>
<td>35</td>
<td>72</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Attitudes</th>
<th>Percent Endorsing Statements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prefer Working with Other People</td>
<td>16.0</td>
</tr>
<tr>
<td>Want Chance for Originality and Creativity</td>
<td>71.5</td>
</tr>
<tr>
<td>Wants to Make a Lot of Money</td>
<td>34.0</td>
</tr>
<tr>
<td>Considers Himself a Political Liberal</td>
<td>42.0</td>
</tr>
<tr>
<td>Thinks of Himself as a Conventional Person</td>
<td>48.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Profession</th>
<th>Median Salary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical Doctors</td>
<td>$28,850</td>
</tr>
<tr>
<td>Middle Managers</td>
<td>25,000</td>
</tr>
<tr>
<td>Attorneys</td>
<td>13,729**</td>
</tr>
<tr>
<td>Chief Accountants</td>
<td>13,127</td>
</tr>
<tr>
<td>Personnel Directors</td>
<td>12,325</td>
</tr>
<tr>
<td>Physicists</td>
<td>12,000</td>
</tr>
<tr>
<td>Engineers</td>
<td>11,325</td>
</tr>
<tr>
<td>Chemists</td>
<td>11,000</td>
</tr>
<tr>
<td>Biologists</td>
<td>10,700</td>
</tr>
<tr>
<td>Earth Scientists</td>
<td>10,300</td>
</tr>
<tr>
<td>Psychologists</td>
<td>10,300</td>
</tr>
<tr>
<td>Profession</td>
<td>Median Salary</td>
</tr>
<tr>
<td>--------------</td>
<td>---------------</td>
</tr>
<tr>
<td>Job Analysts</td>
<td>8,710</td>
</tr>
<tr>
<td>Auditors</td>
<td>8,535</td>
</tr>
</tbody>
</table>


** Does not include self-employed attorneys.
<table>
<thead>
<tr>
<th>Years Since Baccalaureate</th>
<th>Supervisor (51,747)**</th>
<th>Non-Supervisor (132,404)**</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>$ 7,375</td>
<td>$ 7,375</td>
</tr>
<tr>
<td>1</td>
<td>7,599</td>
<td>7,696</td>
</tr>
<tr>
<td>2</td>
<td>7,894</td>
<td>8,214</td>
</tr>
<tr>
<td>3</td>
<td>8,340</td>
<td>8,629</td>
</tr>
<tr>
<td>4</td>
<td>8,839</td>
<td>9,096</td>
</tr>
<tr>
<td>5</td>
<td>9,521</td>
<td>9,646</td>
</tr>
<tr>
<td>6</td>
<td>10,481</td>
<td>10,004</td>
</tr>
<tr>
<td>7</td>
<td>11,344</td>
<td>10,432</td>
</tr>
<tr>
<td>8</td>
<td>12,013</td>
<td>10,664</td>
</tr>
<tr>
<td>9</td>
<td>12,355</td>
<td>10,939</td>
</tr>
<tr>
<td>Years Since Baccalaureate</td>
<td>Supervisor (51,747)**</td>
<td>Non-Supervisor (132,404)**</td>
</tr>
<tr>
<td>---------------------------</td>
<td>------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>10</td>
<td>12,835</td>
<td>11,174</td>
</tr>
<tr>
<td>11</td>
<td>12,938</td>
<td>11,399</td>
</tr>
<tr>
<td>12-13</td>
<td>13,670</td>
<td>11,798</td>
</tr>
<tr>
<td>14-16</td>
<td>14,369</td>
<td>12,125</td>
</tr>
<tr>
<td>17-20</td>
<td>15,273</td>
<td>12,329</td>
</tr>
<tr>
<td>21-25</td>
<td>16,162</td>
<td>12,741</td>
</tr>
<tr>
<td>26-30</td>
<td>16,336</td>
<td>12,534</td>
</tr>
<tr>
<td>31-35</td>
<td>15,782</td>
<td>12,097</td>
</tr>
<tr>
<td>36+</td>
<td>16,076</td>
<td>12,039</td>
</tr>
</tbody>
</table>


