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## ABSTRACT

### A STUDY OF THE ROLE OF THE ENGINEERING MANAGER AND HIS CONTINUING EDUCATION REQUIREMENTS

by Charles A. McKee

#### Purpose of the Study

The main purpose of this study was to investigate the relationships among the perceptions engineering managers have of their role, their continuing education activities, and subject area needs, and among the expectations held for them by their immediate superiors, direct subordinates, and by engineering faculty outside of the organization.

#### Methodology

Role theory was adopted as the conceptual approach to study the position of the engineering manager. A questionnaire-schedule received from 199 engineering managers, 122 immediate superiors, 168 direct subordinates and 50 engineering faculty members produced information about the role of the engineering manager, his continuing education activities, and his subject area needs.

## Conclusions

### Section I--Job Functions

1. The immediate superiors indicated a strong positive feeling on more items concerning the job functions of the engineering manager than any of the other groups.

2. The direct subordinates indicated a strong positive feeling on fewer items concerning the job functions of the engineering manager than any of the other groups.

3. There was common agreement among all four groups on seven items out of twenty-nine.

4. A higher degree of agreement existed between the engineering managers and their immediate superiors concerning the role of the engineering manager than between any other groups. Lesser agreement existed in comparing the engineering managers and the engineering faculty, and in comparing the immediate superiors and the direct subordinates.

### Section II--Continuing Education Activities

1. The engineering managers, immediate superiors and direct subordinates, as individual groups, were essentially in agreement on the continuing education items.



2. The engineering faculty indicated agreement on fewer continuing education items than the other groups.

3. There was common agreement among all four groups on one item out of thirty-four.

4. The engineering managers, immediate superiors, and direct subordinates, when compared, were essentially in agreement on the continuing education activities of the engineering manager. There was very little agreement between the engineering manager and the engineering faculty.

Section III--Subject Areas  
(Mathematics, Physics, Chemistry)

1. The engineering faculty indicated a need for more mathematics, physics, chemistry subjects for the engineering manager than any of the other groups.

2. The direct subordinates did not indicate a need for any of these subjects for the engineering manager, and the immediate superiors indicated a need for only one subject.

3. There was very little agreement among the compared groups concerning the mathematics, physics, chemistry subject needs of the engineering manager. There was no agreement between the managers and subordinates.

(Engineering)

1. There was high agreement by both the engineering managers and the engineering faculty, as individual groups, concerning the need of the engineering manager for the engineering subjects.

2. There was relatively low agreement by both the immediate superiors and the direct subordinates, as individual groups, concerning the need of the engineering manager for the engineering subjects.

3. There was common agreement among all four groups on one item out of fourteen.

4. A much higher degree of agreement existed between engineering managers and engineering faculty concerning engineering subjects than between managers and the other groups. There were no such items on which the superiors and subordinates agreed.

(Management)

1. There was high agreement among the engineering managers and relatively low agreement among the immediate superiors concerning the need of the engineering manager for the management subjects.

2. There was moderate agreement by both the direct subordinates and the engineering faculty, as individual groups, concerning the need of the engineering manager for the management subjects.

3. There was common agreement among all four groups on seven items out of thirty-one.

4. A higher degree of agreement existed in comparing engineering managers with both superiors and subordinates than existed in comparing managers and faculty.

There was moderate agreement between the superiors and subordinates.

5. In comparing engineering managers and engineering faculty, there were more items (8) with high intraposition consensus and a significant difference than for any of the other groupings. There were no such items in comparing engineering managers and superiors.

(Communication Skills)

1. There was uniform agreement among the four individual groups on the need of the engineering manager for the communication skills subjects.

2. There was common agreement among the four groups on five items out of ten.

3. A higher degree of agreement existed in comparing engineering managers with superiors than existed in comparing any of the other groups.

4. There were relatively few items (3) in which the groups showed high intraposition consensus with a significant difference. There were no significant differences in comparing managers and superiors, or in comparing superiors and subordinates.

General Conclusion

As a general conclusion of the entire study:

1. The engineering managers showed the highest degree of consensus of the four individual groups;

2. The engineering managers and the immediate superiors showed the highest degree of consensus of the compared groups; and

3. The engineering managers and the immediate superiors showed the lowest number of significant differences of the compared groups.

A STUDY OF THE ROLE OF THE  
ENGINEERING MANAGER AND HIS  
CONTINUING EDUCATION REQUIREMENTS

By

Charles A. McKee

A THESIS

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## CHAPTER I

### INTRODUCTION

#### Background for the Problem

Since the close of the second world war, there has been an unprecedented, explosive advance in science and engineering. Accompanying this rapidly accelerating growth rate of engineering and scientific knowledge is a rapid technological obsolescence. This rapid rate of change requires engineering and scientific personnel to spend a greater proportion of time in acquiring new knowledge in order to solve new problems. Continuing education, therefore, is no longer incidental to the job but an essential part of it.<sup>1</sup>

The problem of keeping pace with changes in professional knowledge and procedures has been, and will continue to be, particularly acute for the engineer and even more acute for the engineering manager who has risen into management and been made responsible for an engineering activity.

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<sup>1</sup>William W. Evans, "The Problem of Obsolescence of Knowledge," IEEE Transactions on Engineering Management, Vol. 10, No. 1 (March, 1963), pp. 29-31; I. I. Raines and J. C. Missar, "Engineering Obsolescence: A Challenge to the Training Director." Training Directors Journal, Vol. 19, No. 1 (January, 1965), pp. 35-42.

Rubey<sup>2</sup> observes that well over a third of the management of large industry in America today is in the hands of engineers. In 1900 only about 7 percent of top management of American business had a technological background. This had advanced to 13 percent by 1963. Dawson<sup>3</sup> reports that a recent Harvard study of 6,000 executives of 100 corporations with sales of \$100 million or more showed 45 percent in these middle and top management posts had degrees in science or engineering. More significantly perhaps, 51 percent of the executives in the 35-45 age group had such a background as compared to only 36 percent in the 55-65 age group.

Increasing technological complexity of products and services is a prime reason for more corporations filling top management jobs with engineers, but another factor is the change in engineering schools. Liberal arts courses have been introduced into the curriculum because engineering graduates are called upon now to become more involved in social, economic and political problems. Today's engineer must be better prepared for other than a purely technical

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<sup>2</sup>Harry Rubey, "The Engineer Becomes a Professional Manager," Journal of Engineering Education, Vol. 43, No. 5 (January, 1953), p. 338.

<sup>3</sup>Samuel Dawson, "More Engineers in Management," The State Journal, Lansing, Michigan (August 22, 1966), p. C-5.

assignment.<sup>4</sup> Cronstedt in Engineering Management and Administration supports this and states:

Unlike the intellectual, who directs his attention to only one goal, the completion of his work, the engineering manager operates in two directions: toward the engineers he manages, on the one hand, and toward the people to whom he is responsible for results, on the other. In addition to his extraordinary penchant for scientific and technical subjects, the engineering manager must be well versed in commercial matters. He must be completely at home in the role of businessman as well as able to meet the engineer and scientist on their own ground.<sup>5</sup>

Richardson labels the engineering manager as the man in the middle and comments:

The engineering manager is under constant scrutiny not only by higher management, but by the personnel he supervises, both as to his technical competence and his managerial ability. He must be able to interpret the highly technical accomplishments of his people to other segments of management so that they grasp the full significance of what is being done. And, at the same time, he must be able to communicate the corporate goals convincingly to his highly technical associates. He must be able to do an outstanding job of selling--and communicating--up and down the line.<sup>6</sup>

The engineering manager therefore occupies essentially the position of a mediator, administrator, and communicator.<sup>7</sup> Nevertheless, he must also be an unusually

<sup>4</sup>Loc. cit.

<sup>5</sup>V. Cronstedt, Engineering Management and Administration (New York: McGraw-Hill Book Co., Inc., 1961), p. 8.

<sup>6</sup>Howard L. Richardson, "Management and Engineering-Professions of Progress," IEEE Transactions on Engineering Management, Vol. 4, No. 1 (March, 1957), p. 71.

<sup>7</sup>Cronstedt, op. cit., p. 8; Richardson, op. cit., p. 71.



perceptive engineer, quick to pick up new trends and always on the alert to new developments in technology. He must be prepared to spend many hours, mostly in his spare time, absorbing the rudiments of other disciplines.

Although in the breadth of his technical knowledge he must not permit himself to fall behind those who are working for him, he must also realize that in a rapidly expanding technology it is impractical for him to maintain exhaustive proficiency in every category and at the same time to retain his competence in administrative matters.<sup>8</sup> His problem now is that he finds it increasingly difficult to understand what the young engineers under him are talking about. He may even be utterly baffled by any chemists, physicists, or mathematicians in his group. The engineering school he himself attended may have been strong on how-to-do-it courses, but today many engineering colleges give the students vigorous work in the basic science area as well as courses in modern engineering that hardly existed when the forty-five-year-old manager was in school. Does he have difficulty communicating with the men he manages? Can he assess the capabilities of engineers to be hired and advanced, or evaluate proposed development programs, if his own education is out of date? In Fortune magazine, Boehm asks the question; what can be done with him?<sup>9</sup>

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<sup>8</sup>Cronstedt, op. cit., p. 8.

<sup>9</sup>George A. Boehm, "Bringing Engineers Up to Date," Fortune, Vol. 67, No. 5 (May, 1963), p. 120.

It appears that the engineering manager needs a special kind of educational help. He probably lacks the background necessary to take individual courses to update himself in certain areas, but he also lacks the time it would take to re-educate himself from the bottom up. Perhaps what he needs is something in between. This may not be found within the framework of conventional education, but perhaps it does exist in the form of continuing education programs especially planned and prepared by businessmen and educators with a special interest in the problem. Dean Brown of the Massachusetts Institute of Technology stressed the continuing education needs of the engineering manager as follows:

Engineering managers need greater familiarity with such areas of technology as new materials, nuclear power, and the use of sophisticated computers. The concepts and techniques which recently graduated engineers are employing in their work are sometimes well beyond the experience and often beyond the level of comprehension of their engineering managers. The pulling together of today's multitude of diverse technologies elevates the team leader's job to a new level of importance. The new fields interact with traditional fields and with new scientific discoveries in ways that make decision-making more complex than it used to be. Today's engineering managers must then keep themselves at the forefront of scientific and engineering advances, knowing about them to the extent of understanding the concepts, areas of application, and implications to future development if they want to stay "on top" of their roles and responsibilities. This is necessary for the direction and development of their staffs, for the coordination of today's increasingly complex engineering undertakings, and for lending engineering direction to the planning of future programs of their companies.<sup>10</sup>

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<sup>10</sup>G. S. Brown, "Closing the Engineering Gap--One Approach," Electrical Engineering (July, 1963), p. 82.

This same point is emphasized by Dean Williamson of Pennsylvania State University, but he imposes the additional requirement for the engineering manager that as he gets farther away from the bench where the real technical work is done, he becomes more and more aware of other considerations that make business function smoothly. Factors other than the purely technical exert an influence on his thinking.<sup>11</sup> Obviously Williamson is pointing towards the need of the engineering manager for managerial knowledge and skills in addition to his technical training.

#### Statement of the Problem

For engineering managers in today's economy, showing concern about their own career aspirations, as well as the men under them, is a necessary part of helping their company stay in business. Posing real problems for engineering managers in industry are the possible conflicts that arise between each man and the goals and patterns of operation of the firm in which he works. Recognition that the problem exists affords management a real opportunity to give the engineering manager a feeling of greater accomplishment in advancing his career goals and in fulfilling,

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<sup>11</sup>Merritt A. Williamson, "Problems of Engineering Management," IEEE Transactions on Engineering Management, Vol. 5, No. 1 (March, 1958), pp. 61-64; M. A. Williamson, "Professional Growth--A Continuing Obligation," Research and Development (October, 1960), pp. 1-3.

at the same time, the operational objectives of his firm.<sup>12</sup>

In the course of their engineering careers, engineering managers sustain contact with persons holding other positions within the organization--other managers, superiors, subordinates, faculty consultants, et cetera. The relationships engineering managers have with persons in each of these positions are by no means identical. Superiors of engineering managers, for example, may obviously differ from subordinates in their images and expectations of engineering managers. In turn, engineering managers may differ in their expectations. Such a complex of role relationships which persons have by virtue of occupying a particular status has been described by Merton<sup>13</sup> and Kahn<sup>14</sup> as a role set.

The activities of engineering managers are guided by their role perceptions, that is, how they are supposed to act in a given situation.<sup>15</sup> Since engineering managers

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<sup>12</sup>Ernest D. Phelps, "Help Your Engineers to Get Ahead," Harvard Business Review, Vol. 40 (January, 1962), p. 125.

<sup>13</sup>Robert K. Merton, Social Theory and Social Structure (Glencoe, Illinois: The Free Press, 1957, rev. ed.) pp. 368-384.

<sup>14</sup>Robert L. Kahn et al., Organizational Stress: Studies in Role Conflict and Ambiguity (New York: John Wiley and Sons, Inc., 1964), p. 13.

<sup>15</sup>Hjalmar Rosen, "Managerial Role Interaction: A Study of Three Managerial Levels," Journal of Applied Psychology (February, 1961), pp. 30-34.

perform different roles, they must be highly adaptive in order to change from one role to another quickly. The engineering manager's role particularly requires that he be adaptive in working with the extremes of subordinate and superior, and technical and nontechnical. In order to be adaptive, he needs to see his own role as required by the function he is performing and he needs to see his role as seen by others. Obviously he cannot meet the needs of others unless he can perceive what they expect of him. Research shows that where there is wide variance in a manager's role perception of his job and the employees' role expectations of that job, there tends to be poor motivation and inefficiency.<sup>16</sup> Hulett and Stagner found that differences in role expectation and degrees of consensus might result in the lowering of morale within an organization.<sup>17</sup>

Sociologist H. A. Shepard, in his marginal man theory, claims that the work of engineering managers requires them to mediate between the frequently conflicting demands of two different sub-cultures: those of business and of science. Although heavily dependent on both cultures

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<sup>16</sup> Keith Davis, Human Relations at Work (New York: McGraw-Hill Book Co., Inc., 1962), p. 41.

<sup>17</sup> J. E. Hulett and R. Stagner, Problems in Social Psychology, An Interdisciplinary Inquiry, (University of Illinois, 1952).

for his livelihood, the engineering manager is not fully identified with either one. To the extent that he identifies himself with business management, the engineer's work attitude will be dominated by empiricism and considerations of market practicality. To the extent that his role-identification is professional, his work approach will be closer to the pole of disinterested scientific curiosity.<sup>18</sup>

Supporting these roles are certain educational requirements which reflect the need for continuing education in the technical field to keep the engineering manager abreast of the state-of-the-art of engineering and to offset obsolescence; furthermore, he must also acquire knowledge and skills in the managerial area in order to gain acceptance as a professional manager. Role-identification, then, as "managerial" or "professional" appears to pose a real educational dilemma for the engineering manager and raises the general question for study:

Are there differences among the perceptions engineering managers have of their role and their continuing education requirements, and among the expectations held for them by their immediate superiors, direct subordinates, and by engineering faculty outside of the organization?

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<sup>18</sup>Herbert A. Shepard, "Engineers as Marginal Men," Journal of Engineering Education (March, 1957), pp. 536-542.

### Purpose of the Study

The main purpose of this study is to investigate the relationships among the perceptions engineering managers have of their role and their continuing education requirements, and among the expectations held for them by their immediate superiors, direct subordinates, and by engineering faculty outside of the organization.

More specifically, the study will:

1. Examine the relationships among the perceptions engineering managers have of their job functions and among the expectations held for them by their immediate superiors, direct subordinates, and by engineering faculty outside of the organization.
2. Examine the relationships among the perceptions engineering managers have of their continuing education activities, and among the expectations held for them by their immediate superiors, direct subordinates, and by engineering faculty outside of the organization.
3. Examine the relationships among the perceptions engineering managers have of their subject area needs, and among the expectations held for them by their immediate superiors, direct subordinates, and by engineering faculty outside of the organization.

### Hypotheses

Cursory discussions and interviews, along with a preliminary analysis of the literature, have given rise to the formulation of research hypotheses.

The general hypothesis of this study is that engineering managers, their immediate superiors, direct subordinates, and engineering faculty hold different expectations regarding the role of the engineering manager and his continuing education requirements.

### Importance of the Study

An underlying assumption of this study is that the continuing education needs of engineering managers can be more fully understood by ascertaining certain role expectations held for them. Thus, the significance of this analysis is to provide a better understanding of the rationale supporting the educational pursuits of the engineering manager.

In this study an attempt is made to provide more information and insight into areas of agreement and difference regarding the continuing education requirements that support the role of the modern engineering manager, under the assumption that more complete knowledge of the role would aid in decreasing role differences, if any, between the engineering manager and the related groups in the study.



The manner in which the engineering manager views his role obviously contributes to the manner in which he functions in his position. It is hoped that, in contributing to an understanding of the role of engineering managers, a contribution will be made to the solution of problems involved in raising the performance levels of engineers, particularly engineering managers.

Also, it is hoped that this study will lend insight to educators, management, professional societies, and engineers themselves as to the kinds of approaches and subject matter which might be of value to the development of continuing education programs for the modern engineering manager.

#### Limitations of the Study

This study is an attempt to investigate the relationship among the perceptions of the role of the engineering manager as perceived by members of the organizational hierarchy to which he belongs, and from an objective position outside of the organization. The central focus of the investigation concerns the continuing education activities and subject area needs supporting the role of the engineering manager and does not intend to encompass all of the possible sociological and psychological conflicts that may present themselves. There have been

numerous studies by Warner,<sup>19</sup> Henry,<sup>20</sup> Jennings,<sup>21</sup> Bass,<sup>22</sup> Kahn,<sup>23</sup> Argyris<sup>24</sup> and others referring to the psychodynamics of the executive role, i.e. his personality needs, anxieties, and the sociological structure from which he emerges.

Although the engineering manager interacts with many persons within and without the industrial organization, the sample for this study is limited to engineering managers, their immediate superiors and subordinates representing forty companies of various sizes located in Michigan and the surrounding Midwestern states. The companies represented are classified into manufacturing, public utility, and service categories. The engineering faculty sampled in the study include faculty members from the College of Engineering at Michigan State University.

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<sup>19</sup>W. Lloyd Warner and Norman H. Martin, Industrial Man (New York: Harper and Brothers, 1959).

<sup>20</sup>William E. Henry, "The Business Executive: The Psychodynamics of a Social Role," The American Journal of Sociology, Vol. 54, No. 4 (January, 1949), pp. 286-301.

<sup>21</sup>Eugene E. Jennings, The Executive in Crisis (East Lansing, Michigan: Michigan State University Press, 1965).

<sup>22</sup>Leonard M. Bass, Leadership, Psychology and Organizational Behavior (New York: Harper and Brothers, 1960).

<sup>23</sup>Kahn, et al., op. cit.

<sup>24</sup>Chris Argyris, Personality and Organization (New York: Harper and Brothers, 1957).

The items in Section I of the study questionnaire, related to the job functions of the engineering manager, were empirically explored and generated primarily to serve as criteria upon which to support the continuing education activities and subject area needs of the engineering manager. This was necessary since no appropriate job standard was available.

This study will not attempt to survey or evaluate continuing education programs in management development for engineers being conducted by the universities, industry, or the professional societies.

### Summary and Overview

In Chapter I, the introduction, the background for the study and the statement of the problem have been presented in some detail. The purpose of the study was outlined and the general hypotheses were stated. Indicated also were the importance of the study and its delimitations.

Chapter II provided a theoretical orientation for the study in which some central concepts of role theory are discussed, a theoretical model is structured and pertinent definitions are presented. In Chapter III the literature related to the study is reviewed. Chapter IV contains a detailed description of the methodology used in the study including a description of the pilot interviews and the formulation of the final questionnaire. Found in Chapter V

are the presentation and analysis of the data collected. The final chapter, Chapter VI, presents the summary, conclusions, recommendations, and implications of the study.

## CHAPTER II

### THEORETICAL ORIENTATION

#### Concepts of Role Theory

The general theoretical framework used in this study is role theory as conceptualized in the studies by Gross, Mason, and McEachern<sup>1</sup> and by Kahn et al.<sup>2</sup> Role theory, in its broadest sense, maintains that individuals occupy a number of roles, and the role perceptions that they hold for themselves, or the expectations which others define for them, are assigned on the basis of their position in a given social system.<sup>3</sup> That social system is treated here only with respect to the position occupied in the organization charts of the business organizations studied.

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<sup>1</sup>Neil Gross, Ward S. Mason, and Alexander W. McEachern, Explorations in Role Analysis, (New York: John Wiley and Sons, Inc., 1958).

<sup>2</sup>Robert L. Kahn, Donald M. Wolfe, Robert P. Quinn, J. D. Snoek, and Robert A. Rosenthal, Organizational Stress: Studies in Role Conflict and Ambiguity (New York: John Wiley and Sons, Inc., 1964).

<sup>3</sup>Gross, et al., loc. cit.

The central idea in the language of role analysis is the concept of role. Gross<sup>4</sup> formulated three categories into which the definitions of the concept "role" could be placed. The first, "the normative cultural pattern" category includes Linton's definition of role as representing the dynamic aspect of status. "When the individual puts the rights and duties which constitute the status into effect, he is performing a role."<sup>5</sup> A second category treats role as an individual's definition of his situation with reference to his and others' social positions. In the third or final category are included definitions which deal with role as the behavior of actors occupying social positions. Davis's definition of role falls in this category:

How an individual actually performs in a given position, as distinct from how he is supposed to perform, we call his role. The role, then, is the manner in which a person actually carries out the requirements of his position.<sup>6</sup>

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<sup>4</sup>Gross, et al., ibid, pp. 11-13.

<sup>5</sup>Ralph Linton, The Cultural Background of Personality (New York: D. Appleton-Century Co., 1945), p. 77; Ralph Linton, The Study of Man (New York: D. Appleton-Century Co., 1936), pp. 113-114.

<sup>6</sup>Kingsley Davis, Human Society (New York: The Macmillan Co., 1948), p. 90.

According to Brookover<sup>1</sup> and Gross,<sup>2</sup> there is probably more disagreement concerning this concept than there is for any other in role theory. Biddle and Thomas, in their review of role definitions, support this by stating:

The idea of role has been used to denote prescription, description, evaluation, and action; it has referred to covert and overt processes, to the behavior of the self and others, to the behavior an individual initiates versus that which is directed to him. Perhaps the most common definition is that role is the set of prescriptions defining what the behavior of a position member should be. But this much agreement is at best an oasis in a desert of diverging opinion.<sup>9</sup>

Biddle and Thomas go on to point out that a careful review of the definitions reveals, however, that there is one nearly universal common denominator, namely, that the concept pertains to the behavior of particular persons. Their preference is to define role in broader terms and thereby encompass the numerous and subtle ways in which persons may be associated with behaviors. They handle these relationships by developing a person--behavior matrix that deals with interface between persons and behavior.<sup>10</sup>

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<sup>7</sup>Wilbur Brookover and David Gottlieb, A Sociology of Education (New York: American Book Company, 1964), p. 323.

<sup>8</sup>Gross et al., op. cit., pp. 10-11.

<sup>9</sup>Bruce J. Biddle and Edwin J. Thomas, Role Theory: Concepts and Research (New York: John Wiley and Sons, Inc., 1966), p. 29.

<sup>10</sup>Ibid.

Newcomb<sup>11</sup> and Jacobson et al.,<sup>12</sup> chose to call actual behavior, "role behavior," and the perceptions that others share of the behavioral expectations of a particular person, "social role." Their concept of "personal role" focuses on what Argyris terms individual behavior.<sup>13</sup> Bakke and Argyris<sup>14</sup> defined role as the totality of formal tasks, informal tasks, and acts as organized by the individual. They described "formal task" as the formal behavior assigned by the organization, "informal task" as the informal behavior assigned by the work group, and "personal act" as the individual need--fulfilling, self-actualizing behavior.

Gross, Mason and McEachern, from their survey of the literature, conclude that three basic ideas appear in most of the conceptualizations considered, namely that ". . . individuals (1) in social locations (2) behave (3) with reference of expectations."<sup>15</sup> They go on to say that:

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<sup>11</sup>Theodore M. Newcomb, Social Psychology (New York: The Dryden Press, 1951).

<sup>12</sup>E. Jacobson, et al., (eds.), "Human Relations Research in Large Organizations," Journal of Social Issues, Vol. 7, No. 3 (1951), p. 19.

<sup>13</sup>Chris Argyris, Personality and Organization (New York: Harper and Brothers, 1957), p. 242.

<sup>14</sup>E. W. Bakke and C. Argyris, Organizational Structure and Dynamics (New Haven: Labor and Management Center, Yale University, 1955).

<sup>15</sup>Gross et al., op. cit., pp. 17-18.



People do not behave in a random manner. Their behavior is influenced to some extent by their own expectations and those of others in the group or society in which they are participants. . . . Regardless of their deviation, expectations are presumed by most role theorists to be an essential ingredient in any formula for predicting social behavior. Human conduct is in part a function of expectations.<sup>16</sup>

These same concepts are supported and extended by Kahn and his associates who believe:

Each person responds to the organization in terms of his perception of it. . . . He, too, has a conception of his office and a set of attitudes and beliefs about what he should and should not do while in that position. He has some awareness of what behavior will fulfill his responsibilities, lead to the accomplishment of the organizational objectives, or further his own interests. He may even have had a major part in determining the formal responsibilities of his office. Through a long process of socialization and formal training he has acquired a set of values and expectations about his own behavior and abilities.<sup>17</sup>

Other concepts characterizing role theory are those of consensus, conflict, and ambiguity.

Writers on role theory, like Biddle and Thomas,<sup>18</sup> have commonly defined the term "consensus" as the degree of agreement of individuals on a given topic and have restricted the concept to behaviors partitioned as prescription, evaluation, description or sanction. The reason is that ". . . consensus implies that one must

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<sup>16</sup>Gross, loc. cit.

<sup>17</sup>Kahn, et al., op. cit., p. 18.

<sup>18</sup>Biddle and Thomas, op. cit., p. 33.

agree or disagree about something, i.e., there is some object of agreement or disagreement indicated in the individual's behavior."<sup>19</sup>

The Gross group<sup>20</sup> views consensus in terms of the degree of agreement of expectations associated with positions while Etzioni<sup>21</sup> conceives of consensus as the differences and similarities in the orientations of two or more groups. Jacobson, Charters and Lieberman, in applying the concept of consensus to a study of complex organizations, state that:

Behavior can be predicted more accurately in an organization where consensus is highly developed than in one where it is relatively underdeveloped, even though formal organizational charts are identical.<sup>22</sup>

Thomas,<sup>23</sup> in his study of the Michigan State Department of Social Welfare compared the role conceptions, the degree of role consensus, and the quality of work of welfare workers in various organizational units of the state welfare department. In his study role consensus was

<sup>19</sup> Ibid.

<sup>20</sup> Gross, et al., op cit., p. 43.

<sup>21</sup> Amitai Etzioni, A Comparative Analysis of Complex Organizations (Glencoe, Ill.: The Free Press Inc., 1961), p. 128.

<sup>22</sup> Eugene Jacobson, W. W. Charters, Jr., and Seymour Lieberman, "The Use of the Role Concept in the Study of Complex Organizations," The Journal of Social Issues, Vol. 7, No. 3 (1951), pp. 18-20.

<sup>23</sup> Edwin J. Thomas, "Role Conceptions and Organizational Size," American Sociological Review, Vol. 18 (1953), pp. 30-37.

indicated by the degree of agreement between the public assistance worker and his supervisor about the importance of functions performed by workers. The amount of agreement was assumed to reflect the degree to which workers and supervisors shared a frame of reference regarding the importance of workers' functions. Eleven areas of knowledge and skill relevant to performance of the role of the public assistance worker were rated on a seven point scale by workers and supervisors, and discrepancy scores were computed.

By role conflict, Seeman<sup>24</sup> and Gross<sup>25</sup> mean the exposure of the individual to incompatible behavioral expectations in a given position. In some formulations of role conflict it is specified that the individual must occupy simultaneously two or more positions. Sarbin,<sup>26</sup> for example, sees role conflict occurring when a person occupies two or more positions simultaneously and when the role expectations of one are incompatible with the role expectations of the other. The role conflict analysis of

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<sup>24</sup>Melvin Seeman, "Role Conflict and Ambivalence in Leadership," American Sociological Review, Vol. 18 (1953), pp. 373-380.

<sup>25</sup>Gross, et al., op. cit., p. 246.

<sup>26</sup>Theodore S. Sarbin, "Role Theory," in G. Lindzey (Editor), Handbook of Social Psychology, Vol. I (Cambridge: Addison-Wesley Publishing Company, 1954), p. 228.

Getzels and Guba<sup>27</sup> concerning the incompatible expectations to which air force instructors were exposed and Burchard's study<sup>28</sup> of role conflicts of military chaplains are based on the assumption that the persons studied, simultaneously occupied multiple positions. In the air force study the subjects were faced with dilemmas stemming from their roles as instructors and officers. In the chaplain study the role conflict was between military officer and minister.

The study by Kahn et al.,<sup>29</sup> was based on the assumption that the quest for identity is a significant problem for many individuals, that this in combination with other needs leads them to look for certain kinds of satisfactions in the work situation, and that the work situation frequently presents conditions of conflict and ambiguity. Their research was designed to determine the prevalence of these conditions as well as their distribution in organizations and in the population at large. It was designed also to trace the effects of role conflict and ambiguity on the persons exposed to them.

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<sup>27</sup>J. W. Getzels and E. G. Guba, "Role, Role Conflict and Effectiveness, "American Sociological Review, Vol. 19 (1954), pp. 164-175.

<sup>28</sup>W. W. Burchard, "Role Conflicts in Military Chaplains," American Sociological Review, Vol. 19 (1954), pp. 528-535.

<sup>29</sup>Kahn, et al., op. cit.

The Kahn group sees role conflict occurring when members of the role set hold different role expectations toward the focal person and comments:

Much of role conflict, as we have defined it, can be thought of as a kind of inadequate role sending; lack of agreement or coordination among role senders produces a pattern of sent expectations which contains logical incompatibilities or which takes inadequate account of the needs and abilities of the focal person.<sup>30</sup>

A different pattern of inadequacy in role sending constitutes role ambiguity. Kahn defines it thus:

Role ambiguity is conceived as the degree to which required information is available to a given organizational position. To the extent that such information is communicated clearly and consistently to a focal person, it will tend to induce in him an experience of certainty with respect to his role requirements and his place in the organization. To the extent that such information is lacking, he will experience ambiguity.<sup>31</sup>

The use of the role concept in studying complex organizations is illustrated in studies of supervisory practices which have been conducted within the Human Relations Program of the Survey Research Center at the University of Michigan. Inquiries have produced evidence that the perceptions and expectations with respect to a supervisor's behavior are systematically related to productivity, to the facility of change in the behavior of supervisors, and

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<sup>30</sup> Ibid., p. 21.

<sup>31</sup> Ibid., pp. 25-26.

to the attitudes of those who work with them.<sup>32</sup> According to Newcomb, more application of role theory to the analysis of complex hierarchically structured organizations might promote further understanding of the functioning of these organizations and of the determinants of the effectiveness and satisfactions of the individual members. Analyses of standard role prescriptions, role behaviors and role relationships might also furnish fundamental data for predicting the attitudes, perceptions and behavior of the members of organizations, for understanding the success or failure of current organizational functioning, and for anticipating the responses in an organization to projected change programs.<sup>33</sup>

The present research is also a study in the organizational application of role theory. The writer has attempted to bring into a theoretical schema the organization, some of its members and the individual. The central concept in this attempt has been role expectations. In these terms this study is designed to ascertain the degree of role consensus between the engineering manager and those related groups who define his role.

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<sup>32</sup>Jacobson, et al., op. cit., pp. 18-20; W. W. Charters Jr., "A Study of the Role Conflict Among Foremen in a Heavy Industry," (unpublished Ph.D. Thesis, University of Michigan, 1952).

<sup>33</sup>Newcomb, op. cit.

### Theoretical Model

The hierarchic system model<sup>34</sup> symbolized in Figure 1 provides a framework for focusing on one position within the organization (engineering manager) and examining its relationship to various other positions within the organization (superior, subordinate) and outside of the organization (engineering faculty). It also provides for the relationships desired between certain other positions (superior-subordinate). Even though a large corporation may exhibit four or five levels of engineering management, this three-level relationship would still be represented: an engineering manager with a superior above him and a subordinate below him.

### Operational Definitions

For purposes of clarity, communication, and facilitation of analysis, the following definitions of concepts as employed in this study are presented:

#### A. Role Theory Definitions<sup>35</sup>

Position will refer to the social location of an incumbent in a social system.

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<sup>34</sup>Gross, et al., op. cit., p. 54.

<sup>35</sup>The primary sources for role theory definitions are: N. Gross, et al., op. cit., Chapter IV; R. Kahn, et al., op. cit.

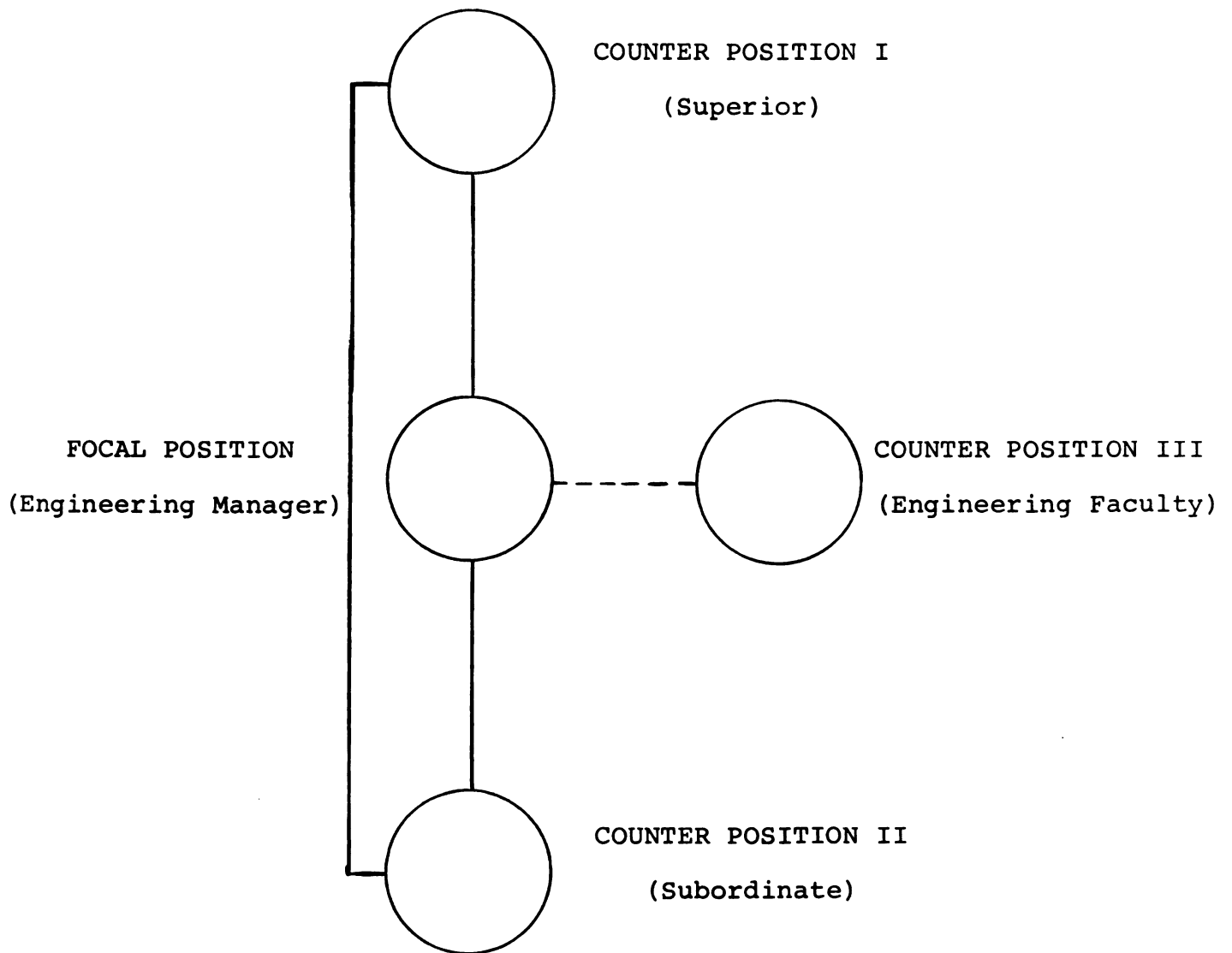


Figure 1. Hierarchic system model



Expectation will refer to an evaluative standard applied to an incumbent of a particular position; that is, how the incumbent should behave with reference to his position.

Role will refer to the set of expectations applied to an incumbent of a particular position.

Role Consensus will refer to the degree of similarity or agreement among role expectations held for an incumbent of a particular position.

Role Differences will refer to the degree of incompatibility among role expectations held for an incumbent of a particular position.

Role Ambiguity will refer to the degree of uncertainty among role expectations for an incumbent of a particular position.

#### B. Other Related Definitions

Engineer will refer to a person having completed a Bachelor of Science degree in engineering from an accredited college of engineering.<sup>36</sup>

Engineering Management is intended to be roughly descriptive of the management of technical matters, merely as contrasted with such other areas of management as financial, sales, personnel, etcetera.<sup>37</sup>

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<sup>36</sup>Samuel S. Dubin and LeRoy H. Marlow, Research Report of Continuing Professional Education for Engineers in Pennsylvania, Pennsylvania State University (1965), p.11.

<sup>37</sup>Cecil E. Combs, "Decision Theory and Engineering

Immediate Superior of the engineering manager will refer to the executive to whom the engineering manager reports directly; a manager of engineering managers.

Engineering Manager will refer to an engineer in a managerial position at the first line of engineering management in charge of an engineering activity, such as a department or unit, and/or responsible for directing the work of engineers or scientific personnel.<sup>38</sup>

Subordinate will refer to an engineer at the operative level reporting directly to the engineering manager.

Engineering Faculty will refer to a full-time faculty member of the Michigan State University College of Engineering.

Continuing Education will refer to the education (knowledge and skills) needed by the professional engineering manager to enhance his total competence in performing his job. This definition emerges from a review of the literature<sup>39</sup> and empirical interviews with engineering personnel currently practicing in industry.

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Management," IRE Transactions on Engineering Management, Vol. 9, No. 4 (December, 1962), pp. 149-154.

<sup>38</sup>Dalton E. McFarland, Management Principles and Practices (New York: The Macmillan Company, 1962), p. 195; Keith Davis, Human Relations at Work (New York: McGraw-Hill Book Co., Inc., 2nd Edition, 1962), p. 195.

<sup>39</sup>A. C. Ingersoll, "A Sampling of Industrially Sponsored Programs in Continuing Education," Proceedings--American Society for Engineering Education Annual Meeting, Orono, Maine (June, 1964).

### Summary

In this chapter the general theoretical framework for the study was presented. Various interpretations of the concept of role were offered with the general conclusion that individuals in social locations behave with reference to expectations held for them. Other concepts such as consensus, conflict and ambiguity were discussed and a theoretical systems model was structured to provide a framework for focusing on one position and examining its relationship to various counter positions. Finally some operational definitions pertinent to the study were provided.

## CHAPTER III

### REVIEW OF THE LITERATURE AND RESEARCH

#### Introduction

In Chapter II, literature concerning role theory and research related to role analysis were reviewed in terms of providing background and rationale for the theoretical framework used in this research study.

The objective of this chapter is to survey selected literature and research related to engineering management. The primary focus for this review will center around the role of the engineering manager and on the continuing education needs and activities that support the role of the engineering manager. In addition, other important data pertinent to this research study will be reviewed.

#### Engineers in Management

Three decades ago, greater emphasis was placed on the art of management rather than on its scientific aspects. Since that time science and engineering have advanced at a tremendous pace, and management has had to become more science oriented. In view of this, government, industry,

and business in general have become more and more dependent on scientific and engineering techniques. It is not surprising, therefore, that engineers should be called upon for the administration and management of large organizations of all kinds.<sup>1</sup>

Historian John B. Rae of Massachusetts Institute of Technology states that " . . . the proper place of the engineer in the management of business is a question which has grown in the last few years from being merely important to being highly critical."<sup>2</sup> He points out that American industry today is faced with two acute shortages of talent; the highly publicized shortage of engineers and a less well-known but equally serious shortage of good executives. "To put engineers into management," Rae comments "is both a proper and a necessary use of engineering talent, made so by the nature of modern industry."<sup>3</sup>

C. E. Gray cites three primary factors which contributed to the rapid increase in the number of engineers in management: (1) the increasing complexity of technology; (2) the rapid growth of science and its immediate application

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<sup>1</sup>Harry Rubey and John Logan, The Engineer and Professional Management (Columbia, Missouri: Artcraft Press, 1963), preface.

<sup>2</sup>John B. Rae, "The Engineer as Manager," Journal of Engineering Education, Vol. 48, No. 1 (October, 1957), p. 25.

<sup>3</sup>Loc. cit., p. 26.

in industry; and (3) the diversifications of product lines.<sup>4</sup>

Alfred P. Sloan, outstanding engineer-administrator and past board chairman of General Motors, supported the need for the engineer in management and stated:

We need the engineer's point of view, his respect for basic facts, his analytical frame of mind, his imagination and his contact with the interpretation and control of physical forces. . . . It is logical that the engineer, in exercising his expanded responsibility, should recognize, as indeed he has, that there is more in business than business itself. . . .<sup>5</sup>

As early as 1924 there was a great demand for engineers in administrative positions, as reported in a survey of 5,000 engineering graduates conducted by the Society for the Promotion of Engineering Education.<sup>6</sup> The drift of engineers from purely technical to administrative duties was shown in even greater proportions in the 1931 survey by the American Society of Mechanical Engineers. This study showed that by forty years of age three-fifths of the engineering graduates surveyed were in management positions. Among those engineers in management positions,

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<sup>4</sup>C. E. Gray, "The Transition from Engineer to Manager," Journal of Industrial Engineering, Vol. 14, No. 1 (January-February, 1963), pp. 28-32.

<sup>5</sup>Alfred P. Sloan, "The Engineer's Place in the Future," Dun's Review and Modern Industry, Vol. 64 (December, 1954), p. 16.

<sup>6</sup>W. E. Wickenden and Elliot D. Smith, "Engineers, Managers and Engineering Education," Mechanical Engineering, Vol. 54, No. 7 (August, 1932), p. 541.

there was a secondary drift from positions in technical management to general management.<sup>7</sup>

Also in the late 1920's, the Society for the Promotion of Engineering Education came to the conclusion that the subject of engineers in management was becoming so important that it appointed a Committee on Instruction in Industrial Relations, headed by E. D. Smith, to make an extensive analysis of the possibilities, aims and methods of teaching engineering students to manage men.<sup>8</sup>

In 1947, a comprehensive study by the Engineers Joint Council revealed that 34 percent of some 38,000 members of six national engineering societies were engaged in work primarily administrative in nature.<sup>9</sup> Rae's study in 1955 of the careers of M.I.T. alumni over the previous forty years showed that almost 50 percent had gone into business roles other than that of the professional engineer. Most of the movement was into managerial positions, with the records showing at least one in five of M.I.T.'s engineering graduates in some kind of managerial role, with the ratio approaching one in two as they advanced in their careers.<sup>10</sup>

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<sup>7</sup>  
Ibid.

<sup>8</sup> Elliot D. Smith, "Can the Engineer Be Taught to Manage Men?," Journal of Engineering Education, Vol. 21, No. 2 (October, 1930), pp. 98-128.

<sup>9</sup> The Engineering Profession in Transition (Engineers' Joint Council Report, 1947).

<sup>10</sup> John B. Rae, "Engineering Education as Preparation for Management: A Study of M.I.T. Alumni," The Business History Review, Vol. 29 (March, 1955), p. 71.

In 1956, a survey by Fortune magazine of the executives in 250 of the largest industrial companies in the United States indicated that nearly 50 percent of all the executives had concentrated on engineering and science, but only a third of them rose to their present eminence through these or related fields of work.<sup>11</sup>

A study of 200 top companies by Dun's Review and Modern Industry in 1961 showed 17 percent of the chief executives were trained in engineering or had moved into that office through the engineering function.<sup>12</sup> These studies, among others, give some indication of the rapid increase in the number of professional managers with engineering training and experience.

In 1959, an extensive research survey on career opportunities and satisfactions of professional engineers in industry was conducted by the Opinion Research Corporation for the Professional Engineers Conference Board for Industry. This survey revealed that the idea of going into management is the route to success is very prominent in the engineer's thinking. Eighty-five percent of approximately 300 professional engineers from eleven companies responded that they thought, in terms of prestige within the company,

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<sup>11</sup>Editors of Fortune, The Executive Life (New York: Doubleday and Company, Inc., 1956), p. 37.

<sup>12</sup>M. Mandell, "How to Make the Top," Dun's Review and Modern Industry, Vol. 78, No. 4 (October, 1961), pp. 46-47.



engineers would be in a better position in five years by going into management rather than by remaining in engineering. Some of the attractions of management are that both the financial and non-financial rewards are more evident. Success in the purely technical world offers no comparable marks of recognition or status.<sup>13</sup>

George Odiorne directed a study for the American Management Association of some 100 senior engineers in an eastern engineering school. Among other questions, the seniors were asked, "Do you expect, eventually, to become an executive?"--to which about 80 percent responded that they did. Odiorne claims that even assuming that many students are thinking of technical administration rather than general management positions, the indications are that engineering students have a decided inclination toward management.<sup>14</sup>

Lee E. Danielson<sup>15</sup> and Howard L. Richardson<sup>16</sup> studied the characteristics of engineers and scientists.

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<sup>13</sup>Career Satisfactions of Professional Engineers in Industry (Washington, D. C.: The Professional Engineers Conference Board for Industry, 1959), pp. 47-48.

<sup>14</sup>George S. Odiorne, "Making Managers Out of Engineers," Personnel, Vol. 33, No. 3 (November, 1956), p. 259.

<sup>15</sup>Lee E. Danielson, Characteristics of Engineers and Scientists, Report No. 11, Bureau of Industrial Relations (Ann Arbor, Michigan: The University of Michigan, 1960).

<sup>16</sup>Howard L. Richardson, "Management and Engineering - Professions of Progress," IRE Transactions on Engineering Management, Vol. 4, No. 1 (March, 1957), p. 71.

Danielson is of the opinion that many follow engineering programs only so that they will be more employable. Once employed, many engineers seek to move out of the technical areas and into more lucrative areas such as management and sales. Richardson claims that to be a good manager, a man must want to be a good manager and must go into a managerial position with a real interest in it.

Raudsepp suggests the following as reasons for this movement into management:

1. A managerial or administrative position gives the engineer a greater sense of power, in that he will be able to exert more influence and control over organizational objectives and subordinates.

2. Many engineers feel that the levels of authority and responsibility in the administrative areas are better defined.

3. Engineers also feel that ability and performance in management positions are valued and rewarded better than outstanding skill in a technical area.<sup>17</sup>

Some interesting research undertaken by Becker and Carper studied the elements of identification engineers have with their occupations. They found that engineers take great pride in their occupational titles and find the field desirable because of the skills and abilities engineering training is supposed to produce in them. They are quite ready, however, to forget the specific kinds of work for

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<sup>17</sup>Eugene V. Raudsepp, Managing Creative Scientists and Engineers (New York: The Macmillan Company, 1964) p. 182.

which they are trained and take on any kind of job which the title of engineer can win for them, such as a position in higher management. Fifty percent of those surveyed indicated that they felt confident that they could compete successfully for any position, technical or managerial.<sup>18</sup> This over-confident attitude may not be entirely justified. Robert Best concludes from his study of 622 engineers and scientists in six large companies, that many engineers and scientists seek out a business career without any real understanding of what business is all about.<sup>19</sup>

Herbert Shepard, in writing about social change in science and engineering, explains that we have become thoroughly accustomed to engineers holding highly respected positions in the power structure of our society. Many present-day top executives were trained as engineers. The business career is not as "normal" a career for a scientist, however, as it is for an engineer.<sup>20</sup> Studies by Marcson<sup>21</sup>

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<sup>18</sup>H. S. Becker and J. Carper, "The Elements of Identification With an Occupation," American Sociological Review, Vol. 21, No. 3 (June, 1956), pp. 341-348.

<sup>19</sup>Robert D. Best, "The Scientific Mind vs. the Managerial Mind," Industrial Research, Vol. 5, No. 9 (October, 1963), pp. 50-52.

<sup>20</sup>Herbert A. Shepard, "Social Change in Science and Engineering," IEEE Transactions on Engineering Management, Vol. 8, No. 1 (March, 1961), pp. 11-14.

<sup>21</sup>Simon Marcson, The Scientist in American Industry, Research Report No. 99, Industrial Relations Section (Princeton, New Jersey: Princeton University, 1960), p. 65.

and Best<sup>22</sup> also point out that engineers aspire in greater numbers to the management career than do scientists, who consider the management career as the last resort.

From interviews with executive, supervisory, and non-supervisory professional personnel in firms with extensive research organizations, Danielson, at the University of Michigan, found that today's engineers and scientists are equally concerned with personal advancement, recognition, and financial reward for their efforts. Danielson believes that companies should open up new routes, other than the managerial one, for the advancement of professional personnel and that engineering managers should be rewarded for developing their subordinates.<sup>23</sup>

In a national study on engineer attitudes, Raudsepp found that nearly 80 percent of the more than 3,000 respondents felt that more opportunity for recognition, advancement and prestige lay outside technical specialization and that, in comparison to management, technical professionals have little or no status. He commented:

The engineer's need for status and prestige has become an increasingly important factor in job satisfaction. Since status and prestige are perceived by many

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<sup>22</sup>R. D. Best, "The Conflict Between the Scientific Mind and the Management Mind," The Public Opinion Index for Industry, Vol. 17, No. 9 (September, 1959), p. 8.