** Sample size.
<table>
<thead>
<tr>
<th>Years Since Baccalaureate</th>
<th>Percentage Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>81.0</td>
</tr>
<tr>
<td>2</td>
<td>76.0</td>
</tr>
<tr>
<td>4</td>
<td>77.0</td>
</tr>
<tr>
<td>6</td>
<td>79.5</td>
</tr>
<tr>
<td>8</td>
<td>85.5</td>
</tr>
<tr>
<td>10</td>
<td>84.5</td>
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<tr>
<td>15</td>
<td>73.0</td>
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<tr>
<td>20</td>
<td>79.5</td>
</tr>
<tr>
<td>25</td>
<td>69.0</td>
</tr>
<tr>
<td>30</td>
<td>61.0</td>
</tr>
<tr>
<td>Years Since Baccalaureate</td>
<td>Percentage Increases</td>
</tr>
<tr>
<td>---------------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>35</td>
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</tr>
<tr>
<td>40</td>
<td>56.5</td>
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<table>
<thead>
<tr>
<th>Family Background</th>
<th>1900</th>
<th>1925</th>
<th>1950</th>
<th>1964</th>
</tr>
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<tbody>
<tr>
<td>Poor</td>
<td>12.3</td>
<td>15.0</td>
<td>12.1</td>
<td>23.3</td>
</tr>
<tr>
<td>Middle Income</td>
<td>42.1</td>
<td>47.8</td>
<td>51.8</td>
<td>66.2</td>
</tr>
<tr>
<td>Wealthy</td>
<td>45.6</td>
<td>36.4</td>
<td>36.1</td>
<td>10.5</td>
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<tr>
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<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
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<table>
<thead>
<tr>
<th>Occupation</th>
<th>1900 Older</th>
<th>1900 Younger</th>
<th>1925 Older</th>
<th>1925 Younger</th>
<th>1950 Older</th>
<th>1950 Younger</th>
<th>1964 Older</th>
<th>1964 Younger</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entrepreneur</td>
<td>27.5</td>
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<td>5.6</td>
<td>4.2</td>
<td>1.2</td>
</tr>
<tr>
<td>Banker or Capitalist</td>
<td>23.8</td>
<td>18.9</td>
<td>9.3</td>
<td>10.1</td>
<td>13.5</td>
<td>7.0</td>
<td>1.6</td>
<td>0.8</td>
</tr>
<tr>
<td>Engineer or Scientist</td>
<td>8.8</td>
<td>13.6</td>
<td>17.8</td>
<td>14.4</td>
<td>17.9</td>
<td>20.4</td>
<td>33.3</td>
<td>36.6</td>
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<td>Lawyer</td>
<td>13.8</td>
<td>12.9</td>
<td>9.3</td>
<td>16.3</td>
<td>10.4</td>
<td>13.2</td>
<td>10.9</td>
<td>10.3</td>
</tr>
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<td>Other Professions</td>
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<td>3.4</td>
<td>2.5</td>
<td>2.9</td>
<td>4.1</td>
<td>10.8</td>
<td>10.6</td>
<td>12.8</td>
</tr>
<tr>
<td>Management</td>
<td>21.2</td>
<td>18.9</td>
<td>35.7</td>
<td>38.9</td>
<td>38.7</td>
<td>43.0</td>
<td>39.4</td>
<td>38.3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
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<td><strong>100.0</strong></td>
<td><strong>100.0</strong></td>
<td><strong>100.0</strong></td>
<td><strong>100.0</strong></td>
<td><strong>100.0</strong></td>
<td><strong>100.0</strong></td>
<td><strong>100.0</strong></td>
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<table>
<thead>
<tr>
<th>Method</th>
<th>Number Of Respondents</th>
<th>Percentage of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Promoted or Elected</td>
<td>363</td>
<td>73.0</td>
</tr>
<tr>
<td>Inherited, Purchased or Established</td>
<td>30</td>
<td>6.1</td>
</tr>
<tr>
<td>Appointed</td>
<td>80</td>
<td>16.1</td>
</tr>
<tr>
<td>Hired</td>
<td>24</td>
<td>4.8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>479</strong></td>
<td><strong>100.0</strong></td>
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<tr>
<td>No information</td>
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</table>

Source: Questionnaire
<table>
<thead>
<tr>
<th>Classification</th>
<th>Number of Respondents</th>
<th>Percentage of Respondents</th>
</tr>
</thead>
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<tr>
<td>First</td>
<td>175</td>
<td>35.2</td>
</tr>
<tr>
<td>Second</td>
<td>79</td>
<td>15.9</td>
</tr>
<tr>
<td>Third</td>
<td>164</td>
<td>33.0</td>
</tr>
<tr>
<td>Fourth</td>
<td>79</td>
<td>15.9</td>
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<tr>
<td>Total</td>
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<tr>
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</table>

Source: Questionnaire
### TABLE 19

**MANAGEMENT FUNCTION**

**ALL RESPONDENTS**

<table>
<thead>
<tr>
<th>Function</th>
<th>Number of Respondents</th>
<th>Percentage of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical</td>
<td>262</td>
<td>52.4</td>
</tr>
<tr>
<td>Non-Technical</td>
<td>77</td>
<td>15.4</td>
</tr>
<tr>
<td>General Management</td>
<td>150</td>
<td>30.0</td>
</tr>
<tr>
<td>Other</td>
<td>11</td>
<td>2.2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>500</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

*Source: Questionnaire*
### TABLE 20

**EVALUATION OF SCIENTIFIC, TECHNICAL OR PROFESSIONAL TRAINING**

**BY TECHNICAL AND NON-TECHNICAL EXECUTIVES - 1964***

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Not very Helpful</td>
<td>10</td>
<td>2</td>
<td>8</td>
<td>1.9</td>
<td>0.7</td>
<td>3.4</td>
</tr>
<tr>
<td>Somewhat Helpful</td>
<td>68</td>
<td>32</td>
<td>36</td>
<td>13.1</td>
<td>11.4</td>
<td>15.1</td>
</tr>
<tr>
<td>Very Helpful</td>
<td>318</td>
<td>163</td>
<td>155</td>
<td>61.4</td>
<td>58.2</td>
<td>65.1</td>
</tr>
<tr>
<td>Absolutely Helpful</td>
<td>122</td>
<td>83</td>
<td>39</td>
<td>23.6</td>
<td>29.7</td>
<td>16.4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>518</strong></td>
<td><strong>280</strong></td>
<td><strong>238</strong></td>
<td><strong>100.0</strong></td>
<td><strong>100.0</strong></td>
<td><strong>100.0</strong></td>
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<tr>
<td>No information</td>
<td>483</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

TABLE 21

ATTITUDES OF GRADUATE STUDENTS*

<table>
<thead>
<tr>
<th>Attitudes</th>
<th>Engineering</th>
<th>Business</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prefer Working With People</td>
<td>16.0</td>
<td>53.0</td>
</tr>
<tr>
<td>Want Chance For Originality &amp; Creativity</td>
<td>71.5</td>
<td>40.0</td>
</tr>
<tr>
<td>Want To Make A Lot Of Money</td>
<td>34.0</td>
<td>47.0</td>
</tr>
<tr>
<td>Considers Himself A Political Liberal</td>
<td>42.0</td>
<td>42.0</td>
</tr>
<tr>
<td>Thinks Of Himself As A Conventional Person</td>
<td>48.0</td>
<td>58.0</td>
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</table>

## TABLE 22

UNDERGRADUATE DEGREE MAJORS

ALL RESPONDENTS

<table>
<thead>
<tr>
<th>Degree</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bachelor of Science</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mechanical Engineering</td>
<td>169</td>
<td>33.8</td>
</tr>
<tr>
<td>Electrical Engineering</td>
<td>94</td>
<td>18.8</td>
</tr>
<tr>
<td>Chemical Engineering</td>
<td>65</td>
<td>13.0</td>
</tr>
<tr>
<td>Civil Engineering</td>
<td>38</td>
<td>7.6</td>
</tr>
<tr>
<td>General Education</td>
<td>31</td>
<td>6.2</td>
</tr>
<tr>
<td>Aeronautical Engineering</td>
<td>25</td>
<td>5.0</td>
</tr>
<tr>
<td>Business Administration</td>
<td>22</td>
<td>4.4</td>
</tr>
<tr>
<td>General Engineering</td>
<td>13</td>
<td>2.6</td>
</tr>
<tr>
<td>Metalurgical Engineering</td>
<td>10</td>
<td>2.0</td>
</tr>
</tbody>
</table>
### TABLE 22 - CONTINUED

<table>
<thead>
<tr>
<th>Degree</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math</td>
<td>4</td>
<td>0.8</td>
</tr>
<tr>
<td>Agriculture Engineering</td>
<td>3</td>
<td>0.6</td>
</tr>
<tr>
<td>Industrial Engineering</td>
<td>1</td>
<td>0.2</td>
</tr>
<tr>
<td>Bachelor Of Arts &amp; Associate Bachelor</td>
<td>25</td>
<td>5.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>500</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Source: Questionnaire
<table>
<thead>
<tr>
<th>Degree</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master of Science</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M.B.A. or Equivalent</td>
<td>54</td>
<td>31.6</td>
</tr>
<tr>
<td>Electrical Engineering</td>
<td>18</td>
<td>10.5</td>
</tr>
<tr>
<td>Mechanical Engineering</td>
<td>15</td>
<td>8.8</td>
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<tr>
<td>General Engineering</td>
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<td>8.8</td>
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<tr>
<td>Chemical Engineering</td>
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<td>5.8</td>
</tr>
<tr>
<td>Aeronautical Engineering</td>
<td>6</td>
<td>3.5</td>
</tr>
<tr>
<td>Civil Engineering</td>
<td>6</td>
<td>3.5</td>
</tr>
<tr>
<td>Miscellaneous Technical</td>
<td>5</td>
<td>2.9</td>
</tr>
<tr>
<td>Degree</td>
<td>Number</td>
<td>Percent</td>
</tr>
<tr>
<td>------------------------------------</td>
<td>--------</td>
<td>---------</td>
</tr>
<tr>
<td>Metallurgical Engineering</td>
<td>2</td>
<td>1.2</td>
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<td>Miscellaneous Non-Technical</td>
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<td><strong>Doctorate</strong></td>
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<td></td>
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<td>Engineering</td>
<td>12</td>
<td>7.0</td>
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<tr>
<td>Science</td>
<td>10</td>
<td>5.9</td>
</tr>
<tr>
<td>Non-Technical</td>
<td>2</td>
<td>1.2</td>
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<tr>
<td><strong>Total</strong></td>
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</table>