<sup>23</sup>Danielson, op. cit., p. 28.

as unrealizable in the engineering profession, the tendency to regard management as the really attractive career alternative has assumed major proportions.<sup>24</sup>

Raudsepp warns of the serious repercussions that could occur if the exodus of engineers to management ranks continues unchecked, irrespective of the presence or absence of requisite administrative skills. He cites such repercussions as: (1) the depletion of valuable technical manpower; (2) the reduction of the effectiveness and utilization of engineers; and (3) the consequences of losing outstanding technical men and gaining poor managers.<sup>25</sup>

### Engineers as Managers

A limited amount of literature and research exists on the subject of engineers as managers. Much of what is available appears to center around the difficulties engineers have in the transition from engineer to manager and on the problems they face in adjusting to and performing in their dual role as engineer-manager.

Karger and Murdick devote a chapter of their book, Managing Engineering Research, to the transition from engineer to manager. They discuss the manager's need for a systematic approach in establishing a new engineering

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<sup>24</sup>Raudsepp, op. cit., p. 180; See also Eugene V. Raudsepp, A National Survey on Engineer Attitudes (Deutsch and Shea, Inc., July, 1958).

<sup>25</sup>Ibid., p. 183.

component or taking over a going organization. The authors point out some of the pressures the engineering manager often finds in this transition:

1. The generalities of management textbooks to plan, organize, initiate, control, and measure aren't specific enough for the time and knowledge he has available.

2. His previous experience is too narrow and his management techniques are too weak.

3. Daily operations and longer range plans are pressing in upon him with increasing intensity.<sup>26</sup>

Bailey and Jensen, in their study of managers at all levels in two large research and development organizations, claim that neither the engineer himself, nor those who are responsible for directing him up the managerial ladder, understand the particular stresses of this transition. Among the managers interviewed, it was generally agreed that a crucial change takes place at the second level of supervision or first line of management. Here the manager is no longer responsible for technical details, but must spend more and more of his time in coordinating the efforts of others under his direction. The interviews uncovered several reasons why this transition is so difficult for the technical man. These are summarized as follows:

1. The specialist must now make a definite commitment to management and in doing so move away from the work at which he has been successful.

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<sup>26</sup>D. W. Karger and R. G. Murdick, Managing Engineering and Research (New York: The Industrial Press, 1963), pp. 650-663.

2. The manager fears the loss of the direct control he formerly exercised over his work.

3. When it comes to coping with human nature, the engineer finds few rules and theorems to fall back on.

4. The technical manager has little or no time to spend on the things he really enjoys doing. He is expected to devote himself to activities that until now have ranked low in his scale of values--the skills of management.<sup>27</sup>

Watson,<sup>28</sup> McCormick<sup>29</sup> and Johnson<sup>30</sup> believe that the engineer-trained mind is an excellent basis for the role of manager, and that engineers have a natural advantage in working toward higher management positions. They learn to gather facts, arrange and analyze them logically, and to base their decisions and judgments on their conclusions. Yet despite this advantage, many engineers find it difficult to step into management jobs.

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<sup>27</sup>Robert E. Bailey and Barry T. Jensen, "The Troublesome Transition from Scientist to Manager," Personnel, Vol. 42, No. 5 (September-October, 1965), pp. 49-55.

<sup>28</sup>Douglas Watson, "Engineers Can Be Managers," IRE Transactions on Engineering Management, Vol. 2 (November, 1954), pp. 28-40.

<sup>29</sup>Brooks McCormick, "Management and the Industrial Engineer," The Journal of Industrial Engineering, Vol. 8, No. 1 (January-February, 1957), pp. 20-22.

<sup>30</sup>Howard W. Johnson, "Developing Engineers for Management Responsibility," Personnel, Vol. 35, No. 2 (September-October, 1958), pp. 66-71.

William Given Jr.<sup>31</sup> and C. E. Gray<sup>32</sup> attribute the difficulty in adjustment to the management role to problems engineering managers have in dealing with intangibles such as human-relations, decision-making, the lack of team orientation, the perfectionist attitude, and the reluctance to accept conclusions and recommendations from others. Gray lists some factors which contribute toward these unique problems of the engineering manager:

1. the rigid adherence to the scientific approach in engineering training, failing to give an appreciation and understanding of other disciplines;
2. the tendency among engineering administration to select managers primarily on the basis of their technical skills;
3. the lack of identification of the technically trained manager with the management profession, thus failing to motivate him to improve his managerial competence; and
4. the failure to develop an over-all business perspective and an appreciation of the interrelationship of the various business functions.<sup>33</sup>

Eugene Jennings, who specializes in adjustment problems of executives in a corporate environment, studies in The Executive in Crisis, movement within the ranks of the

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<sup>31</sup>William B. Given Jr., "The Engineer Goes Into Management," Harvard Business Review, Vol. 33, No. 1 (January-February, 1955), p. 44.

<sup>32</sup>C. E. Gray, "The Transition from Engineer to Manager," Journal of Industrial Engineering, Vol. 14, No. 1 (January-February, 1963), pp. 28-32.

<sup>33</sup>Loc. cit., pp. 30-31.



corporate hierarchy. According to Jennings, whenever there is a separation and a new attachment, there is a degree of anxiety which is most likely to occur at three basic points:

1. First is the anxiety of entrance into the firm which usually ensues from having to make a separation from college life. The attachment to the firm is generally made in a technical sense. This entrance phase, lasting about five years, usually places the individual in a formal or informal training program.

2. The second point is anxiety of movement into the middle rank, which requires dropping the technical attachments and acquiring managerial ones. Since the middle ranks are initially managerial, the technical skills remain with subordinates. The manager is required to know how to direct them to accomplish departmental and sectional goals. Accountants, salesmen, engineers, and scientists too often want to keep their technical expertise, and become anxious at making the required separations and attachments.

3. The third point of anxiety involves meeting the requirements of administration as opposed to management. Here the operating orientation of the middle and upper-middle manager must be left behind and the strategical, evaluative, long-range concerns of administration must be acquired. This separation from the management orientation and attachment to the administrative orientation proves difficult for many.<sup>34</sup>

The engineer-manager role conflict was studied by Gray<sup>35</sup> and by Elliott,<sup>36</sup> both of whom concur that most engineering manager positions are dual in nature in that the manager is expected to make some technical contributions

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<sup>34</sup>Eugene E. Jennings, The Executive in Crisis (East Lansing, Michigan: Michigan State University Press, 1965), pp. 69-70.

<sup>35</sup>Gray, op. cit., p. 29.

<sup>36</sup>Herbert M. Elliott, "The Transition from Engineer to Supervisor," IRE Transactions on Engineering Management, Vol. 5, No. 1 (March, 1958), pp. 29-32.

in addition to his several managerial responsibilities. However, the degree of this direct engineering effort, they believe, should be greater at the first level of supervision--where the supervisor is frequently expected to perform functional work along with others in his group--and, generally should decrease with progress up the manager hierarchy.

This was supported further in the findings of the study, Role Concept of Engineering Managers, conducted by Simon Marcson, at Princeton University.<sup>37</sup> Marcson studied over 600 engineering managers in a large electronics and engineering company. He was concerned with three major problems: (1) an analysis of the needs of engineering supervisors in terms of managerial skills and the difficulties which face engineering management; (2) a determination of the motivations of engineering supervisors; and (3) a study of the degree to which the engineering supervisor is involved in decision-making, integrated into the company, and communicated with through information programs.

Marcson found distinct differences in role concept between managerial levels, suggesting that they constitute significantly different strata in the engineering organization. Members of the highest management level tended to see

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<sup>37</sup> Simon Marcson, "Role Concept of Engineering Managers," IRE Transactions on Engineering Management, Vol. 7 (March, 1960), pp. 30-33.

themselves as business executives, further removed from a professional orientation and more identified with a company orientation. The lower the management level, the more they saw themselves as involved in the skills of planning and directing the technical program of engineers. The lowest management level had a stronger professional orientation than the middle level and saw itself as primarily involved in a technical and engineering type of job.<sup>38</sup>

Commenting on this same point, Karger and Murdick state:

There are those who bear the title of "Manager" who still claim to be doing engineering work; nevertheless, there is ample evidence provided by engineering leaders as well as management analysts to show that a manager who is doing his job correctly does little or no engineering work himself.<sup>39</sup>

A. F. Coleman sets forth some broad responsibilities of the engineering manager in describing his role. Although the responsibility of engineering management is to provide the necessary technical counsel and to help guide the company toward sound solutions to business problems, the main responsibility of the engineering manager, according to Coleman, is the day-to-day management of the engineering group under his direction. He also has a responsibility to work with other departments of his company on problems

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<sup>38</sup>Loc. cit., p. 32.

<sup>39</sup>Karger and Murdick, op. cit., p. 652.

related to engineering. Finally, the engineering manager has the responsibility, to his men and to the company, of taking the initiative in the matter of developing his personnel and providing the guidance they require.<sup>40</sup>

William Crissy believes that a manager in his work environment has many roles to play. The directions in which he strives will be in those that support the roles that are important to him. According to Crissy, we need to study the incentives necessary to motivate him in these directions. If we can enhance this motivation, then we will have a more purposeful manager.<sup>41</sup>

In his article, "Management and the Engineer," General T. C. Rives quotes Ralph C. Cordiner, former president of the General Electric Company, who commented on the responsibilities of a manager as follows:

. . . he is essentially a long-range thinker, a planner, an organizer and a teacher, rather than solely a "doer". . . . The manager makes his best progress through his ability to supply leadership to others, rather than by continued specific personal contributions to the growth or development of scientific knowledge in some particular sphere. . . .

While the manager increasingly, therefore, needs to understand the processes of science, of research and of technical analysis, to uncover and use better facts, his great contribution comes through his capacity to influence, guide and multiply the voluntary

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<sup>40</sup>A. F. Coleman, "The Responsibility of Engineering Management," IRE Transactions on Engineering Management, Vol. 2 (November, 1954), pp. 48-51.

<sup>41</sup>William J. E. Crissy, Paper presented at the Summer School for Executives conference, Michigan State University, East Lansing, Michigan, August, 1966.

work and achievements of his fellow workers in the business.<sup>42</sup>

Rives, on the other hand, sees the engineering manager as an "artist," having the imagination to visualize what his objective is, why it is the best objective and when, where, and with whom he can accomplish it with the least expenditure of manpower and funds.<sup>43</sup>

The importance of role adaptability of the engineering manager in level, function, and interest, in his relations with others, has been stressed by several researchers.<sup>44</sup> They see him as a generalist, rather than a technical specialist, whose job is to integrate the resources of the organization--technical and human, financial and material--in such a way as to achieve its goals. He does this by taking responsibility for setting objectives, complete with a plan and a timetable to meet them; organizing the resources available to him to achieve these goals, including direction and control; and finally, by evaluating his progress.<sup>45</sup>

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<sup>42</sup>T. C. Rives, "Management and the Engineer," IRE Transactions on Engineering Management, Vol. 1 (February, 1954), p. 5.

<sup>43</sup>Ibid., p. 6.

<sup>44</sup>Paul O. Gaddis, "The Project Manager-His Role in Advanced Technology Industry," Westinghouse Engineer, Vol. 19 (July, 1959), pp. 102-106; K. Davis, "The Role of Project Management in Scientific Manufacturing," IRE Transactions on Engineering Management, Vol. 9, No. 3 (September, 1962), pp. 109-113.

<sup>45</sup>H. Johnson, op. cit., p. 67.

The question has been raised as to whether or not a system of education designed to produce successful professional engineers can produce equally successful and satisfied managers. Sociologist N. Z. Medalia submits that perhaps it is the confusion of goals in engineering education itself, with the resultant conflict which this sets up in the mind of the engineer as to what constitutes success for him, that accounts at least partially for the dissatisfaction that many engineers seem to express in their work situation.<sup>46</sup>

Along these same lines, Dale Walton is of the opinion that engineering managers, as a group, find habit and personality clashing with their managerial roles. He claims that in asking engineers to take management positions, we are asking them to take on a job for which they typically have no formal education, very little training, and sometimes a complete lack of interest. According to Walton, this conflict, although found in other professional groups whose members are called upon to assume the manager's role, seems particularly troublesome in the engineering profession.<sup>47</sup>

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<sup>46</sup>Nahum Z. Medalia, "Professional and Managerial Goals in Engineering Education: A Sociologist's Comments," Journal of Engineering Education, Vol. 49, No. 3 (December, 1958), pp. 237-240.

<sup>47</sup>Dale G. Watson, "Engineering Managers--Do You Understand Their Role?" Advanced Management, Vol. 26 (May, 1961), p. 9.

The feeling is also held that technically trained managers have trouble in developing a real appreciation of managerial functions and reaching an understanding with the higher managerial levels as to the results they are expected to achieve.<sup>48</sup> Some recent research conducted by Keith Davis studied the program manager's<sup>49</sup> understanding of his management role as compared with his superior's and his subordinates' understanding of it.<sup>50</sup> The study focuses on the degree to which the program manager's job is seen as causing him to give priority to certain managerial tasks and points of view. These priorities constitute the program manager's view of his managerial role; or when these priorities are seen by others, they constitute an external view of the way the program manager tries to perform his role.

Seven dimensions of the program manager's role were selected for analysis by Davis as follows:

1. Occupational orientation
2. Organizational orientation
3. Functional orientation

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<sup>48</sup>Gray, op. cit., p. 29.

<sup>49</sup>A program manager refers to an engineering manager in charge of a special program within an engineering activity.

<sup>50</sup>Keith Davis, "Mutuality in Understanding of the Program Manager's Management Role," IEEE Transactions on Engineering Management, Vol. 12, No. 4 (December, 1965), pp. 117-122.

4. Leadership style
5. Supervisory orientation
6. Functional tasks
7. Operational tasks

Davis found the data, from some 144 respondents in two electronics companies, showing a remarkable congruence in the understanding of the program manager's job. With regard to functional orientation, all groups agreed that program managers are more managerial than technical in orientation. Program managers apparently see their jobs as primarily managerial, while a significant portion of the others still look to them for technical leadership as well.<sup>51</sup>

Rubin, Stedry and Willits, in a slightly different setting, studied role expectations of 29 department managers and 57 supervisors in research and development. They found that the managers wanted a greater technical contribution from lower supervisors than the supervisors realized. The supervisors, on the other hand, thought their superiors wanted greater managerial contributions. With regard to contributing their personal skills to technical work, over 60 percent of the supervisors under-estimated the expectations of their department managers by 10 percent or more in time allocation to technical work.<sup>52</sup>

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<sup>51</sup>Ibid., p. 120.

<sup>52</sup>I. M. Rubin, A. C. Stedry, and R. D. Willits, "Effort Allocation by Research and Development Managers,"



According to Davis, it appears that program management and research and development supervision offers an ambiguous role to scientists and engineers. Because of unclear guidelines, they have difficulty apportioning technical and managerial duties, and they are not sure of the expectations of their superiors in this matter. "Difficulties may tend to build up," says Davis, "unless this ambiguity is reduced by means of frequent communications, better job design, and clear job assignments."<sup>53</sup>

Other studies of the role of management in an engineering organization have examined the manager's style of leadership and his ability to influence the course of departmental affairs,<sup>54</sup> classified activities performed by engineering management staff at the corporate, division, and production levels,<sup>55</sup> and have explored the major problems confronting the research and development engineer who is manager and leader of a project.<sup>56</sup>

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Research paper, Alfred P. Sloan School of Management, Massachusetts Institute of Technology, Cambridge, Massachusetts, 1964, p. 20.

<sup>53</sup>Davis, op. cit., p. 120.

<sup>54</sup>Raymond R. Ritti, "Engineers and Managers: A Study of Engineering Organization" (unpublished PhD Thesis, Cornell University, 1960).

<sup>55</sup>H. H. Fite, "The Role of the Management Engineering Staff at the Corporate Level," Advanced Management, Vol. 23, No. 10 (October, 1958), pp. 14-17.

<sup>56</sup>Thomas Moranian, The Research and Development Engineer as Manager (New York: Holt, Rinehart and Winston, 1963).

Professor R. C. Heimer maintains that engineers oftentimes shun management positions, since they are not accustomed to management's method of thinking, which involves the profit motive. In his book, Management for Engineers, Heimer directs the attention of the engineer to the profit motive, the costs of production as the principal determinants of profits, the organization of the industrial enterprise, and the place of the engineering manager in the decision-making apparatus of the enterprise as the costs are determined.<sup>57</sup>

With the aim of shedding some light on the question of what technical managers are like, Krugman and Edgerton<sup>58</sup> made a comprehensive study of thirty-three top technical managers of a large chemical corporation. The managers studied ranged in rank from project engineer up to general manager. For purposes of comparison, twenty-one non-technical managers of equivalent rank within the same divisions were studied. Each subject of the two groups was given an "executive appraisal" which included a personal history record, personal data blank, depth interviews with a trained psychologist and a battery of psychological tests

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<sup>57</sup>Roger C. Heimer, Management for Engineers (New York: McGraw-Hill Book Company, Inc., 1958).

<sup>58</sup>Herbert E. Krugman and Harold A. Edgerton, "Profiles of a Scientist-Manager," Personnel, Vol. 36, No. 5 (September-October, 1959), pp. 38-49.

covering such areas as: (1) intellectual functioning; (2) relations with others; (3) work characteristics; (4) aspirations and drive; (5) interests and values; and (6) personal adjustment.

According to the authors, there was basically nothing in the findings which ran counter to the results of earlier research. Technical managers are still more like pure engineers and scientists than they are like the non-technical group. One finding, which may be of interest here, however, was the psychologist's assessment of each subject's single major value on the job. The technical managers were more concerned with professional achievement and growth, while the non-technical managers were more concerned about security, money and position.

Harry Rubey and John Logan allot the first two chapters of their recent book, The Engineer and Professional Management, to the importance of engineers understanding the inter-relationships between engineering and management so that they can:

1. Think from a broad rather than a narrow, specialist's point of view, and have a sympathetic understanding of management and its objectives.
2. Work intelligently with the non-engineering departments.
3. Use engineering methods more effectively for the solution of non-engineering problems.

4. Plan to assume a greater role in management and administration.<sup>59</sup>

Another recent contribution to the literature on engineering management is Val Cronstedt's book, Engineering Management and Administration.<sup>60</sup> This book, written for engineers with little or no previous administrative experience, pulls together all those business matters affecting the engineering department of an organization, that the manager must know. It supplies solutions to many of the problems confronting the administrator, describes administrative methods, and presents procedures for making engineering changes. The author also shows the advantages of separating administrative duties from the technical personnel, and describes the manager's role in terms of his responsibilities both to the general management and to the engineering department.

Continuing Education  
for Engineering Managers

During the last few years, the volume of literature and research on continuing education for engineers has been steadily increasing. Along with this, some of the recent

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<sup>59</sup>Rubey and Logan, op. cit., pp. 5-6.

<sup>60</sup>Val Cronstedt, Engineering Management and Administration (New York: McGraw-Hill Book Company, Inc., 1961).

major research studies and surveys on engineering education conducted by the Societies, industries, and the universities have also given attention to the continuing education aspects of engineering education.<sup>61</sup> Even though much of the available literature and research focuses primarily on continuing education for practicing engineers, a significant amount of interest seems to be developing in the area of continuing education for the engineering manager.<sup>62</sup>

Recent studies, notably those under the auspices of the President's Science Advisory Committee, have stressed the importance of continuing education of scientists and engineers at all levels.<sup>63</sup> In 1961 President John F. Kennedy approved the undertaking of a study to examine the utilization of scientists and engineers in the United States, together with a review of requirements for the development of

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<sup>61</sup>Goals of Engineering Education - The Preliminary Report (Lafayette, Indiana: American Society of Engineering Education, October, 1965); An Engineering Master Plan Study for the University of California (Berkeley, California: University of California Engineering Advisory Council, September 1, 1965).

<sup>62</sup>Continuing Engineering Studies, Report of the Joint Advisory Committee (ECPD, EJC, ASEE, NSPE, 1965); W. L. Everitt, et al., "A Symposium on Continuing Education," IEEE Spectrum (June, 1965), pp. 112-122; W. W. McCallum, "Educating Industrial Managers for Tomorrow," Journal of Engineering Education, Vol. 47, No. 5 (January, 1957), pp. 450-455.

<sup>63</sup>Education for the Age of Science (Washington, D.C.: President's Science Advisory Committee, 1959); Meeting Manpower Needs in Science and Technology: Graduate Training in Engineering, Mathematics and Physical Sciences (Washington, D. C.: President's Advisory Committee, 1962).

scientists and engineers by 1970. In the study, which was released in 1964, the Committee on Utilization of Scientific and Engineering Manpower cited the unmistakable shortages of manpower in the advanced technologies of new engineering systems, and of scientists and engineers with technical and administrative skills required for the effective management of large scientific and technological undertakings.<sup>64</sup>

The Committee recommended that industry, government and the universities all share in the responsibility to train and develop more managers who can combine thorough understanding of the technology they manage with mastery of the art of leadership. The report stated that " . . . the nation needs more managers who understand the interdependence of technical and managerial decisions, and who are equipped to appreciate the technical as well as the managerial issues. . . ."<sup>65</sup>

The nature of some of the problems of transition, role adaptability and adjustment mentioned earlier in this chapter that confront the engineer who moves into engineering management, would seem to suggest that the continuing education requirements necessary to support the role

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<sup>64</sup>Toward Better Utilization of Scientific and Engineering Talent: A Program for Action (Washington, D.C.: National Academy of Sciences, 1964), p. 10.

<sup>65</sup>Ibid., p. 26.

of the engineering manager center around managerial knowledge and skills. This tends to be supported in the literature by the numerous articles directed to "continuing management education" or management development for engineering managers.<sup>66</sup>

It has been pointed out that engineering managers have some unique problems, and ways must be found to fill the gaps that exist in each individual manager's background. C. E. Gray cites several factors that influence the development of managers and are critical for men who have an engineering background:

1. It is imperative that a full managerial position be structured and that technical - engineering functional responsibilities be minimized.
2. In determining rewards of engineering managers, sufficient weight must be given to the managerial functions of the job in addition to the technical.

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<sup>66</sup>H. W. Johnson, "Developing Engineers for Management Responsibility," Personnel, Vol. 35, No. 2 (September-October, 1958), pp. 66-71; George W. Jernstedt, "Engineering Management Development," IRE Transactions on Engineering Management, Vol. 5, No. 1 (March, 1958), pp. 3-6; W. R. G. Baker, "Personnel Selection and Training for Engineering Management," IRE Transactions on Engineering Management, Vol. 4, No. 1 (March, 1957), pp. 79-81; G. C. Jacobus and J. C. Stephens, "The Engineer Manager: Training the Technician for Executive Responsibilities," Personnel, Vol. 30, No. 5 (March, 1954), pp. 374-381; Robert K. Greenleaf, "A Forward Look at Management Development," IRE Transactions on Engineering Management, Vol. 6, No. 1 (March, 1959), pp. 19-30.

3. High level managers should treat subordinate managers as managers and not as engineers.

4. Engineering managers should be given the opportunity and encouraged to develop their managerial skills and increase their appreciation of the business world.<sup>67</sup>

Jucius and Schlender maintain that a manager must know something about the technicalities of the field in which he is the leader. He must have knowledge and skill pertinent to personnel and human relations, and he must get his technicians to work together effectively by planning, organizing, directing, and controlling their work. They describe the needs of the engineering manager in the following way:

. . . a manager is a specialist leading a group of technical experts or specialists. . . . He must possess managerial attributes that will permit him to optimize various goals of his particular team. He must have a fund of managerial knowledge, a set of managerial skills, and an acquaintance with managerial duties to lead his team of engineers . . .<sup>68</sup>

The need to involve professional managers in normal business decisions is considered extremely important by several researchers. Bailey and Jensen suggest that the engineering manager needs training to cover both the immediate and the longer-range aspects of his job. Steps should be taken to see that he gets adequate instruction in handling

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<sup>67</sup>Gray, op. cit., pp. 31-32.

<sup>68</sup>Michael J. Jucius and William E. Schlender, Elements of Managerial Action (Homewood, Illinois: Richard D. Irwin, Inc., 1965), p. 3.



the purely administrative aspects of his job and develops intelligent insight into company policies. Above all, he should be helped to see what being a manager means to him.<sup>69</sup>

Peter Drucker also stresses the importance of the manager's participation in discussions of long-range policy and in decisions on the range of products, as well as his being involved in determining production programs. The professional manager, according to Drucker, needs all the insight into business he can possibly get.<sup>70</sup>

The engineering manager, Rubey believes, often fails to give enough attention to business, political and financial viewpoints, and to public relations. He must guard against too much "how to do it," which his subordinate can handle, and give more thought to broader questions of overall policy. "Knowing what to do, through and by which people, is more useful than knowing how to do it," he comments.<sup>71</sup> Kenneth Olm refers to this as "process knowledge" or knowledge about, rather than knowledge of how to do it.<sup>72</sup>

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<sup>69</sup>Bailey and Jensen, op. cit., p. 53.