Source: Questionnaire
TABLE 24

MILITARY SERVICE

ALL RESPONDENTS

<table>
<thead>
<tr>
<th>Service</th>
<th>Number</th>
<th>Percent</th>
<th>Average Number of Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Officers</td>
<td>180</td>
<td>36.0</td>
<td>4.0</td>
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<tr>
<td>Enlisted</td>
<td>125</td>
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<tr>
<td>No Service</td>
<td>195</td>
<td>39.0</td>
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</tr>
<tr>
<td>Total</td>
<td>500</td>
<td>100.0</td>
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Source: Questionnaire
### TABLE 25

**FORMAL EDUCATION IMPORTANCE**

**ALL RESPONDENTS**

<table>
<thead>
<tr>
<th>Education</th>
<th>Importance Rating</th>
<th>Number Responding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering &amp; Scientific</td>
<td>4.19</td>
<td>492</td>
</tr>
<tr>
<td>Economics &amp; Finance</td>
<td>3.18</td>
<td>484</td>
</tr>
<tr>
<td>Human Relations &amp; Personnel</td>
<td>4.36</td>
<td>478</td>
</tr>
<tr>
<td>Mathematics</td>
<td>3.14</td>
<td>477</td>
</tr>
<tr>
<td>Specific Technologies</td>
<td>2.68</td>
<td>456</td>
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<tr>
<td>Accounting</td>
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<td>474</td>
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<td>Business Administration</td>
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<td>Industrial Engineering</td>
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*Source: Questionnaire*
<table>
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<th>Subject</th>
<th>Number</th>
<th>Percent</th>
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<tbody>
<tr>
<td>Engineering &amp; Scientific</td>
<td>31</td>
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</tr>
<tr>
<td>Economics &amp; Finance</td>
<td>81</td>
<td>14.1</td>
</tr>
<tr>
<td>Human Relations &amp; Personnel</td>
<td>96</td>
<td>16.7</td>
</tr>
<tr>
<td>Mathematics</td>
<td>11</td>
<td>1.9</td>
</tr>
<tr>
<td>Specific Technologies</td>
<td>26</td>
<td>4.5</td>
</tr>
<tr>
<td>Accounting</td>
<td>40</td>
<td>7.0</td>
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<tr>
<td>Business Administration</td>
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<td>31.3</td>
</tr>
<tr>
<td>Industrial Engineering</td>
<td>16</td>
<td>2.8</td>
</tr>
<tr>
<td>Communications, Liberal Arts &amp; Law</td>
<td>81</td>
<td>14.1</td>
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<td>Computer Technology</td>
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<td><strong>Total</strong></td>
<td><strong>575</strong></td>
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Source: Questionnaire
### TABLE 27