<sup>70</sup>Peter F. Drucker, "Management and the Professional Employee," Harvard Business Review, Vol. 30, No. 3 (May-June, 1952), p. 89.

<sup>71</sup>Rubey and Logan, op. cit., p. 4.

<sup>72</sup>Kenneth W. Olm, "The Role of the Industrial Engineer in the Emerging Profession of Management," Journal of Industrial Engineering, Vol. 7, No. 3 (May-June, 1960), p. 217.

The opinion is also held that the administrative engineer must regard himself as a "resource person" rather than as the boss who is supposed to manage, to control, and to make decisions. His major function, Charles Orth contends, should be one of "helping," and he should acquire administrative skills accordingly. The engineering manager should be valued mainly for his ability to release the potential creativity of the operating engineer.<sup>73</sup> Drucker adds that the one contribution a manager is uniquely expected to make is to give others vision and ability to perform.<sup>74</sup>

Simon Marcson's study reveals that little is done to help the engineering manager acquire managerial skills. Marcson attributes this to the fallacious assumptions that somehow the engineering manager has acquired managerial skills because he holds such a position, and that he is mainly an engineer and does not need special preparation for managerial duties. In summarizing on the role concept of engineering managers, Marcson states:

. . . he has acquired a conception of himself as an executive type of manager without the necessary skills. His conception of his role is no longer based on his

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<sup>73</sup>Charles D. Orth, "More Productivity from Engineers," Harvard Business Review, Vol. 35, No. 2 (March-April, 1957), p. 61.

<sup>74</sup>Peter F. Drucker, The Practice of Management (New York: Harper and Brothers, 1954).

professional attainments. In his new role of manager he no longer has the sure footing of training and competence he had as an engineer. The tendency, then, is for him to continue to act as an engineer in a role which calls for executive skills.<sup>75</sup>

The need for training in management skills was voiced by approximately 1500 engineering graduates of the University of California in a recently completed study of continuing education needs. A large number of the respondents considered the broader aspects of education such as organizing, planning and administration, public speaking, letter and report writing, and human relations more important and necessary to their present jobs than highly technical subjects such as advanced mathematical analysis, modern physics, modern chemistry, and advanced probability and statistics. The highest rating by those in management for a technical subject was only 19 percent, that being reached on both computers and advanced design.<sup>76</sup>

In the Fall of 1962, the Engineering College Administrative Council and the Relations with Industry Divisions of the American Society for Engineering Education formed a joint Feedback Committee to determine, analyze, and report

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<sup>75</sup> Marcson, op. cit., p. 33.

<sup>76</sup> A Study of the Engineering Alumni of the University of California, Berkeley; and University of California, Los Angeles, Classes of 1949-1962 (Los Angeles, California: University of California, Department of Engineering, 1965); An Engineering Master Plan Study for the University of California, op. cit., p. 102.

the needs which engineers believe they have for further training several years after they have begun their professional careers in industry.<sup>77</sup>

The primary conclusion of the study is that engineers in general believe that they need more training in both technical and non-technical areas. However, their first needs appear to be for subjects that will enable them to better apply the technical knowledge they already possess. This conclusion is based on the fact that between 60 and 66 percent of the engineers responding designated in order of need, management practices, technical writing, and probability and statistics. In the overall results, nine of the first 15 subjects selected were non-technical; six were technical.

Survey data reported by job functions showed that persons primarily concerned with the management of engineers and scientists chose the highest number of subjects as needed for further training. These respondents placed high priority on the need for instruction in management practices, technical writing, public speaking, working with individuals, and creative thinking.<sup>78</sup>

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<sup>77</sup>"Education in Industry: Synopsis of the Joint ECAC-RWI Feedback Committee Report," Journal of Engineering Education, Vol. 55, No. 9 (May, 1965), pp. 254-256.

<sup>78</sup>Ibid., p. 256.

One of the most recent and extensive studies to be found in the literature, focusing on continuing education needs and pursuits of engineers and engineering managers, is the one conducted by Samuel S. Dubin and H. LeRoy Marlow of the Research Division, Continuing Education, The Pennsylvania State University in 1965. This study was concerned with technological obsolescence in the education of the professional engineer with specific reference to the self-perceived educational needs of 2,090 practicing engineers of all ages employed in Pennsylvania industries of varying size. Group interviews were conducted with managing engineers in 51 companies and included discussion on current and future technical and managerial problems.<sup>79</sup>

When asked about specific areas of technological instruction needed to help them deal more effectively with the tasks they encountered in their work, engineering managers placed the highest priority on computer technology and application, followed by statistics, metallurgy, mathematics, basic physics and chemistry, electronics and solid state physics.<sup>80</sup>

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<sup>79</sup>Samuel S. Dubin and LeRoy H. Marlow, Research Report of Continuing Professional Education for Engineers in Pennsylvania, (The Pennsylvania State University, 1965).

<sup>80</sup>Ibid., p. 88.

Of the desired humanities, social science, and business subjects that would be of help, economics, psychology and English (report writing) ranked highest. Following these were: public speaking, human relations, accounting, management, and communications. The few engineers who desired the humanities expressed the opinion that advancement in management required a broadening of personal development. Most engineers were so pressed by the demands of their work that they felt they scarcely had time to keep up with the technical advances and had little desire for courses that had no immediate application to their work.<sup>81</sup>

Much of the literature and research pertaining to management skills expresses the need for engineering managers to become adroit at human relations.<sup>82</sup> Kilgore and Baker investigated human relations training for engineering managers at Westinghouse through a specially designed course approach. They concluded by large voluntary turnout and by active participation, that engineers are interested in human relations training and do profit from a study of the techniques of getting along with people.<sup>83</sup>

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<sup>81</sup>Ibid., pp. 89-90.

<sup>82</sup>Tyler G. Hicks, Professional Achievement for Engineers and Scientists (New York: McGraw-Hill Book Company, Inc., 1963), p. 182.

<sup>83</sup>L. Kilgore and V. Baker, "Human Relations and Engineers," Westinghouse Engineer, Vol. 17, No. 4 (July, 1957).

Human relations showed up again among the top three goals of general education ranked as most important by 3,800 Purdue engineering alumni, many of whom held engineering management positions. Accompanying human relations were: learning to express one's thoughts effectively, and acquiring the skills for constructive thinking.<sup>84</sup>

Some generalizations from a study conducted by the Opinion Research Corporation for the Professional Engineers Conference Board for Industry that reflect on the attitudes which engineering managers have toward continuing education, came from a question that was asked concerning the type of company training they would prefer. Invariably top billing was given to non-technical subjects. The managers wanted more instruction on organization and planning, how to handle people, letter and report writing, and public speaking. Of the ten choices listed, the managers rated the only two technical subjects, advanced engineering and advanced mathematics, eighth and tenth, respectively.<sup>85</sup>

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<sup>84</sup>William K. LeBold et al., A Study of the Purdue University Engineering Graduate (Lafayette, Indiana: Purdue University, January, 1960); John Gillis, The Attitudes of Purdue Engineering - Alumni, Faculty and Students Toward the Goals of General Education (unpublished doctoral dissertation, Purdue University, 1958); Edward Thoma, A Study of the Purdue University Engineering Graduate (unpublished doctoral dissertation, University of Illinois, 1958).

<sup>85</sup>Career Satisfactions of Professional Engineers in Industry, op. cit., p. 32.

According to the Study, it would appear that the experienced engineer, including the engineering manager, is seeking ways to make himself a more rounded individual. He feels deficient in the non-technical skills, and welcomes company training that will extend his competence beyond the purely technical.<sup>86</sup>

The need for engineering managers to procure education and training in management is further evidenced by the ever-increasing number of management development programs being offered for technical managers by universities and industries throughout the country. For example, the Advanced Management Programs at Harvard University, Massachusetts Institute of Technology, Columbia University, Michigan State University, and at the University of Michigan, to mention a few, are structured so that middle managers can gain an understanding of the processes of management and the role of top administrators; can develop competence in planning and policy formulation; can see the role of business in society; and can refine skills in handling the human elements of organizations. Typical of the subject areas covered in these university programs are: problem solving and mathematical concepts for decision making, human behavior, marketing management, accounting and

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<sup>86</sup>Ibid., p. 48.



financial policy, business history, communication skills, managerial economics, and scientific and technical innovations, among others.<sup>87</sup>

Illustrative of this trend in industry are management development programs for engineering managers of the type being conducted by Ford Motor Company, General Electric, Radio Corporation of America, The Western Electric Company and many others. At Ford Motor Company, for instance, the Engineering Management Education Program consists of special courses, lectures and engineering management conferences designed to increase the managers' skill in understanding and working with people, selection and appraisal interviewing, decision making, delegation and motivation.<sup>88</sup> At Western Electric, on-going management development programs, usually in a seminar or workshop format, are held as off-the-job study for several consecutive days or weeks at a company-training facility. Program content is concerned with such topics as: administrative policies and practices, labor relations, personal development, managerial controls, public

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<sup>87</sup>Advanced Management Programs (unpublished report, General Personnel Planning and Development, Consumers Power Company, Jackson, Michigan, July, 1966).

<sup>88</sup>1967 Education Programs (unpublished report, Personnel Planning Engineering Staff, Ford Motor Company, Dearborn, Michigan, 1967).

affairs, simulation, data processing systems, product and operations research, computer theory, linear programming, systems analysis, inventory control and others.<sup>89</sup>

A survey by Dun's Review and Modern Industry of 100 top executives of some of the largest U.S. industries uncovered few signs of disillusionment with management training as such. There was general agreement, however, that "canned approaches" to the complex problem of developing executive talent had run their course and that company programs in the future should be more tailored to fit the needs of both the organization and the individual. The main focus on outside courses should be on on-the-job training, with prime emphasis on the immediate superior-subordinate relationship. The respondents favored informal, small-group training techniques, such as workshop seminars, business games, and special developmental assignments. There was little enthusiasm for formal lectures and courses aimed at broadening the manager's cultural background.<sup>90</sup>

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<sup>89</sup>Graduate Engineering Education (New York: Western Electric Company, 1966); Management Development Programs (New York: Western Electric Company, 1963).

<sup>90</sup>Editors, "Does Management Training Pay Off?" Dun's Review and Modern Industry, Vol. 74, No. 5 (November, 1959), pp. 41-43.

Dooher and Marquis,<sup>91</sup> and McGehee and Thayer,<sup>92</sup> among others, have assembled a wide variety of methods and techniques employed in management development. The individual may receive training on the job. He may be coached by his immediate superior. He may be given guided job experience on a planned basis. He may receive counseling from professional consultants. The manager may be given additional education outside the company in formal organized programs, such as management conferences, institutes, seminars; technical and professional meetings; university executive development programs; graduate programs in business administration; university extension and night courses; regular college and university work on leave from the job; and in workshops, panels, adult education classes, and forums. Widely used are such company training classes as conferences and skills training classes in planning, organizing, report writing, and conference leadership skills.

Continuing education activities supported by companies to keep engineers abreast of current knowledge were surveyed in The Pennsylvania State University study.

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<sup>91</sup>M. J. Dooher and V. Marquis, The Development of Executive Talent (New York: American Management Association, 1952), pp. 160-174.

<sup>92</sup>William McGehee and Paul Thayer, Training in Business and Industry (New York: John Wiley and Sons, Inc., 1964), pp. 196-224.

Company attitudes toward additional education for engineers ranged from strong support to neutrality. Larger companies gave more vigorous support than the smaller companies. The engineering managers surveyed indicated that companies gave strongest support to such continuing education activities as: convention attendance, professional and technical society membership, technical publications, short seminars and in-plant courses. Evening and full-time courses, the use of consultants, awards for publications, in-plant conferences, sources of information from manufacturers, and visits to other companies were given little positive encouragement.<sup>93</sup>

Technical managers in a Princeton University survey indicated a preference for in-company, evening, seminar type study.<sup>94</sup> Another survey revealed lack of interest in credit course study, in that eighty percent of the engineering managers were not planning to pursue an advanced degree.<sup>95</sup>

Industrial sponsorship of continuing education for engineering managers was also studied by Rice,<sup>96</sup>

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<sup>93</sup>Dubin and Marlow, op. cit., p. 86.

<sup>94</sup>E. Raudsepp, "Who Pays for Technical Retooling?" Machine Design, Vol. 36, No. 16 (July, 1964), p. 94.

<sup>95</sup>E. Raudsepp, "Attitudes on Education," Machine Design, Vol. 36, No. 17 (July, 1964), p. 125.

<sup>96</sup>R. A. Rice, "Education for Specific Needs--Company Sponsored Courses," IEEE Transactions on Education, Vol. 6, No. 2 (December, 1963), pp. 99-104.

Schneider,<sup>97</sup> and in a doctoral dissertation by Wheeler.<sup>98</sup> The trends in sponsorship of continuing education programs which were revealed were: (1) significantly increased use of non-credit technical course programs; (2) slightly increased use of work-study and sabbatical programs; and (3) greater emphasis upon education and less emphasis upon training programs.

A study by Gorr considered the interpretation which the individual and the company place on company-sponsored programs of continuing education. The study focused on companies' and individuals' expectations after completing a degree-study program. The findings suggest that the companies generally viewed their programs as a necessary fringe benefit which made them competitive with other companies in recruiting and retraining personnel. The participants, on the other hand, viewed the advanced-study programs as means toward success-advancement, greater responsibilities, and new job duties.<sup>99</sup>

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<sup>97</sup>Eugene Schneider, "What Industry is Doing for Continued Education of Engineers," Journal of Engineering Education, Vol. 51, No. 3 (December, 1960), pp. 211-217.

<sup>98</sup>Edward Wheeler, Industrial Sponsorship of Continuing Education for Anti-Obsolescence of Engineers and Scientists (unpublished doctoral dissertation, Lehigh University, 1965), p. 62.

<sup>99</sup>M. L. Gorr, et al., A Comparison of Attitudes Regarding the Value of the MBA Degree Towards Personal Advancement (unpublished study, Graduate School of Business, University of Pittsburgh, 1964).

In 1965, Maw and Addison evaluated the attitudes of research and development managers toward management training. Their findings revealed that research and development managers seem to feel that increased management training is needed at both the academic degree and the in-plant levels. Management training at the in-plant level seems to be preferred, however.<sup>100</sup> C. J. Chamberlain has voiced some criticism at company sponsored, "in-house" programs such as management courses and fundamental technical courses. Chamberlain believes that these "quick" courses usually fail to accomplish anything. He maintains that advanced educational status can only be obtained by hard work and intense formal training.<sup>101</sup>

Studies indicate a trend toward on-campus academic servicing of continuing education for engineering managers. However, the trend has just begun and the total number of professional managers attending continuing education programs at universities and colleges is relatively small.<sup>102</sup> Engineering managers have been found, however, to be more consistent participants in non-degree continuing education

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<sup>100</sup>I. L. Maw and A. Addison, "Attitudes of Research and Development Management Toward Management Training," IEEE Transactions on Engineering Management, Vol. 12, No. 4 (December, 1965), pp. 134-138.

<sup>101</sup>Clinton J. Chamberlain, "Coming Era in Engineering Management," Harvard Business Review, Vol. 39, No. 5 (September-October, 1961), p. 90.

<sup>102</sup>Wheeler, op. cit., p. 40.

study at universities than practicing engineers and scientists.<sup>103</sup> Studies by Oberg<sup>104</sup> and Huneryager<sup>105</sup> assessed the effectiveness of university-sponsored executive development programs for middle and top management personnel. The data showed the over-all reaction of managers on their evaluation of this type of continuing education approach to be highly favorable. According to Oberg, the chief advantages of such programs are: (1) they let executives get away from the job pressures and the "party line" thinking and stimulate self-analysis; (2) they provide resource people and material--faculty members, fellow executives, books--to help the executive as he attempts to change, develop, and grow; and (3) they present a challenge to the executive which enhances his motivation to develop himself.<sup>106</sup>

Apparently the concept of continuing education designed for the purpose of technically updating engineering managers is rather new. The predominant thought seems to have been that once a degree in engineering is acquired,

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<sup>103</sup>Ibid., pp. 81-82.

<sup>104</sup>Winston Oberg, "Top Management Assesses University Executive Programs," Business Topics, Vol. 11, No. 2 (1963), pp. 7-27.

<sup>105</sup>Sherwood Huneryager, An Evaluation of University Executive Training (unpublished doctoral dissertation, University of Illinois, 1963).

<sup>106</sup>Oberg, op. cit., pp. 23-24.

the technical knowledge accrued is applicable for all time. The emphasis in the literature appears to center on the acquisition of management knowledge and skills somewhat to the neglect of the need for updating obsolete knowledge in the technical or professional areas. This is evident from the predominance of articles and studies in management development for the engineering manager and the dearth of studies in continuing education in the technical areas.

Undoubtedly this imbalance will change as evidenced by the increasing number of articles and speeches on the explosion of knowledge and the accelerating rate of obsolescence that accompanies it, and by the growing popularity of programs being offered by universities and industries throughout the country, dealing with technical and professional updating for the engineer-manager.

Franklin D. Murphy, Chancellor of the University of California, Los Angeles, commented on the need for technical updating of engineering managers:

The problems we will confront in the next ten or fifteen years will require that our industrial and scientific leaders have a deep understanding of the nature of our technology and the forces which are operative in it. They will be called upon to make technical decisions of far-reaching social and economic impact. Here the engineering executive will provide leadership. To make his leadership effective he must be constantly updating himself to meet the accelerating needs of society.<sup>107</sup>

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<sup>107</sup>Franklin D. Murphy, Modern Engineering for Engineering Executives (Los Angeles, California: University of California, 1962).



J. A. Strelzoff, Professor of Electrical Engineering at Michigan State University and Director of the Modern Engineering Seminars, strongly emphasizes the need for continuing education programs to technically update engineering managers. He believes that engineering managers need:

1. to have an understanding of, and an appreciation for some of the more important scientific and advanced engineering concepts which have become highly essential to our modern way of life.
2. to become acquainted with the numerous changes and newest advancements in the fields of engineering and science.
3. to learn about the latest methods of attacking engineering problems.
4. to seek out the practical aspects of the new technology from the practitioners of the art.
5. to develop a more extensive viewpoint on current engineering problems.
6. to understand the unifying concepts and similarities of many different engineering and related subjects.
7. to become excited as to the possibilities of using some of the "new" science in their work.<sup>108</sup>

In 1959, engineering educators began to realize that many engineering executives were finding it increasingly difficult to keep pace with recent developments in science and engineering. Also, it was felt by many that technical considerations had become so important in business decisions that the engineering manager had to augment his formal

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<sup>108</sup> Joseph A. Strelzoff, 1966-67 Modern Engineering Seminars (East Lansing, Michigan: Michigan State University, 1966).

education to make the necessary technical decisions required by his job. To alleviate this problem, special tailor-made courses and seminars were designed early in the 1960's by the University of California at Los Angeles, Michigan State University and by the General Electric Company.<sup>109</sup>

Michigan State University, for example, in May of 1967 completed its fifth annual Modern Engineering Seminar series for engineering managers representing industries throughout Michigan and the Midwest. Also during the past year, the Continuing Education Service, cooperatively with the College of Engineering at Michigan State University, has offered a Power Systems Engineering Seminar for engineering managers from Michigan public utilities, along with two special seminars for engineering executives from two large automotive industries in Michigan. Judging from the reactions of the participants, the Modern Engineering Seminars seem to be serving a pressing continuing education need. Current appraisals and explorations are being conducted to improve and expand such programs for appropriate development of engineering managers.

Several share the view that new developments and new directions lie ahead in continuing education for engineering management. Some see management becoming more

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<sup>109</sup>George A. Boehm, "Bringing Engineers Up to Date," Fortune, Vol. 67, No. 5 (May, 1963).

analytical and scientific under the impact of technological developments, requiring managers to know more sophisticated techniques of analysis, programming, communication and decision making; and to employ such mathematical and statistical tools as operations research methods, game theory, simulation, and mathematical modeling.<sup>110</sup> It is felt that more concern will be with the manager's judgment development than with his job skill development,<sup>111</sup> and emphasis will be placed more on the conscious application of the social and behavioral sciences to the solution of business problems.<sup>112</sup> Engineering managers will need sabbatical leaves to take courses in the newer areas, and participation in special full-time seminars extending from one to several months will be routine.<sup>113</sup>

Others are of the opinion that the master's degree and even the doctor's degree will become a routine requirement for engineers advancing in managerial positions.

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<sup>110</sup>A. Uris, "What's Ahead for Middle Management," Chemical Engineering, Vol. 70, No. 17 (August 19, 1963), pp. 176-180.

<sup>111</sup>J. T. Emrick, "Training and Development of Middle Managers," Advanced Management Journal, Vol. 30, No. 4 (October, 1965), p. 56.

<sup>112</sup>Leonard Silk, The Education of Businessmen (New York: Committee for Economic Development, December, 1960), p. 9.

<sup>113</sup>Neil W. Chamberlain, "Retooling the Mind," The Atlantic (September, 1964), pp. 48-50.

Joseph Pettit, Dean of Engineering at Stanford University, points out that there is still wide-spread belief that engineers with advanced degrees, particularly the doctorate, are suitable only for research, even though there is abundant evidence that engineers with advanced degrees are already functioning effectively in leadership roles in all aspects of engineering activity.<sup>114</sup>

The real change, however, many believe, will come in formalizing the practice of life-time learning that has become necessary in our society.<sup>115</sup> John D. Ryder, Dean of the College of Engineering at Michigan State University, has emphasized that in atomic terms, today's graduate engineer has a half-life of approximately ten years; i.e., half of what he knows now will be obsolete in about a decade.<sup>116</sup> This infers, then, that about half of what he will need to know is not even available to him today. In view of this, Bass makes a fitting conclusion in his statement that "the manager who is satisfied to rest on his laurels

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<sup>114</sup>Joseph Pettit, "The Changing Status of Graduate Engineering Education," Journal of Engineering Education, Vol. 57, No. 5 (January, 1967), p. 364.

<sup>115</sup>Alan J. Levy, "New Developments in Management," Journal of Industrial Engineering, Vol. 16, No. 3 (May-June, 1965), pp. 171-176.

<sup>116</sup>John D. Ryder, "Education for Modern Engineering," Paper presented at the 1965-66 Modern Engineering Seminars, Michigan State University, East Lansing, Michigan, October 22, 1965.

cannot survive for long in today's rapidly changing world. Thus, for managers, the process of learning is a lifelong affair."<sup>117</sup>

### Summary

Because of the increasing complexity of technology and the rapid growth of science and its immediate application in industry, the literature and research over the past several years have pointed to the acute need for engineers in management. Studies have revealed a decided inclination on the part of engineers toward management and have shown a definite movement of engineers into managerial positions. From all indications in the literature, it would appear that this trend will continue.

A limited amount of literature and research exists, however, on the subject of engineers actually performing in managerial roles. Much of what is available seems to focus on transition problems in the movement from engineer to manager and on the difficulties engineers have in adapting themselves to the dual role of engineer-manager. Studies show distinct differences in role concept between managerial

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<sup>117</sup> Bernard M. Bass and James A. Vaughn, The Psychology of Learning for Managers (American Foundation for Management Research, Inc., 1965), preface.

levels and stress the importance of role adaptibility of the engineering manager in level, function, and interest.

A further examination of the literature reveals an increasing awareness of the importance of continuing education for the modern engineer-manager. Until recently, however, the emphasis on the continuing education needs and activities necessary to support the role of the engineering manager seems to have been primarily on the procurement of managerial knowledge and skills rather than on the need for technical updating. In view of the recent literature and the special efforts being made by universities and industries directed to the need for updating technical managers, a new emphasis is indicated.

## CHAPTER IV

### METHODOLOGY

This study developed out of discussions, evaluations, and informal interviews with university faculty members and engineering managers who participated in the Modern Engineering Seminars conducted annually by the Continuing Education Service and the College of Engineering at Michigan State University. The writer has served as the administrator of the Modern Engineering Seminars since their inception in 1962.

The main objective of this study is to investigate the relationships between the perceptions engineering managers have of the continuing education requirements supporting their role and the expectations defined for them by their immediate superiors, direct subordinates, and by engineering faculty outside of the organization.

The research procedures chosen to achieve the objectives of the study stem from those employed in studies by Kahn et al.,<sup>1</sup> and by Gross, Mason, and McEachern.<sup>2</sup>

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<sup>1</sup>Kahn et al., op. cit.

<sup>2</sup>Gross et al., op. cit.

### Population Sample

The subject population consists of engineering managers employed by 40 companies of various types and sizes located throughout Michigan and the Midwest.

The problem in identifying role-definers was to decide on those persons whose behavior was likely to have an influence on the content of the engineering manager's role and on the continuing education requirements supporting his role. Criteria, established a priori, dictated the selection of the other role-definer groups. These included the selection of the other role-definers in positions defined by the hierarchical authority structure and the work-flow structure in the engineering activity within the organization. Therefore, immediate superiors and direct subordinates of the engineering managers were selected. In order to provide an objective view from outside of the organization, full-time faculty members of the Michigan State University College of Engineering were also selected as role definers.

Disproportionate stratified sampling procedures<sup>3</sup> were employed in the selection of the role-definers. To assist in obtaining the sample of engineering managers,

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<sup>3</sup>Mildred Parten, Surveys, Polls, and Samples: Practical Procedures (New York: Harper and Brothers, 1950), Chapter 7; Russell L. Ackoff, The Design of Social Research (Chicago: The University of Chicago Press, 1953), Chapter 4.



company organization charts were studied and interviews conducted with engineering personnel officers and engineering managers attending the Modern Engineering Seminars. The sample of engineering managers in turn generated the sample of immediate superiors and the sample of direct subordinates, as explained later in the chapter. Because of the relatively small number of full-time faculty members in the Michigan State University College of Engineering, all members were included in the analysis.

#### Questionnaire-Schedule Construction

Two separate instruments were developed for this study using Gross et al.,<sup>4</sup> and Anderson<sup>5</sup> as sources of reference.

To generate role-expectation items measuring the three major consensus areas selected for analysis, a structured interview schedule consisting of open-ended questions was devised and utilized (see Appendix A). This Open-ended Interview Schedule<sup>6</sup> was administered in forty-five minute

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<sup>4</sup>Gross, et al., op. cit., Chapter 7.

<sup>5</sup>Robert C. Anderson, "A Method and Instrument for Predicting the Consequences of Intra-Organizational Action" (unpublished Ph.D. Thesis, Michigan State University, 1963).

<sup>6</sup>This instrument is a modification of the analytical Open-ended Question Device used by Robert C. Anderson by which to generate elements or descriptive statements about any specific social system or organization under analysis.

interviews with eight respondents from each of the role-definer groups at the three levels of the organizational hierarchy (See Figure 1, Chapter II) and with eight members of the faculty of Michigan State University.

From the responses to the Open-ended Interview Schedule, a preliminary set of role-expectation items was developed and an instrument prepared and submitted to faculty judges to be assessed for construct validity and for critical evaluation.

Based upon the evaluation of the faculty judges, a modified role-expectation instrument was structured and a pretest administered to the thirty-two respondents of the Open-ended Interview Schedule and to four additional respondents from each of the four role-definer groups. One hundred percent return was achieved on the pretest from the forty-eight respondents. The results of the pretest were subjected to item analysis and the final instrument was prepared.

The instrument used in the study was a self-administered questionnaire-schedule containing 130 role-expectation items in three sections, and 15 personal data items in a fourth section. The differences in types of role definers involved in the investigation necessitated slight variations in the questionnaire instructions as well as the omission of the personal data section in

the faculty questionnaire. The questionnaires have been color-keyed into four groups to make these distinctions.

The questionnaire-schedule contains items clustered around three categories:

1. Section I contains 29 items dealing with the types of functions in which engineering managers may or may not be expected to engage. These items were generated primarily to serve as criteria upon which to support the continuing education requirements of the engineering manager. This was necessary since no appropriate job standard was available.
2. Section II contains 35 items dealing with the types of continuing education activities in which engineering managers may or may not be expected to engage.

Responses to the role expectation items in the questionnaire-schedule were in terms of a Likert-type scale.<sup>7</sup> Each item in Sections I and II was characterized by five forced-choice responses. They were Absolutely Must (AM), Preferably Should (PS), May or May Not (MMN), Preferably Should Not (PSN), and Absolutely Must Not (AMN). Numerical values were assigned to each response choice: AM-1, PS-2, MMN-3, PSN-4, and AMN-5.

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<sup>7</sup>Partens, op. cit., pp. 196-198; C. Selltitz, M. Jahoda, M. Deutsch, and S. Cook, Research Methods in Social Relations (New York: Holt, Rinehart and Winston, Inc., 1961), pp. 357-384.

3. Section III contains 66 items dealing with specific technical and nontechnical subjects. The question to which they are directed concerns the extent of knowledge that the engineering manager should have concerning each subject. Each item in Section III was characterized by three forced-choice responses. They were Acquire a Working Knowledge of (AWK), Acquire an Overview only (AOV), and Doesn't Really Need (DRN). Numerical values were assigned to each response choice: AWK-1, AOV-2, and DRN-3.

Exhibit 1 of Appendix B contains one of the four role-analysis instruments. This instrument was used for the engineering managers and is illustrative of the two instruments used for the immediate superiors and the direct subordinates of the engineering managers. These three instruments differed only in color code and in variations in instructions. The items in Section IV of Exhibit 1 are concerned with personal data and were not included in the faculty instrument.

#### Questionnaire-Schedule Distribution and Response

A package containing two questionnaires, two self-addressed stamped envelopes, a self-addressed stamped postcard (see Appendix C), and an individually typed and personally addressed cover letter (see Appendix D) was

either mailed or distributed personally to some 230 engineering managers employed by the 40 firms mentioned. The mailing or distribution occurred on November 1, 1966. The engineering manager was asked to indicate on the enclosed postcard the name, title, company, and company address of his immediate superior and to return the postcard immediately. The engineering manager was also asked to complete and return his questionnaire, and to give the remaining questionnaire and envelope to a direct subordinate engineer employed within the engineering activity. Information from the returned postcard was used to direct a similar package containing a questionnaire, self-addressed stamped envelope and cover letter to the immediate superior of the engineering manager.

A questionnaire, self-addressed envelope and cover letter were distributed to some 81 full-time faculty members in the College of Engineering, Michigan State University. This distribution was made possible through the Acting Dean of the College of Engineering who personally secured the cooperation of the College of Engineering Department Chairmen to see that the questionnaire material was distributed directly from the department offices.

Follow-up letters were sent as needed to members of each group. Final tabulations of the data include all responses which were received by February 1, 1967. Usable questionnaires were received from 199 engineering managers,

122 immediate superiors of engineering managers, 168 direct subordinates and 50 faculty members, totaling 539 questionnaires. This represents a return of 77 percent of the total distributed. Table 1 indicates the questionnaire-schedule distribution and returns based on the sample groupings.

### Analysis of the Data

All responses to each of the statements comprising the questionnaire-schedule were coded and the information key punched on IBM cards and verified for use with the Control Data Corporation 3600 computer at Michigan State University. The Analysis of Contingency Tables written program (ACT)<sup>8</sup> was used in determining the chi-square statistic. The chi-square test was used to determine the significance of differences between two independent groups, thereby providing the basis for determining the extent of consensus between role groups on each of the statements. The level of significance established a priori was the .05 level. This methodology provided the basis for acceptance or rejection of the null hypotheses. According to Siegel, the chi-square test is applicable to data in a contingency

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<sup>8</sup>The Analysis of Contingency Tables (ACT) program was written for the Control Data Corporation 3600 computer by A. M. Lesgold, F. M. Sim, and L. C. Widmayer, Computer Institute of Social Science Research, Michigan State University, Revised, January 27, 1966.

Table 1. Questionnaire-schedule distribution and response.

| Sample                  | Questionnaire-<br>Schedules<br>Distributed | First<br>Return | Percent<br>First<br>Return | Second<br>Return | Percent<br>Second<br>Return | Total<br>Returns | Percent<br>Total<br>Returns |
|-------------------------|--------------------------------------------|-----------------|----------------------------|------------------|-----------------------------|------------------|-----------------------------|
| Immediate<br>Superiors  | 163                                        | 105             | 64.4                       | 17               | 10.4                        | 122              | 74.8                        |
| Engineering<br>Managers | 230                                        | 176             | 76.5                       | 23               | 10.0                        | 199              | 86.5                        |
| Direct<br>Subordinates  | 230                                        | 154             | 66.9                       | 14               | 6.1                         | 168              | 73.0                        |
| Engineering<br>Faculty  | 81                                         | 42              | 51.9                       | 8                | 10.0                        | 50               | 61.9                        |
| Totals                  | 704                                        | 477             | 67.7                       | 62               | 9.0                         | 539              | 76.7                        |

table only if the expected frequencies are sufficiently large. When the expected frequencies do not meet certain requirements, one may increase their values by combining adjacent classifications and thus reducing the number of cells. This may be done only if such combining does not alter the data of their meaning.<sup>9</sup> It was necessary in Sections I and II of this analysis to combine the two negative categories (PSN) and (AMN), to assure sufficient numbers of responses in the cells of the contingency table. Therefore, in the final analysis for all statements in Sections I and II, there were four responses per statement, "Absolutely Must," "Preferably Should," "May or may not," and a combination of "Preferably Should Not" and "Absolutely Must Not."

### Characteristics of the Respondents

Some characteristics and statistical information about the engineering managers, their immediate superiors, and their direct subordinates were gathered in Section IV of the questionnaire-schedule.

Age groupings on the basis of 5-year intervals were established. The data reveal a common modal age range of 40-44 years of all three respondent groups. Table 2 shows the age distribution of the above respondents.

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<sup>9</sup>Sidney Siegel, Nonparametric Statistics for the Behavioral Sciences (New York: McGraw-Hill Book Co., Inc., 1956), p. 109.



Table 2. Age distribution of respondents.

| Age Ranges     | Immediate Superiors |         | Engineering Managers |         | Direct Subordinates |         |
|----------------|---------------------|---------|----------------------|---------|---------------------|---------|
|                | Number              | Percent | Number               | Percent | Number              | Percent |
| Under 25 years | -                   | -       | -                    | -       | 5                   | 3.0     |
| 25-29          | -                   | -       | 4                    | 2.0     | 15                  | 8.9     |
| 30-34          | 1                   | .8      | 11                   | 5.6     | 33                  | 19.6    |
| 35-39          | 13                  | 10.7    | 44                   | 22.1    | 32                  | 19.1    |
| 40-44          | 42                  | 34.4    | 58                   | 29.1    | 49                  | 29.1    |
| 45-50          | 39                  | 32.0    | 50                   | 25.1    | 24                  | 14.3    |
| 51-55          | 12                  | 9.8     | 26                   | 13.1    | 6                   | 3.6     |
| Over 55 years  | 15                  | 12.3    | 6                    | 3.0     | 4                   | 2.4     |
| Totals         | 122                 | 100.0   | 199                  | 100.0   | 168                 | 100.0   |

The respondents were also asked to indicate the highest level of formal education which they had attained. The findings show the Bachelor's Degree as the modal educational level for all three groups. They further reveal that over 20 percent of each group had earned advanced degrees, and in fact over 5 percent of the engineering managers and their superiors had earned the doctorate. The response distribution is shown in Table 3.

The length of time that had elapsed since receiving their highest degree in engineering was also analyzed. The modal period of time elapsed was 16-20 years in the case of the superiors and the engineering managers as compared to 11-15 years for the subordinates. The data also indicated that nearly 30 percent of the superiors had received their degrees over 25 years ago. Table 4 enumerates the findings.

The respondents were also asked if they were currently enrolled for another degree and, if not enrolled, did they plan to enroll for another degree. Approximately 8 percent of the engineering managers indicated that they were enrolled for another degree, and an additional 9 percent stated that they were planning to enroll for another degree. Approximately 10 percent of the direct subordinates indicated that they were enrolled for another degree; however, 25 percent stated that they were planning to enroll. Two percent of the immediate superiors were currently enrolled for another degree, and 4 percent indicated that

Table 3. Highest level of formal education attained by the respondents.

| Education Level   | Immediate Superiors |         | Engineering Managers |         | Direct Subordinates |         |
|-------------------|---------------------|---------|----------------------|---------|---------------------|---------|
|                   | Number              | Percent | Number               | Percent | Number              | Percent |
| High School       | 1                   | .8      | 2                    | 1.0     | 1                   | .6      |
| 1-3 years college | 11                  | 9.0     | 15                   | 7.6     | 10                  | 6.0     |
| Bachelor's degree | 74                  | 60.7    | 128                  | 64.6    | 122                 | 72.5    |
| Master's degree   | 29                  | 23.8    | 43                   | 21.7    | 32                  | 19.1    |
| Doctoral degree   | 7                   | 5.7     | 10                   | 5.1     | 3                   | 1.8     |
| Totals            | 122                 | 100.0   | 198                  | 100.0   | 168                 | 100.0   |

Table 4. Length of time since receiving highest degree in engineering.

| Time Elapsed<br>Since Degree | Immediate<br>Superiors |              | Engineering<br>Managers |              | Direct<br>Subordinates |              |
|------------------------------|------------------------|--------------|-------------------------|--------------|------------------------|--------------|
|                              | Number                 | Percent      | Number                  | Percent      | Number                 | Percent      |
| 5 years or less              | -                      | -            | 7                       | 3.7          | 25                     | 15.2         |
| 6-10                         | 7                      | 5.8          | 25                      | 13.1         | 39                     | 23.8         |
| 11-15                        | 20                     | 16.7         | 40                      | 21.1         | 40                     | 24.4         |
| 16-20                        | 38                     | 31.7         | 59                      | 31.1         | 36                     | 21.9         |
| 21-25                        | 21                     | 17.5         | 27                      | 14.2         | 9                      | 5.5          |
| Over 25 years                | 34                     | 28.3         | 32                      | 16.8         | 15                     | 9.2          |
| Totals                       | <u>120</u>             | <u>100.0</u> | <u>190</u>              | <u>100.0</u> | <u>164</u>             | <u>100.0</u> |

they were planning to enroll for another degree. The distribution of responses is shown in Table 5 and Table 6.

Another statement in the questionnaire-schedule referred to the interest of the respondents in doing graduate work if they had their education to do over again. Eighty-seven percent of the engineering managers stated that they would do graduate work if they had their education to do over again. Approximately 90 percent of the subordinates and 94 percent of the superiors indicated that they would also do graduate work if they had their education to do over again. Thus, approximately 90 percent of all the respondents indicated that they would do graduate work if they had their education to do over again, whereas Tables 3, 5, and 6 revealed that approximately 40 percent had actually done so or were planning to do so. The data also indicated an equal interest on the part of engineering managers and their superiors in graduate work in Engineering and Business Administration, and a nearly equal interest on the part of the subordinates. These findings are shown among the distributions of responses in Table 7.

Those respondents indicating that they were enrolled for another degree or planning to enroll for another degree were also asked to indicate the academic area and level of the degree they were pursuing or planning to pursue. Since the questionnaire-schedule was designed to examine the

Table 5. Respondents currently enrolled for another degree.

| Currently Enrolled | Immediate Superiors |         | Engineering Managers |         | Direct Subordinates |         |
|--------------------|---------------------|---------|----------------------|---------|---------------------|---------|
|                    | Number              | Percent | Number               | Percent | Number              | Percent |
| Yes                | 2                   | 1.6     | 16                   | 8.1     | 17                  | 10.1    |
| No                 | 120                 | 98.4    | 182                  | 91.9    | 151                 | 89.9    |
| Totals             | 122                 | 100.0   | 198                  | 100.0   | 168                 | 100.0   |

Table 6. Respondents planning to enroll for another degree.

| Planning to Enroll | Immediate Superiors |         | Engineering Managers |         | Direct Subordinates |         |
|--------------------|---------------------|---------|----------------------|---------|---------------------|---------|
|                    | Number              | Percent | Number               | Percent | Number              | Percent |
| Yes                | 5                   | 4.2     | 14                   | 7.7     | 38                  | 24.5    |
| No                 | 115                 | 95.8    | 168                  | 92.3    | 117                 | 75.5    |
| Totals             | 120                 | 100.0   | 182                  | 100.0   | 155                 | 100.0   |

Table 7. Interest of respondents in graduate work if they had their education to do over again.

| Interest in<br>Graduate Work              | Immediate<br>Superiors |         | Engineering<br>Managers |         | Direct<br>Subordinates |         |
|-------------------------------------------|------------------------|---------|-------------------------|---------|------------------------|---------|
|                                           | Number                 | Percent | Number                  | Percent | Number                 | Percent |
| No                                        | 7                      | 5.8     | 25                      | 13.0    | 16                     | 9.7     |
| Yes - Engineering                         | 49                     | 40.5    | 70                      | 36.2    | 67                     | 40.6    |
| Yes - Mathematics or<br>Physical Sciences | 12                     | 9.9     | 20                      | 10.4    | 9                      | 5.5     |
| Yes - Business<br>Administration          | 49                     | 40.5    | 70                      | 36.2    | 61                     | 36.9    |
| Yes - Other                               | 4                      | 3.3     | 8                       | 4.2     | 12                     | 7.3     |
| Totals                                    | 121                    | 100.0   | 193                     | 100.0   | 165                    | 100.0   |

Table 8. Academic area of interest of respondents currently enrolled or planning to enroll for another degree.

| Academic Area | Immediate Superiors |          | Engineering Managers |         | Direct Subordinates |         |
|---------------|---------------------|----------|----------------------|---------|---------------------|---------|
|               | Number              | Percent* | Number               | Percent | Number              | Percent |
| Engineering   | 2                   | -*       | 7                    | 21.9    | 20                  | 38.5    |
| Business      | 5                   | -        | 22                   | 68.7    | 30                  | 57.7    |
| Sciences      | -                   | -        | 1                    | 3.1     | -                   | -       |
| Other         | -                   | -        | 2                    | 6.3     | 2                   | 3.8     |
| Totals        | 7                   | -        | 32                   | 100.0   | 52                  | 100.0   |

\*Because of limited frequencies in this response category, percentages were not computed.



Table 9. Degree level pursued by respondents currently enrolled or planning to enroll for another degree.

| Degree Level    | Immediate Superiors |          | Engineering Managers |         | Direct Subordinates |         |
|-----------------|---------------------|----------|----------------------|---------|---------------------|---------|
|                 | Number              | Percent* | Number               | Percent | Number              | Percent |
| Additional B.S. | 2                   | -*       | 2                    | 6.7     | 4                   | 7.4     |
| Masters         | 4                   | -        | 27                   | 90.0    | 47                  | 87.0    |
| Doctorate       | 1                   | -        | 1                    | 3.3     | 3                   | 5.6     |
| Post Doctoral   | -                   | -        | -                    | -       | -                   | -       |
| Totals          | 7                   | -        | 30                   | 100.0   | 54                  | 100.0   |

\*Because of limited frequencies in this response category, percentages were not computed.

continuing education pursuits and academic areas necessary to support the role of the engineering manager, this is a relatively select segment of the sample. The responses in Table 8 and Table 9 show a greater interest on the part of the engineering managers and their subordinates in pursuing degree work on a masters level in the area of Business than in Engineering or the Sciences.

The questionnaire-schedule also disclosed that approximately two-thirds of the engineering managers as well as the superiors received their degrees in Michigan, whereas approximately one-half of the subordinates received their degrees in Michigan.

## CHAPTER V

### PRESENTATION AND ANALYSIS OF THE DATA

The objective of this chapter is to present and analyze the combined data from the engineering managers, their immediate superiors, direct subordinates, and from engineering faculty relating to consensus on: (1) the job functions of the engineering manager; (2) the continuing education activities of the engineering manager; and (3) the subject area needs of the engineering manager.

#### Macroscopic Consensus Analysis

Basic to macroscopic consensus analysis is the distinction between interposition consensus, that is, consensus between any two samples of role-definers, and intraposition consensus, or consensus among all of the engineering managers or among all of the immediate superiors. To determine the extent to which there is consensus or lack of consensus between any two samples of role-definers being compared (interposition consensus), it would have been possible merely to determine the proportion of items for which a significant difference exists. This approach, however, neglects the dimension of intraposition consensus

for the groups being compared. The fact that on a given item no significant difference occurs between the responses of any two groups does not necessarily mean that they are in agreement; it may mean that there exist similar patterns of disagreement. Therefore, to provide a more accurate indication of macroscopic consensus, both the intraposition and interposition dimensions were analyzed.

According to Gross, in the measurement of consensus at least two elements need to be considered: central tendencies and variability of the distribution. To take only one of these into account would be to ignore important information.<sup>1</sup> In view of this, the variance of the distribution was used as the measure of intraposition consensus. The mean score and variance were computed for each role-expectation item for each role-definer group. The distinction between high intraposition consensus and low intraposition consensus was made by ranking the items in each section of the questionnaire for all four samples on the basis of the variance. The cutting points selected were the median variance scores of the distribution of variance scores obtained for all items in each section for all samples.

The chi-square test was used as the measure of interposition consensus to distinguish between items on which there was and was not a significant difference

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<sup>1</sup>Gross et al., op. cit., pp. 105-106.

between the distributions of any two role-definer groups. To account for these two kinds of measures of macroscopic consensus (intraposition and interposition), the data have been aggregated to accommodate comparisons within and between the four groups under analysis.

### Hypotheses of Macroscopic Analysis

Hypothesis 1.--There is no significant difference in the perceptions engineering managers have of their job functions and in the expectations held for them by their immediate superiors, direct subordinates, and by engineering faculty.

The group mean and variance responses as well as the level of significance of difference between the compared groups for each of the 29 items concerning the job functions of the engineering manager are summarized in Table 10.

### Engineering Managers--Immediate Superiors

An examination of the items in Section I revealed that consensus (no significant difference in expectations) existed between the engineering managers and their immediate superiors on twenty-eight of the twenty-nine items. On twelve of the items on which the chi-square between the two distributions is insignificant there is low consensus within both samples. This suggests that for these items,

Table 10. Group frequency, mean, and variance responses, and significance of difference between groups on twenty-nine items concerning job functions of the engineering manager.