**GAPS IN FORMAL SCIENTIFIC, TECHNICAL OR PROFESSIONAL EDUCATION**

**AS EVALUATED BY TECHNICAL AND NON-TECHNICAL EXECUTIVES - 1964**

<table>
<thead>
<tr>
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<th></th>
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<th></th>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Engineering</td>
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<td>14</td>
<td>55</td>
<td>25.4</td>
<td>13.0</td>
<td>33.5</td>
</tr>
<tr>
<td>Physics, Chemistry Math &amp; Biology</td>
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<td>11</td>
<td>23</td>
<td>12.5</td>
<td>10.2</td>
<td>14.0</td>
</tr>
<tr>
<td>Other Science</td>
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<td>2</td>
<td>15</td>
<td>6.2</td>
<td>1.8</td>
<td>9.2</td>
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<td><strong>Total Technical</strong></td>
<td>120</td>
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<td>93</td>
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<td>25.0</td>
<td>56.7</td>
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<td><strong>Non-Technical Fields</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>23</td>
<td>15.8</td>
<td>18.5</td>
<td>14.0</td>
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<td>------------------</td>
<td>------------------</td>
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<td>----------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>Economics</td>
<td>24</td>
<td>15</td>
<td>9</td>
<td>8.8</td>
<td>13.9</td>
<td>5.5</td>
</tr>
<tr>
<td>Accounting</td>
<td>35</td>
<td>20</td>
<td>15</td>
<td>12.9</td>
<td>18.5</td>
<td>9.1</td>
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<td>Law</td>
<td>38</td>
<td>20</td>
<td>18</td>
<td>14.0</td>
<td>18.5</td>
<td>11.0</td>
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<tr>
<td>Other</td>
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<td>6</td>
<td>4.4</td>
<td>5.6</td>
<td>3.7</td>
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<td><strong>Total Non-Technical</strong></td>
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<td><strong>81</strong></td>
<td><strong>71</strong></td>
<td><strong>55.9</strong></td>
<td><strong>75.0</strong></td>
<td><strong>43.3</strong></td>
</tr>
<tr>
<td><strong>Total</strong></td>
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<td><strong>164</strong></td>
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<td><strong>100.0</strong></td>
<td><strong>100.0</strong></td>
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</tbody>
</table>

## TABLE 28

**DIFFICULTIES ENCOUNTERED IN TRANSITION FROM ENGINEER TO MANAGER**

### ALL RESPONDENTS

<table>
<thead>
<tr>
<th>Difficulties</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human Relations</td>
<td>101</td>
<td>26.7</td>
</tr>
<tr>
<td>Delegation of Work</td>
<td>69</td>
<td>18.3</td>
</tr>
<tr>
<td>Business Administration Skills</td>
<td>62</td>
<td>16.4</td>
</tr>
<tr>
<td>Management Principles</td>
<td>83</td>
<td>22.0</td>
</tr>
<tr>
<td>Decision Making</td>
<td>7</td>
<td>1.8</td>
</tr>
<tr>
<td>Technical Skills</td>
<td>3</td>
<td>0.8</td>
</tr>
<tr>
<td>Communications, Political &amp; Legal Skills</td>
<td>27</td>
<td>7.1</td>
</tr>
<tr>
<td>Accomplishment of Job</td>
<td>26</td>
<td>6.9</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>378</strong></td>
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Source: Questionnaire
### TABLE 29

**FUTURE FORMAL GRADUATE EDUCATION**

**FIRST PREFERENCE**

<table>
<thead>
<tr>
<th>Education Preference</th>
<th>All Respondents</th>
<th>Respondents With No Graduate Education</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Percent</td>
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</tr>
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<td>48</td>
<td>9.6</td>
</tr>
<tr>
<td>Specific Technologies</td>
<td>11</td>
<td>2.2</td>
</tr>
<tr>
<td>Mathematics &amp; Computer Technologies</td>
<td>11</td>
<td>2.2</td>
</tr>
<tr>
<td>Industrial Engineering</td>
<td>14</td>
<td>2.8</td>
</tr>
<tr>
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<td>Respondents With No Graduate Education</td>
</tr>
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<td>----------------------------------------</td>
</tr>
<tr>
<td></td>
<td>Number</td>
<td>Percent</td>
</tr>
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</tr>
<tr>
<td>Liberal Arts, Law &amp; Other</td>
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Source: Questionnaire
### TABLE 30

**FUTURE FORMAL GRADUATE EDUCATION**

**RESPONDENT WITH NO GRADUATE STUDY**

**SECOND PREFERENCE**

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<thead>
<tr>
<th>Education Preference</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
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<td>Engineering &amp; Scientific</td>
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</tr>
<tr>
<td>General Engineering</td>
<td>10</td>
<td>10.1</td>
</tr>
<tr>
<td>Specific Technologies</td>
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<td>10.1</td>
</tr>
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<td>8.1</td>
</tr>
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<td>Industrial Engineering</td>
<td>4</td>
<td>4.0</td>
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<tr>
<td>Business Administration</td>
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<td>Management Principles</td>
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<tr>
<td>Specific Administration Skills</td>
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<td>26.2</td>
</tr>
<tr>
<td>Education Preference</td>
<td>Number</td>
<td>Percent</td>
</tr>
<tr>
<td>------------------------------</td>
<td>--------</td>
<td>---------</td>
</tr>
<tr>
<td>Human Relations &amp; Personnel</td>
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<td>8.1</td>
</tr>
<tr>
<td>Liberal Arts, Law &amp; Other</td>
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<td>11.2</td>
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Source: Questionnaire
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<th>Education or Skills</th>
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<th>Percent</th>
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</thead>
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</tr>
<tr>
<td>General Engineering &amp; Technical Knowledge</td>
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<td>Specific Engineering &amp; Technical Skills</td>
<td>33</td>
<td>7.7</td>
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<tr>
<td>Specific Business Administration Skills</td>
<td>49</td>
<td>11.4</td>
</tr>
<tr>
<td>Management Principles</td>
<td>130</td>
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<tr>
<td>Experience &amp; Personal Qualifications</td>
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<tr>
<td>Mathematics, Statistics &amp; Computer Technology</td>
<td>72</td>
<td>16.9</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>428</strong></td>
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Source: Questionnaire
### Table 32