| Job Functions                                                             | Sample | N   | Responses |    |     |     |     | Mean | Var. | Compared Samples | Chi-Square Test |  |
|---------------------------------------------------------------------------|--------|-----|-----------|----|-----|-----|-----|------|------|------------------|-----------------|--|
|                                                                           |        |     | AM        | PS | MMN | PSN | AMN |      |      |                  |                 |  |
| Section I                                                                 |        |     |           |    |     |     |     |      |      |                  |                 |  |
| (1-6) Plan departmental or unit operations.                               | IS     | 120 | 88        | 19 | 10  | 3   | -   | 1.40 | .55* | EM-IS            | N.S.            |  |
|                                                                           | EM     | 199 | 148       | 27 | 17  | 7   | -   | 1.41 | .62  | EM-EF            | N.S.            |  |
|                                                                           | DS     | 168 | 94        | 47 | 24  | 3   | -   | 1.62 | .64  | EM-DS            | .001            |  |
|                                                                           | EF     | 48  | 27        | 12 | 8   | 1   | -   | 1.65 | .71  | IS-DS            | .05             |  |
| (1-7) Determine departmental or unit objectives.                          | IS     | 120 | 79        | 26 | 15  | -   | -   | 1.47 | .50* | EM-IS            | N.S.            |  |
|                                                                           | EM     | 199 | 128       | 48 | 19  | 3   | 1   | 1.49 | .55* | EM-EF            | N.S.            |  |
|                                                                           | DS     | 168 | 107       | 39 | 18  | 2   | 2   | 1.52 | .61  | EM-DS            | N.S.            |  |
|                                                                           | EF     | 48  | 21        | 18 | 8   | 1   | -   | 1.77 | .66  | IS-DS            | N.S.            |  |
| (1-8) Organize resources for carrying out plans.                          | IS     | 120 | 70        | 28 | 17  | 3   | 2   | 1.64 | .77  | EM-IS            | N.S.            |  |
|                                                                           | EM     | 199 | 117       | 49 | 29  | 4   | -   | 1.60 | .66  | EM-EF            | N.S.            |  |
|                                                                           | DS     | 168 | 70        | 46 | 43  | 8   | 1   | 1.95 | .88  | EM-DS            | .005            |  |
|                                                                           | EF     | 49  | 30        | 16 | 2   | 1   | -   | 1.47 | .46* | IS-DS            | .05             |  |
| (1-9) Delegate authority.                                                 | IS     | 120 | 86        | 26 | 8   | -   | -   | 1.35 | .36* | EM-IS            | N.S.            |  |
|                                                                           | EM     | 199 | 148       | 41 | 9   | -   | 1   | 1.31 | .34* | EM-EF            | N.S.            |  |
|                                                                           | DS     | 168 | 119       | 39 | 9   | 1   | -   | 1.36 | .37* | EM-DS            | N.S.            |  |
|                                                                           | EF     | 48  | 34        | 9  | 5   | -   | -   | 1.40 | .46* | IS-DS            | N.S.            |  |
| (1-10) Coordinate the efforts of subordinates.                            | IS     | 120 | 91        | 24 | 3   | 2   | -   | 1.30 | .36* | EM-IS            | N.S.            |  |
|                                                                           | EM     | 198 | 142       | 46 | 9   | 1   | -   | 1.34 | .35* | EM-EF            | N.S.            |  |
|                                                                           | DS     | 168 | 97        | 45 | 21  | 4   | 1   | 1.36 | .67  | EM-DS            | .005            |  |
|                                                                           | EF     | 49  | 34        | 14 | 1   | -   | -   | 1.33 | .27* | IS-DS            | .005            |  |
| (1-11) Motivate employees to achieve objectives.                          | IS     | 120 | 96        | 21 | 3   | -   | -   | 1.23 | .23* | EM-IS            | N.S.            |  |
|                                                                           | EM     | 199 | 144       | 44 | 11  | -   | -   | 1.33 | .34* | EM-EF            | N.S.            |  |
|                                                                           | DS     | 168 | 90        | 58 | 19  | 1   | -   | 1.59 | .50* | EM-DS            | .005            |  |
|                                                                           | EF     | 48  | 34        | 12 | 2   | -   | -   | 1.33 | .31* | IS-DS            | .001            |  |
| (1-12) Make decisions concerning the technical work of subordinates.      | IS     | 120 | 26        | 22 | 50  | 19  | 3   | 2.57 | 1.06 | EM-IS            | N.S.            |  |
|                                                                           | EM     | 199 | 30        | 38 | 93  | 31  | 7   | 2.70 | .90  | EM-EF            | .05             |  |
|                                                                           | DS     | 168 | 14        | 30 | 85  | 35  | 4   | 2.89 | .74  | EM-DS            | N.S.            |  |
|                                                                           | EF     | 48  | 13        | 14 | 15  | 5   | 1   | 2.29 | 1.02 | IS-DS            | .05             |  |
| (1-13) Direct employees toward established objectives.                    | IS     | 120 | 70        | 29 | 13  | 7   | 1   | 1.66 | .85  | EM-IS            | N.S.            |  |
|                                                                           | EM     | 199 | 102       | 62 | 26  | 7   | 2   | 1.71 | .74  | EM-EF            | N.S.            |  |
|                                                                           | DS     | 168 | 63        | 64 | 35  | 6   | -   | 1.90 | .72  | EM-DS            | .05             |  |
|                                                                           | EF     | 48  | 24        | 13 | 9   | 2   | -   | 1.77 | .81  | IS-DS            | .005            |  |
| (1-14) Rely on specialists for technical decisions.                       | IS     | 120 | 24        | 44 | 47  | 5   | -   | 2.28 | .69  | EM-IS            | N.S.            |  |
|                                                                           | EM     | 199 | 36        | 66 | 91  | 4   | 2   | 2.34 | .66  | EM-EF            | N.S.            |  |
|                                                                           | DS     | 168 | 37        | 64 | 59  | 6   | 2   | 2.23 | .72  | EM-DS            | N.S.            |  |
|                                                                           | EF     | 48  | 9         | 23 | 15  | 1   | -   | 2.17 | .56* | IS-DS            | N.S.            |  |
| (1-15) Facilitate communication on all levels.                            | IS     | 120 | 75        | 39 | 6   | -   | -   | 1.42 | .35* | EM-IS            | N.S.            |  |
|                                                                           | EM     | 199 | 122       | 60 | 16  | 1   | -   | 1.48 | .45* | EM-EF            | N.S.            |  |
|                                                                           | DS     | 168 | 98        | 48 | 19  | 3   | -   | 1.57 | .58* | EM-DS            | N.S.            |  |
|                                                                           | EF     | 48  | 29        | 11 | 8   | -   | -   | 1.56 | .59  | IS-DS            | N.S.            |  |
| (1-16) Manage engineers, not work alongside them.                         | IS     | 120 | 67        | 36 | 14  | 3   | -   | 1.61 | .62  | EM-IS            | N.S.            |  |
|                                                                           | EM     | 199 | 90        | 71 | 34  | 3   | 1   | 1.76 | .66  | EM-EF            | N.S.            |  |
|                                                                           | DS     | 168 | 72        | 61 | 32  | 1   | 2   | 1.80 | .66  | EM-DS            | N.S.            |  |
|                                                                           | EF     | 47  | 14        | 18 | 14  | 1   | -   | 2.04 | .69  | IS-DS            | N.S.            |  |
| (1-17) Create and propose new ideas in engineering.                       | IS     | 120 | 22        | 46 | 50  | 2   | -   | 2.27 | .59  | EM-IS            | N.S.            |  |
|                                                                           | EM     | 199 | 32        | 68 | 92  | 6   | 1   | 2.37 | .62  | EM-EF            | N.S.            |  |
|                                                                           | DS     | 168 | 17        | 50 | 97  | 4   | -   | 2.52 | .50* | EM-DS            | N.S.            |  |
|                                                                           | EF     | 48  | 12        | 20 | 14  | 2   | -   | 2.13 | .71  | IS-DS            | .05             |  |
| (1-18) Represent engineering in management decisions.                     | IS     | 120 | 82        | 27 | 9   | 2   | -   | 1.42 | .50* | EM-IS            | .05             |  |
|                                                                           | EM     | 199 | 114       | 66 | 19  | -   | -   | 1.52 | .45* | EM-EF            | N.S.            |  |
|                                                                           | DS     | 168 | 102       | 51 | 13  | 1   | 1   | 1.49 | .48* | EM-DS            | N.S.            |  |
|                                                                           | EF     | 47  | 31        | 15 | 1   | -   | -   | 1.36 | .28* | IS-DS            | N.S.            |  |
| (1-19) Justify and "sell" projects, ideas and plans to higher management. | IS     | 120 | 69        | 36 | 14  | 1   | -   | 1.56 | .53* | EM-IS            | N.S.            |  |
|                                                                           | EM     | 198 | 112       | 64 | 21  | 1   | -   | 1.55 | .49* | EM-EF            | N.S.            |  |
|                                                                           | DS     | 168 | 84        | 51 | 30  | 3   | -   | 1.71 | .67  | EM-DS            | N.S.            |  |
|                                                                           | EF     | 48  | 26        | 19 | 2   | 1   | -   | 1.54 | .46* | IS-DS            | N.S.            |  |

Table 10. Continued.

| Job Functions                                                                                   | Sample | N   | Responses |     |     |     |     | Mean | Var. | Compared Samples | Chi-Square Test |
|-------------------------------------------------------------------------------------------------|--------|-----|-----------|-----|-----|-----|-----|------|------|------------------|-----------------|
|                                                                                                 |        |     | AM        | PS  | MMN | PSN | AMN |      |      |                  |                 |
| (1-20) Assess problems and progress.                                                            | IS     | 120 | 93        | 23  | 4   | -   | -   | 1.26 | .26* | EM-IS            | N.S.            |
|                                                                                                 | EM     | 199 | 142       | 43  | 13  | 1   | -   | 1.36 | .40* | EM-EF            | N.S.            |
|                                                                                                 | DS     | 168 | 90        | 56  | 21  | 1   | -   | 1.60 | .53* | EM-DS            | .01             |
|                                                                                                 | EF     | 48  | 30        | 17  | 1   | -   | -   | 1.40 | .29* | IS-DS            | .001            |
| (1-21) Ask penetrating questions to provide insight.                                            | IS     | 120 | 62        | 45  | 13  | -   | -   | 1.59 | .46* | EM-IS            | N.S.            |
|                                                                                                 | EM     | 199 | 87        | 78  | 31  | 3   | -   | 1.75 | .59* | EM-EF            | N.S.            |
|                                                                                                 | DS     | 167 | 54        | 80  | 30  | 3   | -   | 1.89 | .56* | EM-DS            | N.S.            |
|                                                                                                 | EF     | 48  | 18        | 20  | 10  | -   | -   | 1.83 | .56* | IS-DS            | .01             |
| (1-22) Encourage his engineers to justify and "sell" projects, ideas and plans to him.          | IS     | 120 | 38        | 66  | 15  | 1   | -   | 1.83 | .45* | EM-IS            | N.S.            |
|                                                                                                 | EM     | 199 | 70        | 102 | 25  | 1   | 1   | 1.79 | .48* | EM-EF            | N.S.            |
|                                                                                                 | DS     | 168 | 51        | 89  | 22  | 5   | 1   | 1.90 | .58* | EM-DS            | N.S.            |
|                                                                                                 | EF     | 48  | 16        | 20  | 12  | -   | -   | 1.92 | .59  | IS-DS            | N.S.            |
| (1-23) Recruit and select engineers.                                                            | IS     | 120 | 28        | 41  | 41  | 9   | 1   | 2.28 | .85  | EM-IS            | N.S.            |
|                                                                                                 | EM     | 199 | 45        | 79  | 67  | 8   | -   | 2.19 | .69  | EM-EF            | N.S.            |
|                                                                                                 | DS     | 168 | 29        | 49  | 74  | 14  | 2   | 2.46 | .79  | EM-DS            | .05             |
|                                                                                                 | EF     | 47  | 13        | 15  | 17  | 2   | -   | 2.17 | .79  | IS-DS            | N.S.            |
| (1-24) Keep abreast of the current state of the art of engineering.                             | IS     | 120 | 50        | 55  | 13  | 2   | -   | 1.73 | .52* | EM-IS            | N.S.            |
|                                                                                                 | EM     | 199 | 80        | 101 | 16  | 2   | -   | 1.70 | .44* | EM-EF            | N.S.            |
|                                                                                                 | DS     | 168 | 54        | 93  | 19  | 2   | -   | 1.82 | .45* | EM-DS            | N.S.            |
|                                                                                                 | EF     | 48  | 23        | 18  | 7   | -   | -   | 1.67 | .52* | IS-DS            | N.S.            |
| (1-25) Keep abreast of the current state of the art of management.                              | IS     | 120 | 62        | 50  | 8   | -   | -   | 1.55 | .38* | EM-IS            | N.S.            |
|                                                                                                 | EM     | 199 | 124       | 68  | 7   | -   | -   | 1.41 | .31* | EM-EF            | .05             |
|                                                                                                 | DS     | 168 | 93        | 66  | 9   | -   | -   | 1.50 | .36* | EM-DS            | N.S.            |
|                                                                                                 | EF     | 48  | 21        | 21  | 6   | -   | -   | 1.69 | .48* | IS-DS            | N.S.            |
| (1-26) Promote, organize, implement and support educational development programs for employees. | IS     | 120 | 34        | 57  | 25  | 3   | 1   | 1.99 | .62  | EM-IS            | N.S.            |
|                                                                                                 | EM     | 199 | 68        | 82  | 44  | 4   | 1   | 1.93 | .66  | EM-EF            | N.S.            |
|                                                                                                 | DS     | 166 | 42        | 72  | 44  | 6   | 2   | 2.11 | .71  | EM-DS            | N.S.            |
|                                                                                                 | EF     | 48  | 14        | 17  | 13  | 4   | -   | 2.15 | .90  | IS-DS            | N.S.            |
| (1-27) Familiarize himself in general with the work of those engineers reporting to him.        | IS     | 120 | 84        | 33  | 2   | 1   | -   | 1.33 | .31* | EM-IS            | N.S.            |
|                                                                                                 | EM     | 199 | 140       | 53  | 4   | 2   | -   | 1.34 | .32* | EM-EF            | N.S.            |
|                                                                                                 | DS     | 168 | 110       | 51  | 5   | 1   | 1   | 1.40 | .37* | EM-DS            | N.S.            |
|                                                                                                 | EF     | 48  | 31        | 16  | 1   | -   | -   | 1.38 | .28* | IS-DS            | N.S.            |
| (1-28) Familiarize himself in detail with the work of those engineers reporting to him.         | IS     | 120 | 3         | 7   | 48  | 41  | 21  | 3.41 | .52* | EM-IS            | N.S.            |
|                                                                                                 | EM     | 199 | 2         | 20  | 86  | 67  | 24  | 3.34 | .49* | EM-EF            | .005            |
|                                                                                                 | DS     | 168 | 1         | 17  | 62  | 65  | 23  | 3.41 | .48* | EM-DS            | N.S.            |
|                                                                                                 | EF     | 48  | 2         | 11  | 25  | 10  | -   | 2.90 | .61  | IS-DS            | N.S.            |
| (1-29) Familiarize himself in detail with the job of his immediate superior.                    | IS     | 120 | 10        | 52  | 27  | 25  | 6   | 2.66 | .92  | EM-IS            | N.S.            |
|                                                                                                 | EM     | 199 | 16        | 90  | 53  | 29  | 11  | 2.59 | .81  | EM-EF            | N.S.            |
|                                                                                                 | DS     | 168 | 15        | 55  | 63  | 25  | 10  | 2.70 | .81  | EM-DS            | N.S.            |
|                                                                                                 | EF     | 48  | 5         | 20  | 17  | 6   | -   | 2.50 | .72  | IS-DS            | .05             |
| (1-30) Be available for consultation with his engineers as much as possible.                    | IS     | 120 | 49        | 62  | 8   | 1   | -   | 1.67 | .41* | EM-IS            | N.S.            |
|                                                                                                 | EM     | 199 | 73        | 102 | 21  | 3   | -   | 1.77 | .48* | EM-EF            | N.S.            |
|                                                                                                 | DS     | 168 | 44        | 98  | 21  | 4   | 1   | 1.92 | .50* | EM-DS            | N.S.            |
|                                                                                                 | EF     | 48  | 16        | 24  | 7   | 1   | -   | 1.85 | .55* | IS-DS            | .05             |
| (1-31) Train engineers on the job.                                                              | IS     | 120 | 30        | 30  | 35  | 18  | 7   | 2.46 | 1.17 | EM-IS            | N.S.            |
|                                                                                                 | EM     | 199 | 35        | 57  | 60  | 41  | 6   | 2.60 | 1.06 | EM-EF            | .01             |
|                                                                                                 | DS     | 168 | 15        | 45  | 52  | 41  | 15  | 2.89 | .96  | EM-DS            | .01             |
|                                                                                                 | EF     | 48  | 3         | 7   | 25  | 11  | 2   | 3.00 | .69  | IS-DS            | .005            |
| (1-32) Evaluate the work being done by his engineers.                                           | IS     | 120 | 77        | 32  | 8   | 2   | 1   | 1.48 | .53* | EM-IS            | N.S.            |
|                                                                                                 | EM     | 199 | 121       | 62  | 10  | 6   | -   | 1.50 | .53* | EM-EF            | .05             |
|                                                                                                 | DS     | 168 | 88        | 60  | 17  | 3   | -   | 1.61 | .55* | EM-DS            | N.S.            |
|                                                                                                 | EF     | 48  | 22        | 19  | 7   | -   | -   | 1.69 | .52* | IS-DS            | N.S.            |
| (1-33) Advise and counsel his engineers concerning technical aspects of their work.             | IS     | 120 | 23        | 43  | 44  | 6   | 4   | 2.34 | .77  | EM-IS            | N.S.            |
|                                                                                                 | EM     | 199 | 43        | 72  | 72  | 11  | 1   | 2.27 | .76  | EM-EF            | N.S.            |
|                                                                                                 | DS     | 168 | 15        | 70  | 70  | 11  | 2   | 2.48 | .59  | EM-DS            | .05             |
|                                                                                                 | EF     | 48  | 8         | 15  | 22  | 3   | -   | 2.42 | .72  | IS-DS            | N.S.            |
| (1-34) Counsel his engineers in personal problems affecting their work.                         | IS     | 120 | 23        | 38  | 46  | 12  | 1   | 2.41 | .85  | EM-IS            | N.S.            |
|                                                                                                 | EM     | 199 | 36        | 65  | 76  | 20  | 2   | 2.42 | .83  | EM-EF            | N.S.            |
|                                                                                                 | DS     | 168 | 17        | 52  | 70  | 23  | 6   | 2.66 | .77  | EM-DS            | N.S.            |
|                                                                                                 | EF     | 48  | 6         | 8   | 25  | 8   | 1   | 2.77 | .81  | IS-DS            | N.S.            |

\*Variance below median cutting point of .585, indicating high intraposition consensus.

the findings can more reasonably be interpreted as indicating "lack of disagreement" rather than "agreement." Further examination of the twenty-eight items, for which interposition consensus existed, revealed fourteen items (50 percent) where the variance for both samples was relatively low and, therefore, exhibited high intraposition consensus as categorized in Table 11. This occurred for items 7, 9, 10, 11, 15, 19, 20, 22, 24, 25, 27, 28, 30, and 32. Consensus between the engineering managers and their immediate superiors was one of decided positive reaction for the following: determine departmental or unit objectives; delegate authority; coordinate the efforts of subordinates; motivate employees to achieve objectives; facilitate communication on all levels; justify and "sell" projects, ideas and plans to higher management; assess problems and progress; encourage his engineers to justify and "sell" projects, ideas and plans to him; keep abreast of the current state of the art of engineering; keep abreast of the current state of the art of management; familiarize himself in general with the work of those engineers reporting to him; be available for consultation with his engineers as much as possible; and, evaluate work being done by his engineers. Consensus in a negative vein was noted when both groups indicated that the engineering manager preferably should not familiarize himself in detail with the work of those engineers reporting to him (Item 1-28).

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Table 11. Classification of twenty-nine job function items according to consensus within each of the samples and according to significant degree of disagreement between two samples. (Engineering Managers--Immediate Superiors.)

| Disagreement<br>Between the<br>Two Samples | High (H) or Low (L) Consensus Within Each Sample |                                 |                                 |                                 | Totals |
|--------------------------------------------|--------------------------------------------------|---------------------------------|---------------------------------|---------------------------------|--------|
|                                            | H <sub>EM</sub> H <sub>IS</sub>                  | H <sub>EM</sub> L <sub>IS</sub> | L <sub>EM</sub> H <sub>IS</sub> | L <sub>EM</sub> L <sub>IS</sub> |        |
| Nonsignificant                             | 14                                               | -                               | 2                               | 12                              | 28     |
| Significant                                | 1                                                | -                               | -                               | -                               | 1      |
| Totals                                     | 15                                               | -                               | 2                               | 12                              | 29     |

A further analysis of the data disclosed a significant difference between the engineering managers and their immediate superiors on only one of the twenty-nine items in the job function section of the questionnaire-schedule. This difference occurred at the .05 level on item 1-18 where the engineering managers indicated a lesser (57 percent) preference than the superiors (68 percent) that the engineering manager "absolutely must" represent engineering in management decisions. High intraposition consensus was exhibited on this item for both samples as shown in Table 11. When comparing the responses of the engineering managers and their immediate superiors, the null hypothesis can thus be rejected for one item: (1-18) represent engineering in management decisions.

#### Engineering Managers--Direct Subordinates

In comparing the responses of the engineering managers and their direct subordinates to the items related to the job function of the engineering manager, interposition consensus existed on twenty of the twenty-nine items. Analysis of these twenty items revealed high intraposition consensus for both samples on ten items as shown in Table 12. Interposition and intraposition consensus occurred on items 9, 15, 18, 22, 24, 25, 27, 28, 30, and 32. Nine of these items, for which consensus existed between and within the samples of engineering managers and their direct subordinates,

Table 12. Classification of twenty-nine job function items according to consensus within each of the samples and according to significant degree of disagreement between two samples. (Engineering Managers--Direct Subordinates.)

| Disagreement<br>Between the<br>Two Samples | High (H) or Low (L) Consensus Within Each Sample |                                 |                                 |                                 | Totals |
|--------------------------------------------|--------------------------------------------------|---------------------------------|---------------------------------|---------------------------------|--------|
|                                            | H <sub>EM</sub> H <sub>DS</sub>                  | H <sub>EM</sub> L <sub>DS</sub> | L <sub>EM</sub> H <sub>DS</sub> | L <sub>EM</sub> L <sub>DS</sub> |        |
| Nonsignificant                             | 10                                               | 2                               | 2                               | 6                               | 20     |
| Significant                                | 2                                                | 1                               | -                               | 6                               | 9      |
| Totals                                     | 12                                               | 3                               | 2                               | 12                              | 29     |

were among those fourteen items disclosing interposition and intraposition consensus for the engineering managers and the immediate superiors. The engineering managers and the direct subordinates expressed positive consensus that the engineering manager should represent engineering in management decisions (Item 1-18). Negative consensus was exhibited on Item 1-28 for the engineering managers and the direct subordinates. That is, both samples responded that the engineering manager "preferably should not" familiarize himself in detail with the work of those engineers reporting to him.

Significant differences in expectations occurred in comparing the responses of the engineering managers and their direct subordinates on nine of the twenty-nine job function items. The data revealed, that for all nine items indicating significant differences in the responses of the engineering managers and their direct subordinates, the engineering managers expressed a more positive attitude than their subordinates. Seventy-four (74) percent of the engineering managers responded that the engineering manager "absolutely must" plan departmental or unit operations, while 56 percent of the direct subordinates indicated such (Item 1-6). In addition, the engineering managers noted a stronger preference for engineering managers to organize resources for carrying out plans (Item 1-8). Fifty-nine (59) percent of the engineering managers

indicated that the engineering manager "absolutely must" do this as compared to 42 percent of the direct subordinates. With regard to coordinating the efforts of subordinates, 72 percent of the engineering managers responded "absolutely must," while 58 percent of the subordinates reacted thus (Item 1-10). A similar pattern of replies to Item 1-11, motivate employees to achieve objectives, revealed an "absolutely must" response from 72 percent of the managers and 54 percent of the direct subordinates. Another job function of the engineering manager, in which the managers and their direct subordinates differed in intensity of response, dealt with directing employees toward established objectives (Item 1-13). More than 50 percent of the engineering managers believed that they "absolutely must" direct employees toward established objectives, while this same feeling was expressed by only 37 percent of their subordinates. Also given high preference as a job function of the engineering manager but still revealing a significant difference in the responses of the managers and their subordinates was Item 1-20, assess problems and progress. Seventy-one (71) percent of the managers responded "absolutely must" to this item compared to 54 percent of the direct subordinates.

Another item in which a significant difference in response occurred was Item 1-23. Sixty-three (63) percent of the engineering managers felt that the engineering

managers should recruit and select engineers compared to 46 percent of the direct subordinates. In addition, the engineering managers indicated a stronger preference for managers to train engineers on the job (Item 1-31). Forty-seven (47) percent of the engineering managers so indicated, while 36 percent of the subordinates indicated likewise. On the final item in the section (Item 1-33) for which a significant difference in responses occurred, 68 percent of the engineering managers were of the opinion that the engineering manager should advise and counsel his engineers concerning technical aspects of their work. Fifty-one (51) percent of the direct subordinates shared this same preference.

Table 12 shows the disagreement between the engineering managers and their direct subordinates, and classifies the 29 job function items according to consensus within each of the samples. Six of the nine items showing that significant differences exist between the engineering managers and their direct subordinates indicate high variance or low intraposition consensus for both samples. On only two of the items is there a combination of high intraposition consensus within both samples and a significant difference representing divergence of opinion between the engineering managers and their direct subordinates. When comparing the responses of the engineering managers and the direct subordinates the null hypothesis is rejected

for two items, namely:

- (1-11) Motivate employees to achieve objectives; and
- (1-20) Assess problems and progress.

#### Engineering Managers--Engineering Faculty

The responses of the engineering managers concerning the job role of the engineering manager were also compared with those of the engineering faculty. The data revealed interposition consensus on twenty-four of the twenty-nine items as seen in Table 13. Further analysis disclosed high intraposition consensus for both samples on nine items, namely; 9, 10, 11, 18, 19, 20, 24, 27, and 30. Consensus on these items was positive for the following: delegate authority; coordinate the efforts of subordinates; motivate employees to achieve objectives; represent engineering in management decisions; justify and "sell" projects, ideas and plans to higher management; assess problems and progress; keep abreast of the current state of the art of engineering; familiarize himself in general with the work of those engineers reporting to him; and, be available for consultation with his engineers as much as possible. Four of the items as underlined above, revealed high intraposition consensus for all three samples. These were items 9, 24, 27, and 30.

Significant differences in expectations between the engineering managers and the engineering faculty existed on five of the twenty-nine items. There was a significant

Table 13. Classification of twenty-nine job function items according to consensus within each of the samples and according to significant degree of disagreement between two samples. (Engineering Managers--Engineering Faculty.)

| Disagreement<br>Between the<br>Two Samples | High (H) or Low (L) Consensus Within Each Sample |                                 |                                 |                                 | Totals |
|--------------------------------------------|--------------------------------------------------|---------------------------------|---------------------------------|---------------------------------|--------|
|                                            | H <sub>EM</sub> H <sub>EF</sub>                  | H <sub>EM</sub> L <sub>EF</sub> | L <sub>EM</sub> H <sub>EF</sub> | L <sub>EM</sub> L <sub>EF</sub> |        |
| Nonsignificant                             | 9                                                | 3                               | 3                               | 9                               | 24     |
| Significant                                | 2                                                | 1                               | -                               | 2                               | 5      |
| Totals                                     | 11                                               | 4                               | 3                               | 11                              | 29     |



difference in expectations regarding the engineering manager making decisions concerning the technical work of subordinates (Item 1-12). Thirty-four (34) percent of the engineering managers were of the opinion that the engineering manager should do this, as compared to 56 percent of the engineering faculty. (The modal response of the engineering managers to this item was "may or may not.")

Another item in which the engineering managers expressed a less positive attitude than the faculty was Item 1-28. Forty-three (43) percent of the engineering managers responded that the engineering manager may or may not familiarize himself in detail with the work of those engineers reporting to him, as compared to 52 percent of the engineering faculty. (The modal response of the engineering managers to this item, however, was that he preferably should not do this.) Both the managers and faculty preferred that the engineering manager keep abreast of the current state of the art of management (Item 1-25).

However, 62 percent of the managers responded that he "absolutely must" do this compared to 44 percent of the engineering faculty. A similar pattern of response occurred for Item 1-32. Sixty-one (61) percent of the engineering managers felt that the manager "absolutely must" evaluate work being done by his engineers, while only 44 percent of the engineering faculty were of this strong an opinion. Finally, there was a significant difference in

expectations regarding the engineering manager training engineers on the job (Item 1-31). The modal response of the engineering managers was that he "preferably should" do this with 47 percent of the sample responding as such. The modal response of the engineering faculty was that the manager "may or may not" do this with 52 percent of the engineering faculty expressing this opinion.