**Formal Education or Skills Increasingly Required**

*By Present Position in Next Ten Years*

**All Respondents**

<table>
<thead>
<tr>
<th>Education or Skills</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human Relations</td>
<td>58</td>
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</tr>
<tr>
<td>General Engineering &amp; Technical Knowledge</td>
<td>21</td>
<td>6.8</td>
</tr>
<tr>
<td>Specific Engineering &amp; Technical Skills</td>
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<td>Management Principles</td>
<td>41</td>
<td>13.3</td>
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<td>Experience &amp; Personal Qualifications</td>
<td>25</td>
<td>8.1</td>
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<td>Mathematics, Statistics &amp; Computer Technology</td>
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*Source: Questionnaire*
<table>
<thead>
<tr>
<th>Bachelor of Science</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical Engineering</td>
<td>18</td>
<td>34.0</td>
</tr>
<tr>
<td>Electrical Engineering</td>
<td>11</td>
<td>20.7</td>
</tr>
<tr>
<td>Chemical Engineering</td>
<td>6</td>
<td>11.3</td>
</tr>
<tr>
<td>Civil Engineering</td>
<td>3</td>
<td>5.7</td>
</tr>
<tr>
<td>General Engineering</td>
<td>2</td>
<td>3.8</td>
</tr>
<tr>
<td>Aeronautical Engineering</td>
<td>1</td>
<td>1.9</td>
</tr>
<tr>
<td>Metallurgical Engineering</td>
<td>1</td>
<td>1.9</td>
</tr>
</tbody>
</table>

<p>| Associate Bachelor                     |        |         |
| Engineering                            | 1      | 1.9     |
| Non-Technical                          | 5      | 9.4     |</p>
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<thead>
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<th>Bachelor Business Administration</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
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Source: Questionnaire
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<thead>
<tr>
<th>Bachelor of Science</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
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<td>Electrical Engineering</td>
<td>19</td>
<td>25.3</td>
</tr>
<tr>
<td>Mechanical Engineering</td>
<td>17</td>
<td>22.6</td>
</tr>
<tr>
<td>Chemical Engineering</td>
<td>14</td>
<td>18.7</td>
</tr>
<tr>
<td>Civil Engineering</td>
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<td>10.7</td>
</tr>
<tr>
<td>Aeronautical Engineering</td>
<td>5</td>
<td>6.7</td>
</tr>
<tr>
<td>General</td>
<td>5</td>
<td>6.7</td>
</tr>
<tr>
<td>Metallurgical Engineering</td>
<td>2</td>
<td>2.7</td>
</tr>
<tr>
<td>General Engineering</td>
<td>2</td>
<td>2.7</td>
</tr>
<tr>
<td>Agricultural Engineering</td>
<td>1</td>
<td>1.3</td>
</tr>
<tr>
<td>Economics</td>
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<td><strong>Associate Bachelor Engineering</strong></td>
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<td><strong>Total</strong></td>
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Source: Questionnaire
**TABLE 35**

**MASTER OF SCIENCE - ENGINEERING**

**AREAS OF TECHNICAL SPECIALITY**

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<th>Number</th>
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<td>Electrical Engineering</td>
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<tr>
<td>Mechanical Engineering</td>
<td>15</td>
<td>19.5</td>
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<tr>
<td>General Engineering</td>
<td>15</td>
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<td>13.0</td>
</tr>
<tr>
<td>Aeronautical Engineering</td>
<td>6</td>
<td>7.8</td>
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<tr>
<td>Civil Engineering</td>
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<td>7.8</td>
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<tr>
<td>Other Specialties</td>
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<td>2.6</td>
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<tr>
<td><strong>Total</strong></td>
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</table>