Table 13 categorizes the disagreement between the engineering managers and the engineering faculty, and classifies the items according to consensus within each of the two samples. Two of the five items showing that significant differences exist between the engineering managers and the engineering faculty indicate low intraposition consensus for both samples. High intraposition consensus is revealed for two items which show significant differences. The null hypothesis can thus be rejected for two items when comparing the responses of the engineering managers and the engineering faculty, namely:

(1-25) Keep abreast of the current state of the art of management; and

(1-32) Evaluate work done by his engineers.

Inasmuch as both the Immediate Superiors and the Direct Subordinates have a direct influence on the Engineering Managers, an additional comparison of these two groups was undertaken.

Hypothesis 1a.--There is no significant difference in the expectations that immediate superiors and direct subordinates hold for the job functions of the engineering manager.

The group mean and variance responses, as well as the level of significance of difference between the two groups for each of the 29 items concerning the job functions of the engineering manager, are summarized in Table 10.

#### Immediate Superiors--Direct Subordinates

The data revealed interposition consensus on seventeen of the twenty-nine items, as shown in Table 14. Further analysis revealed high intraposition consensus for both groups on eight items, namely, 9, 15, 18, 22, 24, 25, 27, and 28. Consensus on these items was positive for the following: delegate authority; facilitate communication on all levels; represent engineering in management decisions; encourage his engineers to justify and "sell" projects, ideas and plans to him; keep abreast of the current state of the art of engineering; keep abreast of the current state of the art of management; familiarize himself in general with the work of those engineers reporting to him. Consensus on Item 28, familiarize himself in detail with the work of those engineers reporting to him, was negative.

Table 14. Classification of twenty-nine job function items according to consensus within each of the samples and according to significant degree of disagreement between two samples. (Immediate Superiors--Direct Subordinates.)

| Disagreement<br>Between the<br>Two Samples | High (H) or Low (L) Consensus Within Each Sample |                                 |                                 |                                 | Totals |
|--------------------------------------------|--------------------------------------------------|---------------------------------|---------------------------------|---------------------------------|--------|
|                                            | H <sub>IS</sub> H <sub>DS</sub>                  | H <sub>IS</sub> L <sub>DS</sub> | L <sub>IS</sub> H <sub>DS</sub> | L <sub>IS</sub> L <sub>DS</sub> |        |
| Nonsignificant                             | 8                                                | 3                               | -                               | 6                               | 17     |
| Significant                                | 4                                                | 2                               | 1                               | 5                               | 12     |
| Totals                                     | 12                                               | 5                               | 1                               | 11                              | 29     |

Significant differences in expectations between the immediate superiors and the direct subordinates existed on twelve (41 percent) of the twenty-nine items. The modal response for both the superiors and the subordinates on Item (1-10) revealed that the engineering manager "absolutely must" coordinate the efforts of subordinates; however, 73 percent of the immediate superiors indicated this expectation as compared to 58 percent of the direct subordinates. Similar patterns occurred in the responses of the superiors and the subordinates for Items (1-11) and (1-20). Eighty (80) percent of the immediate superiors felt that the engineering manager "absolutely must" motivate employees to achieve objectives, while 54 percent of the direct subordinates felt that this "absolute must" be done. Likewise, 78 percent of the superiors were of the opinion that the engineering manager "absolutely must" assess problems and progress compared to 54 percent of the direct subordinates.

In addition, the immediate superiors noted a much stronger preference for engineering managers directing employees toward established objectives (Item 1-13). Fifty-eight (58) percent of the superiors believed that the engineering manager "absolutely must" do this as compared to a modal response of 38 percent of the direct subordinates who felt that he "preferably should." The function of the engineering manager to train engineers on the job was the

topic of Item (1-31). The responses of both groups of role-definers were somewhat scattered over the first four points on the scale, making it difficult for a definite role expectation to emerge from this item. However, 50 percent of the immediate superiors did express a positive attitude toward this as a job function of the engineering manager compared to 36 percent of the direct subordinates.

More immediate superiors than direct subordinates strongly preferred that the engineering manager plan departmental or unit operations (Item 1-6). Seventy-three (73) percent of the superiors believed that he "absolutely must" do this, compared to 56 percent of the direct subordinates. Immediate superiors also preferred that the engineering manager organize resources for carrying out plans (Item 1-8). Fifty-eight (58) percent of the immediate superiors felt that the engineering manager "absolutely must" do this as compared to 42 percent of the direct subordinates. Even though both the immediate superiors and the direct subordinates were of the opinion that the engineering manager should ask penetrating questions to provide insight (Item 1-21), 52 percent of the superiors felt that this was mandatory as compared to 32 percent of the subordinates.

A significant difference existed in expectations regarding the function of the engineering manager to create and propose new ideas in engineering (Item 1-17). Fifty-six

(56) percent of the immediate superiors were of the opinion that the engineering manager "preferably should" do this, whereas the modal response (58 percent) of the direct subordinates indicated that he "may or may not" do so. With regard to the engineering manager making decisions concerning the technical work of subordinates (Item 1-12), the immediate superiors exhibited a slightly more positive attitude (40 percent) than did the direct subordinates (25 percent). Both the immediate superiors and the direct subordinates expressed a positive attitude with regard to Item (1-29). Forty-three (43) percent of the superiors felt that the engineering manager "preferably should" familiarize himself in detail with the job of his immediate superior compared to 33 percent of the subordinates. Finally, with regard to the engineering manager being available for consultation with his engineers as much as possible (Item 1-30), the modal response of both groups was that he "preferably should." Fifty-two (52) percent of the superiors and 58 percent of the subordinates responded as such; however, 41 percent of the superiors were of the opinion that he "absolutely must" be available as compared to 26 percent of the subordinates.

Table 14 categorizes the disagreement between the immediate superiors and the direct subordinates, and classifies the items according to consensus within each of the two samples. Five of the twelve items showing that

significant differences exist between the immediate superiors and the direct subordinates indicate low intraposition consensus for both samples. High intraposition consensus is revealed for four items which show significant differences. The null hypothesis can thus be rejected for four items when comparing the responses of the immediate superiors and the direct subordinates, namely:

- (1-11) Motivate employees to achieve objectives;
- (1-20) Assess problems and progress;
- (1-21) Ask penetrating questions to provide insight;  
and
- (1-30) Be available for consultation with his engineers as much as possible.

#### Analysis of Role Differences

An examination of those items for which there is high intraposition consensus within the samples but significant disagreement between the samples will aid in determining some areas of possible role differences. On some of the items the differences revealed may be considered to be due to varying degrees of intensity with which the respondents express their expectations, that is, the disagreement may be on whether the expectation is mandatory or preferred.

The engineering managers and their immediate superiors disagreed on only one item on which there was substantial intraposition consensus. In response to Item 1-18,



57 percent of the engineering managers felt that the engineering manager "absolutely must" represent engineering in management decisions as compared to 68 percent of the immediate superiors.

The engineering managers disagreed with their direct subordinates on Items 1-11 and 1-20. The managers expressed a stronger opinion than the subordinates that the engineering manager "absolutely must" motivate employees to achieve objectives (Item 1-11). The managers also expressed a stronger opinion than the subordinates that the engineering manager "absolutely must" assess problems and progress (Item 1-20). In both instances, over 70 percent of the engineering managers indicated that these functions were mandatory, as compared to 54 percent of the direct subordinates.

Significant differences in expectations were noted between the engineering managers and the engineering faculty for two items. The managers indicated a stronger preference than the faculty that the engineering manager keep abreast of the current state of the art of management (Item 1-25), and that he evaluate work done by his engineers (Item 1-32). These conclusions are supported by the finding that over 60 percent of the engineering managers felt that these functions were mandatory as compared to 44 percent of the engineering faculty.

The immediate superiors and the direct subordinates disagreed on four items, namely, 11, 20, 21, and 30. Eighty percent (80) of the superiors believed that the engineering manager "absolutely must" motivate employees to achieve objectives (Item 1-11), as compared to 54 percent of the direct subordinates. A similar pattern of response was expressed on Item 1-20 when 78 percent of the superiors and 54 percent of the subordinates felt that the engineering manager "absolutely must" assess problems and progress. Further comparisons revealed the modal response (52 percent) of the immediate superiors to Item 1-21 indicating that the manager "absolutely must" ask penetrating questions to provide insight; whereas, only 32 percent of the direct subordinates held this strong an opinion. In response to Item 1-30, 41 percent of the superiors believed that it was mandatory that the engineering manager should be available for consultation with his engineers as much as possible, compared to 26 percent of the direct subordinates.

#### Analysis of Role Ambiguity

Role ambiguity refers to the degree of uncertainty among role expectations for an incumbent of a particular position. Criteria of role ambiguity include: low consensus among the responses; the tendency for the modal response to fall in the neutral category; and the occurrence

of a bimodal distribution. Analysis of the data reveals seven items which satisfy one or more of these criteria for all four groups and indicate areas of role ambiguity:

- (1-12) Make decisions concerning the technical work of subordinates;
- (1-23) Recruit and select engineers;
- (1-26) Promote, organize, implement and support educational development programs for employees;
- (1-29) Familiarize himself in detail with the job of his immediate superior;
- (1-31) Train engineers on the job;
- (1-33) Advise and counsel his engineers concerning technical aspects of their work; and
- (1-34) Counsel his engineers in personal problems affecting their work.

These seven items encompass various aspects of the role of the engineering manager. Items 1-12, 1-23, 1-31, 1-33, and 1-34 all pertain to the engineering manager's direct relationship with his subordinates. Three of these items deal with the technical orientation and involvement of the engineering manager with his subordinates and reveal that the role-definers are not in agreement as to the amount of initiative he should take with respect to making decisions concerning the technical work of subordinates, training engineers on the job, and advising and counseling his engineers concerning technical aspects of their work. The other two items are concerned with the engineering manager recruiting and selecting

engineers, and counseling them in personal problems affecting their work. Item 1-29 discloses ambiguity with respect to the orientation of the engineering manager toward the job of his immediate superior. Finally, there are mixed feelings among the role-definers as to whether the engineering manager should promote, organize, implement and support educational development programs for employees (Item 1-26).

#### Analysis of Role Consensus

To complete the macroscopic consensus analysis, emphasis will be placed on those role-expectation items which most of the members of a given sample agree "absolutely must" be a job function of the engineering manager. Examination of these items in terms of intraposition consensus for all four role-definer groups will give a positive expression of the job expectations which the majority of the members of a group hold for the engineering manager.

Focusing first on the sample of engineering managers, the following eleven items are listed according to modal frequencies ranging from 74.4 percent for Item 1-9 to 56.6 percent for Item 1-19:

- (1-9) Delegate authority;
- (1-11) Motivate employees to achieve objectives;
- (1-10) Coordinate the efforts of subordinates; and
- (1-20) Assess problems and progress.

- (1-27) Familiarize himself in general with the work of those engineers reporting to him;
- (1-7) Determine departmental or unit objectives;
- (1-25) Keep abreast of the current state of the art of management;
- (1-15) Facilitate communication on all levels;
- (1-32) Evaluate work being done by his engineers;
- (1-18) Represent engineering in management decisions;
- (1-19) Justify and "sell" projects, ideas, and plans to higher management.

In view of the fact that the majority of the engineering managers are in agreement that these are aspects of the role which the engineering manager must fulfill, the items will assist in developing a profile of that role.

For the immediate superiors, most of the members of the sample were in consensus that the engineering manager "absolutely must" meet the following thirteen role expectations which ranged from 80 percent for Item 1-11 to 51.7 percent for Item 1-21:

- (1-11) Motivate employees to achieve objectives;
- (1-20) Assess problems and progress;
- (1-10) Coordinate the efforts of subordinates;
- (1-6) Plan departmental or unit operations;
- (1-9) Delegate authority;
- (1-27) Familiarize himself in general with the work of those engineers reporting to him;
- (1-18) Represent engineering in management decisions;
- (1-7) Determine departmental or unit objectives;

- (1-32) Evaluate work being done by his engineers;
- (1-15) Facilitate communication on all levels;
- (1-19) Justify and "sell" projects, ideas, and plans to higher management;
- (1-25) Keep abreast of the current state of the art of management; and
- (1-21) Ask penetrating questions to provide insight.

Eleven of these thirteen items are common to those resulting from the responses of the engineering managers. Items 6 and 21 were not among the responses of the managers because there was less consensus among the engineering managers concerning the degree to which the engineering manager should plan departmental or unit operations and ask penetrating questions to provide insight. Otherwise, the engineering managers and their immediate superiors appear to be in consensus on the role of the engineering manager.

The responses of the direct subordinates showed greater dispersion; therefore, fewer items (eight) with intraposition consensus resulted. The modal frequencies ranged from 70.8 percent for Item 1-9 to 52.4 percent for Item 1-32:

- (1-9) Delegate authority;
- (1-27) Familiarize himself in general with the work of those engineers reporting to him;
- (1-18) Represent engineering in management decisions;
- (1-15) Facilitate communication on all levels;

- (1-25) Keep abreast of the current state of the art of management;
- (1-11) Motivate employees to achieve objectives;
- (1-20) Assess problems and progress; and
- (1-32) Evaluate work being done by his engineers.

All of these items coincide with the expectations of the engineering managers and the immediate superiors, indicating that there is some basic agreement on the role of the engineering manager among persons occupying different positions in the organizational hierarchy.

The majority of the engineering faculty members agreed that the following eleven items must be expected from the engineering manager, with percentages ranging from 70.8 for Item 1-11 to 43.8 for Item 1-25:

- (1-11) Motivate employees to achieve objectives;
- (1-9) Delegate authority;
- (1-10) Coordinate the efforts of subordinates;
- (1-18) Represent engineering in management decisions;
- (1-27) Familiarize himself in general with the work of those engineers reporting to him;
- (1-20) Assess problems and progress;
- (1-8) Organize resources for carrying out plans;
- (1-19) Justify and "sell" projects, ideas, and plans to higher management;
- (1-24) Keep abreast of the current state of the art of engineering;
- (1-32) Evaluate work being done by his engineers; and
- (1-25) Keep abreast of the current state of the art of management.

Seven of these eleven items also were included among those items common to the other three role-definer groups, lending additional support to the established area of consensus among the role-definers and to the development of a job standard for the engineering manager. Items 1-10 and 1-19 were common to the group of engineering managers and the group of immediate superiors, but were not common to the group of direct subordinates. Two items were unique to the engineering faculty. These items pertained to the expectations that the engineering manager must organize resources for carrying out plans (Item 1-8), and must keep abreast of the current state of the art of engineering (Item 1-24).

Those items, not in the above category, which showed intraposition consensus, involving the four individual groups, are now enumerated.

The four individual groups indicated a feeling of "preferably should" for the following item:

- (1-30) Be available for consultation with his engineers as much as possible.

The engineering managers, immediate superiors, and direct subordinates, as individual groups, expressed a feeling of "preferably should" for two items:

- (1-22) Encourage his engineers to justify and "sell" products, ideas, and plans to him; and
- (1-24) Keep abreast of the current state of the art of engineering.



The direct subordinates and the engineering faculty as individual groups, indicated a feeling of "preferably should" for the following item:

(1-21) Ask penetrating questions to provide insight.

The engineering faculty expressed a feeling of "preferably should" for the following item:

(1-14) Rely on specialists for technical decisions.

The engineering managers, immediate superiors, and direct subordinates expressed a negative feeling for the following item:

(1-28) Familiarize himself in detail with the work of those engineers reporting to him.

Hypothesis 2.--There is no significant difference in the perceptions engineering managers have of their continuing education activities and in the expectations held for them by their immediate superiors, direct subordinates, and by engineering faculty.

The group mean and variance responses, as well as the level of significance of difference between the compared groups for each of the 34 items concerning the continuing education activities of the engineering manager, are summarized in Table 15.

#### Engineering Managers--Immediate Superiors

An examination of the items in Section II revealed that consensus (no significant difference in expectations) existed between the engineering managers and their immediate

Table 15. Group frequency, mean, and variance responses, and significance of difference between groups on thirty-four items concerning continuing education activities of the engineering manager.

| Continuing Education Activities                                                                                              | Sample | N   | Responses |     |     |     |     | Mean | Var. | Compared Samples | Chi-Square Test |
|------------------------------------------------------------------------------------------------------------------------------|--------|-----|-----------|-----|-----|-----|-----|------|------|------------------|-----------------|
|                                                                                                                              |        |     | AM        | PS  | MMN | PSN | AMN |      |      |                  |                 |
| Section II                                                                                                                   |        |     |           |     |     |     |     |      |      |                  |                 |
| (1-35) Be active in a professional engineering society.                                                                      | IS     | 122 | 17        | 68  | 37  | -   | -   | 2.16 | .42  | EM-IS            | N.S.            |
|                                                                                                                              | EM     | 199 | 19        | 105 | 73  | 2   | -   | 2.29 | .42  | EM-EF            | .001            |
|                                                                                                                              | DS     | 168 | 14        | 90  | 63  | 1   | -   | 2.30 | .40* | EM-DS            | N.S.            |
|                                                                                                                              | EF     | 50  | 14        | 32  | 4   | -   | -   | 1.80 | .32* | IS-DS            | N.S.            |
| (1-36) Be active in a professional business or management society.                                                           | IS     | 122 | 3         | 44  | 74  | 1   | -   | 2.60 | .31* | EM-IS            | N.S.            |
|                                                                                                                              | EM     | 199 | 5         | 78  | 114 | 2   | -   | 2.57 | .31* | EM-EF            | N.S.            |
|                                                                                                                              | DS     | 168 | 8         | 67  | 92  | 1   | -   | 2.51 | .36* | EM-DS            | N.S.            |
|                                                                                                                              | EF     | 50  | 2         | 25  | 21  | 2   | -   | 2.46 | .42  | IS-DS            | N.S.            |
| (1-37) Pursue an advanced degree in engineering.                                                                             | IS     | 122 | -         | 20  | 97  | 5   | -   | 2.88 | .19* | EM-IS            | N.S.            |
|                                                                                                                              | EM     | 199 | 4         | 37  | 147 | 9   | 2   | 2.83 | .29* | EM-EF            | N.S.            |
|                                                                                                                              | DS     | 168 | 2         | 25  | 128 | 13  | -   | 2.90 | .27* | EM-DS            | N.S.            |
|                                                                                                                              | EF     | 50  | 2         | 10  | 33  | 5   | -   | 2.82 | .44  | IS-DS            | N.S.            |
| (1-38) Pursue an advanced degree in mathematics or the basic sciences.                                                       | IS     | 122 | -         | 4   | 103 | 14  | 1   | 3.09 | .15* | EM-IS            | N.S.            |
|                                                                                                                              | EM     | 199 | 2         | 9   | 150 | 35  | 3   | 3.13 | .26* | EM-EF            | N.S.            |
|                                                                                                                              | DS     | 168 | -         | 6   | 129 | 29  | 4   | 3.16 | .21* | EM-DS            | N.S.            |
|                                                                                                                              | EF     | 50  | 1         | 1   | 34  | 13  | 1   | 3.22 | .34* | IS-DS            | N.S.            |
| (1-39) Pursue an advanced degree in business management.                                                                     | IS     | 122 | 1         | 24  | 94  | 3   | -   | 2.81 | .22* | EM-IS            | .05             |
|                                                                                                                              | EM     | 199 | 5         | 68  | 124 | 2   | -   | 2.62 | .30* | EM-EF            | .001            |
|                                                                                                                              | DS     | 168 | 2         | 59  | 101 | 6   | -   | 2.66 | .32* | EM-DS            | N.S.            |
|                                                                                                                              | EF     | 50  | -         | 5   | 42  | 3   | -   | 2.96 | .16* | IS-DS            | .05             |
| (1-40) Take graduate credit work in engineering not necessarily for degree.                                                  | IS     | 122 | 5         | 30  | 84  | 3   | -   | 2.70 | .35* | EM-IS            | .05             |
|                                                                                                                              | EM     | 199 | 9         | 78  | 105 | 5   | 2   | 2.55 | .41  | EM-EF            | N.S.            |
|                                                                                                                              | DS     | 168 | 3         | 46  | 113 | 5   | 1   | 2.73 | .30* | EM-DS            | .05             |
|                                                                                                                              | EF     | 50  | 1         | 13  | 31  | 5   | -   | 2.80 | .41  | IS-DS            | N.S.            |
| (1-41) Take graduate credit work in mathematics or basic sciences, not necessarily for degree.                               | IS     | 122 | 2         | 20  | 92  | 8   | -   | 2.87 | .28* | EM-IS            | N.S.            |
|                                                                                                                              | EM     | 199 | 3         | 43  | 135 | 15  | 3   | 2.84 | .35* | EM-EF            | N.S.            |
|                                                                                                                              | DS     | 168 | 1         | 24  | 127 | 13  | 3   | 2.94 | .26* | EM-DS            | N.S.            |
|                                                                                                                              | EF     | 50  | 1         | 4   | 37  | 8   | -   | 3.04 | .32* | IS-DS            | N.S.            |
| (1-42) Take graduate credit work in business management, not necessarily for degree.                                         | IS     | 122 | 4         | 46  | 72  | -   | -   | 2.56 | .31* | EM-IS            | .05             |
|                                                                                                                              | EM     | 199 | 11        | 101 | 85  | 2   | -   | 2.39 | .37* | EM-EF            | .001            |
|                                                                                                                              | DS     | 168 | 10        | 72  | 84  | 2   | -   | 2.46 | .40* | EM-DS            | N.S.            |
|                                                                                                                              | EF     | 50  | -         | 13  | 34  | 3   | -   | 2.80 | .28* | IS-DS            | N.S.            |
| (1-43) Become familiar with the modern engineering curricula being offered in the leading colleges & universities.           | IS     | 122 | 26        | 79  | 16  | 1   | -   | 1.93 | .37* | EM-IS            | N.S.            |
|                                                                                                                              | EM     | 199 | 41        | 123 | 35  | -   | -   | 1.97 | .38* | EM-EF            | N.S.            |
|                                                                                                                              | DS     | 168 | 31        | 107 | 28  | 2   | -   | 2.01 | .40* | EM-DS            | N.S.            |
|                                                                                                                              | EF     | 50  | 12        | 30  | 7   | 1   | -   | 1.94 | .46  | IS-DS            | N.S.            |
| (1-44) Become familiar with the modern trends in business and management curricula in the leading colleges and universities. | IS     | 122 | 17        | 75  | 29  | 1   | -   | 2.11 | .40* | EM-IS            | N.S.            |
|                                                                                                                              | EM     | 199 | 35        | 108 | 55  | -   | 1   | 2.11 | .46  | EM-EF            | N.S.            |
|                                                                                                                              | DS     | 168 | 20        | 97  | 48  | 3   | -   | 2.20 | .44  | EM-DS            | N.S.            |
|                                                                                                                              | EF     | 50  | 5         | 27  | 17  | 1   | -   | 2.28 | .45  | IS-DS            | N.S.            |
| (1-45) Acquire certification as Professional Engineer.                                                                       | IS     | 122 | 15        | 33  | 73  | 1   | -   | 2.49 | .52  | EM-IS            | N.S.            |
|                                                                                                                              | EM     | 199 | 29        | 45  | 119 | 5   | 1   | 2.51 | .61  | EM-EF            | N.S.            |
|                                                                                                                              | DS     | 168 | 20        | 49  | 94  | 5   | -   | 2.50 | .55  | EM-DS            | N.S.            |
|                                                                                                                              | EF     | 50  | 9         | 15  | 23  | 3   | -   | 2.40 | .74  | IS-DS            | N.S.            |
| (1-46) Write and present technical and professional papers.                                                                  | IS     | 122 | 6         | 49  | 62  | 5   | -   | 2.54 | .44  | EM-IS            | N.S.            |
|                                                                                                                              | EM     | 199 | 4         | 88  | 98  | 9   | -   | 2.56 | .38* | EM-EF            | .05             |
|                                                                                                                              | DS     | 168 | 7         | 41  | 103 | 16  | 1   | 2.77 | .46  | EM-DS            | .001            |
|                                                                                                                              | EF     | 50  | 4         | 28  | 16  | 2   | -   | 2.32 | .46  | IS-DS            | .05             |
| (1-47) Attend local and national technical meetings on engineering.                                                          | IS     | 122 | 23        | 78  | 20  | 1   | -   | 1.99 | .38* | EM-IS            | N.S.            |
|                                                                                                                              | EM     | 199 | 23        | 131 | 45  | -   | -   | 2.11 | .34* | EM-EF            | .005            |
|                                                                                                                              | DS     | 168 | 15        | 107 | 44  | 2   | -   | 2.20 | .36* | EM-DS            | N.S.            |
|                                                                                                                              | EF     | 50  | 15        | 30  | 5   | -   | -   | 1.80 | .37* | IS-DS            | .05             |

\*Variance below median cutting point of .405, indicating high intraposition consensus.