* Two respondents had two M.S. Engineering degrees
<table>
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<th>All Respondents</th>
<th>Number M.B.A. Graduates</th>
<th>M.S. Engr. Graduates</th>
<th>All Respondents</th>
<th>Percent M.B.A. Graduates</th>
<th>M.S. Engr. Graduates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial</td>
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<td>35</td>
<td>26</td>
<td>59.8</td>
<td>64.8</td>
<td>34.7</td>
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<td>1</td>
<td>4</td>
<td>3.0</td>
<td>1.9</td>
<td>5.3</td>
</tr>
<tr>
<td>Government</td>
<td>23</td>
<td>2</td>
<td>7</td>
<td>4.6</td>
<td>3.7</td>
<td>9.3</td>
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<tr>
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<td>1.4</td>
<td>3.7</td>
<td>0.0</td>
</tr>
<tr>
<td>Research &amp; Development</td>
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<td>11</td>
<td>6.2</td>
<td>1.9</td>
<td>14.7</td>
</tr>
<tr>
<td>Electronic &amp; Aerospace</td>
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<td>21</td>
<td>14.8</td>
<td>14.8</td>
<td>28.0</td>
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<tr>
<td>Other</td>
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<td>10.2</td>
<td>9.2</td>
<td>8.0</td>
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<tr>
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<td>75</td>
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Source: Questionnaire
<table>
<thead>
<tr>
<th>Years Since Baccalaureate</th>
<th>All Industries (186,213)**</th>
<th>Aerospace (34,831)**</th>
</tr>
</thead>
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<td>8,173</td>
<td>8,564</td>
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<td>3</td>
<td>8,545</td>
<td>9,105</td>
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<td>8,993</td>
<td>9,576</td>
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<td>5</td>
<td>9,523</td>
<td>10,224</td>
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<td>9,994</td>
<td>10,630</td>
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<td>7</td>
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<td>11,262</td>
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<td>12,271</td>
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<tr>
<td>Years Since Baccalaureate</td>
<td>All Industries (186,213)**</td>
<td>Median Salary Aerospace (34,831)**</td>
</tr>
<tr>
<td>--------------------------</td>
<td>----------------------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>11</td>
<td>11,763</td>
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<tr>
<td>12-13</td>
<td>12,280</td>
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<td>14-16</td>
<td>12,924</td>
<td>14,286</td>
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<td>17-20</td>
<td>13,747</td>
<td>15,017</td>
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<td>21-25</td>
<td>14,537</td>
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<td>31-35</td>
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<td>13,235</td>
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** Sample Size
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<th>M.S. Engr Graduates</th>
<th>All Respondents</th>
<th>Percent M.B.A. Graduates</th>
<th>Percent M.S. Engr Graduates</th>
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<td>0.0</td>
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<td>25 to 30</td>
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<td>2.0</td>
<td>3.7</td>
<td>1.3</td>
</tr>
<tr>
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<td>5</td>
<td>9.8</td>
<td>14.8</td>
<td>6.7</td>
</tr>
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<td>16.7</td>
<td>14.7</td>
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<td>23.6</td>
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<td>29.3</td>
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<td>7</td>
<td>18</td>
<td>18.7</td>
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<td>24.0</td>
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<td>51 to 55</td>
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<td>5</td>
<td>12.4</td>
<td>11.1</td>
<td>6.7</td>
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<td>56 to 60</td>
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<td>10</td>
<td>9.5</td>
<td>7.4</td>
<td>13.3</td>
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<td>2.7</td>
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No information 1

Source: Questionnaire
### TABLE 39

**MILITARY SERVICE**

<table>
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<th></th>
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<th></th>
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<tr>
<td>Officers</td>
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<td>23</td>
<td>31</td>
<td>36.0</td>
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<td>41.4</td>
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<tr>
<td>Enlistees</td>
<td>125</td>
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<td>16</td>
<td>25.0</td>
<td>25.9</td>
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<tr>
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<td>28</td>
<td>39.0</td>
<td>31.5</td>
<td>37.3</td>
</tr>
<tr>
<td>Total</td>
<td>500</td>
<td>54</td>
<td>75</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
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</tbody>
</table>

**Average Number Yrs.**

<table>
<thead>
<tr>
<th>Service</th>
<th>M.B.A.</th>
<th>M.S. Engr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Officers</td>
<td>4.0</td>
<td>3.8</td>
</tr>
<tr>
<td>Enlistees</td>
<td>2.3</td>
<td>2.4</td>
</tr>
</tbody>
</table>

Source: Questionnaire
### TABLE 40

**FORMAL EDUCATION IMPORTANCE**

<table>
<thead>
<tr>
<th>Education</th>
<th>Importance Rating</th>
<th>Number Responding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering &amp; Scientific</td>
<td>4.19</td>
<td>3.83</td>
</tr>
<tr>
<td>Economics &amp; Finance</td>
<td>3.81</td>
<td>3.96</td>
</tr>
<tr>
<td>Human Relations &amp; Personnel</td>
<td>4.36</td>
<td>4.36</td>
</tr>
<tr>
<td>Mathematics</td>
<td>3.14</td>
<td>2.79</td>
</tr>
<tr>
<td>Specific Technologies</td>
<td>2.68</td>
<td>2.08</td>
</tr>
<tr>
<td>Accounting</td>
<td>2.98</td>
<td>3.15</td>
</tr>
<tr>
<td>Business Administration</td>
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<tr>
<td>Industrial Engineering</td>
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Source: Questionnaire
<table>
<thead>
<tr>
<th>Education</th>
<th>Importance Rating</th>
<th>Number Responding</th>
</tr>
</thead>
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</tr>
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<td>4.18</td>
</tr>
<tr>
<td>Economics &amp; Finance</td>
<td>3.81</td>
<td>3.96</td>
</tr>
<tr>
<td>Human Relations &amp; Personnel</td>
<td>4.36</td>
<td>4.39</td>
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<tr>
<td>Mathematics</td>
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<td>3.04</td>
</tr>
<tr>
<td>Specific Technologies</td>
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<td>2.30</td>
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<tr>
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<td>3.26</td>
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<tr>
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No information 7

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<td>31</td>
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</tr>
<tr>
<td><strong>Economics &amp; Finance</strong></td>
<td>81</td>
<td>3</td>
</tr>
<tr>
<td><strong>Human Relations &amp; Personnel</strong></td>
<td>96</td>
<td>4</td>
</tr>
<tr>
<td><strong>Mathematics</strong></td>
<td>11</td>
<td>4</td>
</tr>
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<td><strong>Specific Technologies</strong></td>
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<td><strong>Accounting</strong></td>
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<td>11</td>
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Source: Questionnaire
### TABLE 44

**FORMAL EDUCATION OR SKILLS INCREASINGLY REQUIRED BY PRESENT POSITION IN NEXT TEN YEARS**

#### FIRST IMPORTANCE

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<tr>
<th>Education or Skills</th>
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<td>33</td>
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</tr>
<tr>
<td>Specific Business Administration Skills</td>
<td>49</td>
<td>5</td>
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<td>Management Principles</td>
<td>130</td>
<td>8</td>
</tr>
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<td>----------------------------------------</td>
<td>-------------</td>
<td>--------------</td>
</tr>
<tr>
<td>Experience &amp; Personal Qualifications</td>
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</tr>
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Source: Questionnaire
## TABLE 45

**FORMAL EDUCATION OR SKILLS INCREASINGLY REQUIRED**
**BY POSITION PRESENT IN NEXT TEN YEARS**

**SECOND IMPORTANCE**

<table>
<thead>
<tr>
<th>Education or Skills</th>
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Source: Questionnaire
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<td>Delegation of Work</td>
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<td>Business Admin. Skills</td>
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<td>Management Principles</td>
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<td>Technical Skills</td>
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<td>Communications, Political &amp; Legal</td>
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<td>Accomplishment of Job</td>
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No information 3

Source: Questionnaire
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<tr>
<td>71,000 to 80,000</td>
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<td>Salary</td>
<td>Number</td>
<td>Percent</td>
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<tr>
<td>------------------------</td>
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Source: Questionnaire


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<th>Number</th>
<th>Percent</th>
<th>Percent</th>
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<td>16,000 to 20,000</td>
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<td>24.3</td>
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<tr>
<td>21,000 to 25,000</td>
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<td>7.5</td>
<td>20.0</td>
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<tr>
<td>Salary</td>
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<td>Percent</td>
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<td></td>
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</tr>
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<td></td>
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Source: Questionnaire
### TABLE 51

**MEDIAN ANNUAL SALARY SINCE BACCALAUREATE**

**ALL INDUSTRIES***

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<tr>
<th>Years Since Baccalaureate</th>
<th>All Graduates (186,213)**</th>
<th>M.S. Graduates (23,745)**</th>
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<tr>
<td>0</td>
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<td>$ 0</td>
</tr>
<tr>
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<td>7,690</td>
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<td>2</td>
<td>8,173</td>
<td>9,123</td>
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<td>3</td>
<td>8,545</td>
<td>9,521</td>
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<td>4</td>
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<tr>
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<td>Median Salaries M.S. Graduates (23,745)</td>
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<td>--------------------------</td>
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* Professional Income of Engineers, pp. 16 and 18.

** Sample Size.
### TABLE 52

**AVERAGE ANNUAL SALARY BY AGE GROUP**

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<th>Respondents' Age</th>
<th>All Respondents</th>
<th>M.B.A. Graduates</th>
<th>M.S. Engr. Graduates</th>
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<td>$13,000</td>
<td>$13,000</td>
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<td>41 to 45</td>
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<td>33,568</td>
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<td>Over 65</td>
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**Source:** Questionnaire
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<tr>
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Source: Questionnaire