Table 15. Continued.

| Continuing Education Activities                                                                           | Sample | N   | Responses |     |     |     |     | Mean | Var. | Compared Samples | Chi-Square Test |
|-----------------------------------------------------------------------------------------------------------|--------|-----|-----------|-----|-----|-----|-----|------|------|------------------|-----------------|
|                                                                                                           |        |     | AM        | PS  | MMN | PSN | AMN |      |      |                  |                 |
| (1-48) Subscribe to engineering or scientific journals.                                                   | IS     | 122 | 50        | 65  | 7   | -   | -   | 1.65 | .35* | EM-IS            | N.S.            |
|                                                                                                           | EM     | 199 | 73        | 106 | 19  | 1   | -   | 1.74 | .42  | EM-EF            | N.S.            |
|                                                                                                           | DS     | 168 | 44        | 107 | 17  | -   | -   | 1.84 | .34* | EM-DS            | N.S.            |
|                                                                                                           | EF     | 50  | 21        | 25  | 4   | -   | -   | 1.66 | .40* | IS-DS            | .05             |
| (1-49) Subscribe to business and management journals.                                                     | IS     | 122 | 27        | 67  | 28  | -   | -   | 2.01 | .45  | EM-IS            | N.S.            |
|                                                                                                           | EM     | 199 | 42        | 120 | 36  | 1   | -   | 1.98 | .41  | EM-EF            | N.S.            |
|                                                                                                           | DS     | 168 | 28        | 102 | 38  | -   | -   | 2.06 | .40* | EM-DS            | N.S.            |
|                                                                                                           | EF     | 50  | 10        | 29  | 10  | 1   | -   | 2.04 | .49  | IS-DS            | N.S.            |
| (1-50) Take time off during regular working hours to pursue continuing education programs.                | IS     | 122 | 3         | 21  | 70  | 28  | -   | 3.01 | .50  | EM-IS            | .05             |
|                                                                                                           | EM     | 199 | 8         | 54  | 111 | 25  | 1   | 2.78 | .52  | EM-EF            | N.S.            |
|                                                                                                           | DS     | 168 | 3         | 33  | 90  | 36  | 6   | 3.02 | .52  | EM-DS            | .05             |
|                                                                                                           | EF     | 50  | 4         | 18  | 19  | 9   | -   | 2.66 | .76  | IS-DS            | N.S.            |
| (1-51) Take time off for sabbatical leave to pursue advanced degree work.                                 | IS     | 122 | -         | 5   | 77  | 38  | 2   | 3.29 | .29* | EM-IS            | N.S.            |
|                                                                                                           | EM     | 199 | 1         | 13  | 118 | 61  | 6   | 3.26 | .36* | EM-EF            | .001            |
|                                                                                                           | DS     | 168 | -         | 6   | 105 | 51  | 6   | 3.30 | .28* | EM-DS            | N.S.            |
|                                                                                                           | EF     | 50  | 2         | 12  | 29  | 6   | 1   | 2.82 | .52  | IS-DS            | N.S.            |
| (1-52) Pursue advanced degree work simultaneously with job responsibilities.                              | IS     | 120 | -         | 22  | 74  | 23  | 1   | 3.02 | .38* | EM-IS            | N.S.            |
|                                                                                                           | EM     | 199 | 4         | 51  | 115 | 27  | 2   | 2.85 | .46  | EM-EF            | .05             |
|                                                                                                           | DS     | 168 | -         | 38  | 98  | 22  | 10  | 2.96 | .42  | EM-DS            | N.S.            |
|                                                                                                           | EF     | 50  | 1         | 2   | 37  | 10  | -   | 3.12 | .31* | IS-DS            | N.S.            |
| (1-53) Take advanced non-credit engineering courses.                                                      | IS     | 122 | 3         | 41  | 73  | 5   | -   | 2.66 | .36* | EM-IS            | N.S.            |
|                                                                                                           | EM     | 199 | 9         | 69  | 110 | 10  | 1   | 2.62 | .44  | EM-EF            | .05             |
|                                                                                                           | DS     | 168 | 3         | 38  | 110 | 14  | 3   | 2.84 | .37* | EM-DS            | .05             |
|                                                                                                           | EF     | 50  | 2         | 11  | 29  | 6   | 2   | 2.86 | .53  | IS-DS            | N.S.            |
| (1-54) Take advanced non-credit business and management courses.                                          | IS     | 122 | 3         | 46  | 73  | -   | -   | 2.55 | .29* | EM-IS            | .005            |
|                                                                                                           | EM     | 199 | 6         | 106 | 81  | 6   | -   | 2.44 | .37* | EM-EF            | .001            |
|                                                                                                           | DS     | 168 | 4         | 58  | 99  | 6   | 1   | 2.65 | .36* | EM-DS            | .005            |
|                                                                                                           | EF     | 50  | 1         | 11  | 32  | 5   | 1   | 2.86 | .41  | IS-DS            | N.S.            |
| (1-55) Take advanced non-credit courses in basic sciences.                                                | IS     | 122 | -         | 24  | 90  | 7   | 1   | 2.87 | .25* | EM-IS            | N.S.            |
|                                                                                                           | EM     | 199 | 6         | 50  | 125 | 17  | 1   | 2.78 | .41  | EM-EF            | N.S.            |
|                                                                                                           | DS     | 168 | 2         | 31  | 111 | 21  | 3   | 2.93 | .37* | EM-DS            | N.S.            |
|                                                                                                           | EF     | 50  | 1         | 6   | 33  | 8   | 2   | 3.04 | .41  | IS-DS            | N.S.            |
| (1-56) Become acquainted with the new technological ideas and associated terminology used in engineering. | IS     | 122 | 65        | 53  | 4   | -   | -   | 1.50 | .31* | EM-IS            | N.S.            |
|                                                                                                           | EM     | 198 | 112       | 81  | 5   | -   | -   | 1.46 | .30* | EM-EF            | .001            |
|                                                                                                           | DS     | 168 | 74        | 81  | 12  | 1   | -   | 1.64 | .41  | EM-DS            | .05             |
|                                                                                                           | EF     | 50  | 29        | 13  | 7   | 1   | -   | 1.40 | .66  | IS-DS            | N.S.            |
| Keep updated by attending such activities as:                                                             |        |     |           |     |     |     |     |      |      |                  |                 |
| (1-57) Engineering lectures and seminars.                                                                 | IS     | 122 | 45        | 71  | 6   | -   | -   | 1.68 | .31* | EM-IS            | N.S.            |
|                                                                                                           | EM     | 199 | 73        | 111 | 15  | -   | -   | 1.71 | .36* | EM-EF            | N.S.            |
|                                                                                                           | DS     | 168 | 45        | 96  | 27  | -   | -   | 1.89 | .42  | EM-DS            | .05             |
|                                                                                                           | EF     | 50  | 18        | 26  | 6   | -   | -   | 1.76 | .44  | IS-DS            | .05             |
| (1-58) Lectures and seminars on business management.                                                      | IS     | 122 | 27        | 78  | 17  | -   | -   | 1.92 | .36* | EM-IS            | N.S.            |
|                                                                                                           | EM     | 199 | 46        | 123 | 30  | -   | -   | 1.92 | .37* | EM-EF            | N.S.            |
|                                                                                                           | DS     | 168 | 30        | 108 | 30  | -   | -   | 2.00 | .36* | EM-DS            | N.S.            |
|                                                                                                           | EF     | 50  | 9         | 28  | 12  | 1   | -   | 2.10 | .50  | IS-DS            | N.S.            |
| (1-59) Short technical refresher courses.                                                                 | IS     | 122 | 15        | 66  | 40  | 1   | -   | 2.22 | .44  | EM-IS            | .05             |
|                                                                                                           | EM     | 199 | 36        | 124 | 36  | 2   | 1   | 2.03 | .42  | EM-EF            | N.S.            |
|                                                                                                           | DS     | 168 | 18        | 96  | 52  | 2   | -   | 2.23 | .41  | EM-DS            | .05             |
|                                                                                                           | EF     | 50  | 8         | 27  | 15  | -   | -   | 2.14 | .45  | IS-DS            | N.S.            |
| (1-60) Lectures in the liberal arts and humanities.                                                       | IS     | 122 | 6         | 26  | 82  | 8   | -   | 2.75 | .42  | EM-IS            | .05             |
|                                                                                                           | EM     | 199 | 3         | 70  | 112 | 12  | 2   | 2.69 | .38* | EM-EF            | .05             |
|                                                                                                           | DS     | 168 | 9         | 36  | 108 | 14  | 1   | 2.77 | .46  | EM-DS            | .01             |
|                                                                                                           | EF     | 50  | 4         | 11  | 34  | 1   | -   | 2.64 | .44  | IS-DS            | N.S.            |

Table 15. Continued.

| Continuing Education Activities                           | Sample | N   | Responses |     |     |     |     | Mean | Var. | Compared Samples | Chi-Square Test |
|-----------------------------------------------------------|--------|-----|-----------|-----|-----|-----|-----|------|------|------------------|-----------------|
|                                                           |        |     | AM        | PS  | MMN | PSN | AMN |      |      |                  |                 |
| Keep updated by utilizing such sources of information as: |        |     |           |     |     |     |     |      |      |                  |                 |
| (1-61) Technical and trade journals.                      | IS     | 122 | 66        | 52  | 4   | -   | -   | 1.49 | .31* | EM-IS            | N.S.            |
|                                                           | EM     | 199 | 100       | 85  | 14  | -   | -   | 1.57 | .38* | EM-EF            | N.S.            |
|                                                           | DS     | 168 | 56        | 96  | 15  | 1   | -   | 1.77 | .40* | EM-DS            | .01             |
|                                                           | EF     | 50  | 23        | 23  | 4   | -   | -   | 1.62 | .41  | IS-DS            | .005            |
| (1-62) Technical abstracts and indexes.                   | IS     | 122 | 34        | 60  | 28  | -   | -   | 1.95 | .50  | EM-IS            | N.S.            |
|                                                           | EM     | 199 | 43        | 89  | 64  | 2   | 1   | 2.14 | .58  | EM-EF            | N.S.            |
|                                                           | DS     | 168 | 29        | 78  | 56  | 5   | -   | 2.22 | .58  | EM-DS            | N.S.            |
|                                                           | EF     | 50  | 15        | 25  | 9   | 1   | -   | 1.92 | .56  | IS-DS            | .05             |
| (1-63) Technical books and reports.                       | IS     | 122 | 33        | 67  | 22  | -   | -   | 1.91 | .45  | EM-IS            | N.S.            |
|                                                           | EM     | 199 | 42        | 107 | 45  | 4   | 1   | 2.07 | .53  | EM-EF            | N.S.            |
|                                                           | DS     | 167 | 21        | 99  | 46  | 1   | -   | 2.16 | .40* | EM-DS            | N.S.            |
|                                                           | EF     | 50  | 14        | 27  | 9   | -   | -   | 1.90 | .46  | IS-DS            | .01             |
| (1-64) Business reports (marketing, sales, etc).          | IS     | 122 | 24        | 58  | 37  | 3   | -   | 2.16 | .58  | EM-IS            | N.S.            |
|                                                           | EM     | 199 | 24        | 114 | 60  | 1   | -   | 2.19 | .41  | EM-EF            | N.S.            |
|                                                           | DS     | 168 | 15        | 87  | 64  | 2   | -   | 2.32 | .42  | EM-DS            | N.S.            |
|                                                           | EF     | 50  | 7         | 25  | 18  | -   | -   | 2.22 | .46  | IS-DS            | .05             |
| (1-65) Manufacturer's literature.                         | IS     | 122 | 14        | 66  | 39  | 3   | -   | 2.25 | .48  | EM-IS            | N.S.            |
|                                                           | EM     | 199 | 20        | 84  | 89  | 6   | -   | 2.41 | .50  | EM-EF            | N.S.            |
|                                                           | DS     | 168 | 12        | 59  | 85  | 11  | 1   | 2.58 | .53  | EM-DS            | N.S.            |
|                                                           | EF     | 50  | 9         | 16  | 24  | 1   | -   | 2.34 | .64  | IS-DS            | .005            |
| (1-66) Business and management journals.                  | IS     | 122 | 21        | 60  | 41  | -   | -   | 2.16 | .49  | EM-IS            | N.S.            |
|                                                           | EM     | 199 | 27        | 116 | 56  | -   | -   | 2.15 | .40* | EM-EF            | N.S.            |
|                                                           | DS     | 168 | 15        | 97  | 54  | 2   | -   | 2.26 | .40* | EM-DS            | N.S.            |
|                                                           | EF     | 50  | 7         | 24  | 19  | -   | -   | 2.24 | .48  | IS-DS            | N.S.            |
| (1-67) Engineering Consultants                            | IS     | 122 | 9         | 31  | 76  | 5   | 1   | 2.65 | .48  | EM-IS            | N.S.            |
|                                                           | EM     | 199 | 18        | 68  | 105 | 7   | 1   | 2.52 | .52  | EM-EF            | N.S.            |
|                                                           | DS     | 168 | 6         | 58  | 97  | 6   | 1   | 2.63 | .40* | EM-DS            | N.S.            |
|                                                           | EF     | 50  | 7         | 21  | 22  | -   | -   | 2.30 | .50  | IS-DS            | N.S.            |
| (1-68) Management consultants                             | IS     | 122 | 4         | 27  | 81  | 8   | 2   | 2.80 | .40* | EM-IS            | N.S.            |
|                                                           | EM     | 199 | 11        | 58  | 118 | 11  | 1   | 2.66 | .46  | EM-EF            | N.S.            |
|                                                           | DS     | 168 | 4         | 56  | 100 | 6   | 2   | 2.67 | .37* | EM-DS            | N.S.            |
|                                                           | EF     | 50  | 6         | 17  | 26  | 1   | -   | 2.44 | .53  | IS-DS            | N.S.            |

superiors on twenty-seven of the thirty-four items. On eight of the items on which the chi-square between the two distributions is insignificant, there is low consensus within both groups. Further examination revealed eleven items (41 percent) which exhibited high intra-position consensus as shown in Table 16. This occurred for items 36, 37, 38, 41, 43, 47, 51, 56, 57, 58, and 61. Consensus between the engineering managers and their immediate superiors was in the positive direction for the following six items: become familiar with the modern engineering curricula being offered in the leading colleges and universities; attend local and national technical meetings on engineering; become acquainted with the new technological ideas and associated terminology used in engineering; keep updated by attending such activities as engineering lectures and seminars, and lectures and seminars on business management; and, keep updated by utilizing such sources of information as technical and trade journals. Consensus in a more neutral vein was noted for the following five items: be active in a professional business or management society; pursue an advanced degree in engineering; pursue an advanced degree in mathematics or the basic sciences; take graduate credit work in mathematics or basic sciences, not necessarily for a degree; and, take time off for sabbatical leave to pursue advanced degree work.

Table 16. Classification of thirty-four continuing education activity items according to consensus within each of the samples and according to significant degree of disagreement between two samples. (Engineering Managers--Immediate Superiors.)

| Disagreement<br>Between the<br>Two Samples | High (H) or Low (L) Consensus Within Each Sample |                                 |                                 |                                 | Totals |
|--------------------------------------------|--------------------------------------------------|---------------------------------|---------------------------------|---------------------------------|--------|
|                                            | H <sub>EM</sub> H <sub>IS</sub>                  | H <sub>EM</sub> L <sub>IS</sub> | L <sub>EM</sub> H <sub>IS</sub> | L <sub>EM</sub> L <sub>IS</sub> |        |
| Nonsignificant                             | 11                                               | 2                               | 6                               | 8                               | 27     |
| Significant                                | 3                                                | 1                               | 1                               | 2                               | 7      |
| Totals                                     | 14                                               | 3                               | 7                               | 10                              | 34     |

Significant differences in expectations occurred between the engineering managers and their immediate superiors on seven (21 percent) of the thirty-four items. For all seven items the engineering managers expressed a more positive attitude than their immediate superiors. Thirty-four (34) percent of the engineering managers felt that the manager "preferably should" pursue an advanced degree in business management, as compared to 20 percent of their immediate superiors (Item 1-39). (In both instances, the modal response was "may or may not.") On the other hand, the engineering managers noted a stronger preference for the engineering manager to take graduate credit work in business management, not necessarily for a degree (Item 1-42). Fifty-one (51) percent of the managers responded that the engineering manager "preferably should" do this, while 38 percent of the superiors indicated such. (The modal response for the superiors was "may or may not.") With regard to taking graduate credit work in engineering, not necessarily for a degree, 39 percent of the engineering managers replied "preferably should," compared to 25 percent of their immediate superiors (Item 1-40). (The modal response for both groups was "may or may not.") Another item revealing a difference in response was Item 1-50. Twenty-seven (27) percent of the managers believed that the engineering manager "preferably should" take time off during regular working hours to pursue continuing

education programs. Only 17 percent of the immediate superiors shared this same feeling. (The modal response in both instances was "may or may not.") Fifty-three (53) percent of the engineering managers were of the opinion that the engineering manager "preferably should" take advanced non-credit business and management courses, while this same feeling was shared by only 38 percent of their immediate superiors (Item 1-54). (The modal response for the superiors was "may or may not.") Two final items for which significant differences in response occurred were Items 1-59 and 1-60. Both items referred to ways by which the engineering manager can keep updated. Sixty-two (62) percent of the managers felt that the engineering manager "preferably should" attend short technical refresher courses, as compared to 54 percent of the superiors. As for attending lectures in the liberal arts and humanities, 35 percent of the managers and 21 percent of their superiors believed that the engineering manager "preferably should" do this. (In both instances, the modal response was "may or may not.")

Table 16 categorizes the 34 items according to disagreement between the engineering managers and their immediate superiors and according to consensus within each of the samples. Low intraposition consensus exists for both samples on two of the seven items showing significant differences between the managers and their superiors.



High intraposition consensus within both samples, combined with significant differences between samples, exists for three of the items. Thus, when comparing the responses of the engineering managers and their immediate superiors, the null hypothesis is rejected for three items, namely:

- (1-39) Pursue an advanced degree in business management;
- (1-42) Take graduate credit work in business management, not necessarily for degree; and
- (1-54) Take advanced non-credit business and management courses.

#### Engineering Managers--Direct Subordinates

In comparing the responses of the engineering managers and their direct subordinates to the items related to the continuing education activities of the engineering manager, interposition consensus existed on twenty-four of the thirty-four items. Examination of these twenty-four items revealed high intraposition consensus for both samples on eleven items as shown in Table 17. Interposition and intraposition consensus occurred on items 36, 37, 38, 39, 41, 42, 43, 47, 51, 58, and 66. Eight of these items were among those eleven items revealing interposition and intraposition consensus for the engineering managers and their immediate superiors. Consensus on these items was positive for the following five items: take graduate credit work in business management, not necessarily for a

Table 17. Classification of thirty-four continuing education activity items according to consensus within each of the samples and according to significant degree of disagreement between two samples. (Engineering Managers--Direct Subordinates.)

| Disagreement<br>Between the<br>Two Samples | High (H) or Low (L) Consensus Within Each Sample |                                 |                                 |                                 | Totals |
|--------------------------------------------|--------------------------------------------------|---------------------------------|---------------------------------|---------------------------------|--------|
|                                            | H <sub>EM</sub> H <sub>DS</sub>                  | H <sub>EM</sub> L <sub>DS</sub> | L <sub>EM</sub> H <sub>DS</sub> | L <sub>EM</sub> L <sub>DS</sub> |        |
| Nonsignificant                             | 11                                               | 0                               | 7                               | 6                               | 24     |
| Significant                                | 2                                                | 4                               | 2                               | 2                               | 10     |
| Totals                                     | 13                                               | 4                               | 9                               | 8                               | 34     |

degree; become familiar with the modern engineering curricula being offered in leading colleges and universities; attend local and national technical meetings on engineering; keep updated by attending such activities as lectures and seminars on business management; and, keep updated by utilizing such sources of information as business and management journals. Consensus of a more neutral type was disclosed for five items: be active in a professional business or management society; pursue an advanced degree in engineering; pursue an advanced degree in mathematics or the basic sciences; pursue an advanced degree in business management; and, take graduate credit work in mathematics or basic sciences, not necessarily for a degree. Finally, a more negative consensus was expressed on Item 1-51 for the engineering managers and the direct subordinates. Thirty-four (34) percent of the members of both samples responded that the engineering manager "preferably should not" take time off for sabbatical leave to pursue advanced degree work.

In comparing the responses of the engineering managers and the direct subordinates, significant differences in expectations were revealed for ten of the thirty-four items. For all ten items, the engineering managers expressed a more positive attitude than the direct subordinates. Thirty-nine (39) percent of the engineering managers believed that the engineering manager "preferably should"

take graduate credit work in engineering, not necessarily for a degree, while 27 percent of the direct subordinates indicated such (Item 1-40). (The modal response for both groups was "may or may not.") Forty-four (44) percent of the managers were of the opinion that the engineering manager "preferably should" write and present technical and professional papers, as compared to only 24 percent of the subordinates (Item 1-46). (In both instances, the modal response was "may or may not.") With regard to taking time off during regular working hours to pursue continuing education programs, 27 percent of the engineering managers responded "preferably should," compared to 20 percent of the direct subordinates (Item 1-50). (The modal response was "may or may not" for both groups.)

Another activity of the engineering manager, in which the managers and their direct subordinates differed in intensity of response, involved taking advanced non-credit engineering courses (Item 1-53). Thirty-five (35) percent of the managers believed that they "preferably should" take non-credit engineering courses, while this same feeling was expressed by only 23 percent of their subordinates. (In both instances, the modal response was "may or may not.") Given a preference as an activity of the engineering manager and still showing a significant difference in the responses was Item 1-54, take advanced non-credit business and management courses. Fifty-three

(53) percent of the engineering managers indicated "preferably should" to this item compared to 35 percent of the direct subordinates. (The modal response for the subordinates was "may or may not.") More engineering managers than direct subordinates strongly preferred that the engineering manager become acquainted with the new technological ideas and associated terminology used in engineering (Item 1-56). Fifty-seven (57) percent of the managers believed that he "absolutely must" do this compared to 44 percent of the subordinates. (The modal response for the subordinates was "preferably should.") In terms of the engineering manager keeping updated, thirty-seven (37) percent of the engineering managers felt that he "absolutely must" attend engineering lectures and seminars, while 27 percent of the direct subordinates were of this opinion (Item 1-57). (The modal response for both groups was "preferably should.") In addition, 18 percent of the managers responded that the engineering manager "absolutely must" attend short technical refresher courses, as compared to only 11 percent of the subordinates (Item 1-59). (For both groups, the modal response was "preferably should.") As for the engineering manager attending lectures in the liberal arts and humanities, 35 percent of the managers indicated that he "preferably should" as compared to 21 percent of the direct subordinates (Item 1-60). (In both instances, the modal response was "may or may not.") On

the final item for which a significant difference in responses occurred, 50 percent of the engineering managers were of the opinion that the manager "absolutely must" utilize technical and trade journals to keep updated (Item 1-61). Thirty-three (33) percent of the direct subordinates shared this same opinion. (The modal response for the subordinates was "preferably should.")

Table 17 shows the disagreement between the engineering managers and their direct subordinates, and classifies the 34 items according to consensus within each of the samples. Two of the ten items indicating significant differences between the samples reveal low intraposition consensus for both samples. On two of the items there is a combination of high intraposition consensus within both samples and a significant difference representing divergence of opinion between samples. Therefore, when comparing the responses of the engineering managers and their direct subordinates, the null hypothesis is rejected for two items, namely:

- (1-54) Take advanced non-credit business and management courses; and
- (1-61) Keep updated by utilizing such sources of information as technical and trade journals.

#### Engineering Managers--Engineering Faculty

The responses of the engineering managers concerning the continuing education activities of the engineering manager were also compared with those of the engineering

faculty. The data showed interposition consensus on twenty-three of the thirty-four items as seen in Table 18. Further analysis disclosed high intraposition consensus for both samples on two items: pursue an advanced degree in mathematics or the basic sciences (Item 1-38); and, take graduate credit work in mathematics or basic sciences, not necessarily for a degree (Item 1-41). Consensus between the engineering managers and the engineering faculty on both of these items was neutral. Items 38 and 41 revealed high intraposition consensus for all three samples.

Significant differences in expectations between the engineering managers and the engineering faculty existed on eleven (32 percent) of the thirty-four items. There was a significant difference in expectations regarding the engineering managers being active in a professional engineering society (Item 1-35). Sixty-two (62) percent of the engineering managers were of the opinion that the engineering manager should do this, as compared to 92 percent of the engineering faculty. Another item in which the engineering managers expressed a less positive attitude than the faculty was Item 1-46. Forty-four (44) percent of the engineering managers felt that the engineering manager "preferably should" write and present technical and professional papers, as compared to 56 percent of the engineering faculty. Both the managers and the faculty

Table 18. Classification of thirty-four continuing education activity items according to consensus within each of the samples and according to significant degree of disagreement between two samples. (Engineering Managers--Engineering Faculty.)

| Disagreement<br>Between the<br>Two Samples | High (H) or Low (L) Consensus Within Each Sample |                                 |                                 |                                 | Totals |
|--------------------------------------------|--------------------------------------------------|---------------------------------|---------------------------------|---------------------------------|--------|
|                                            | H <sub>EM</sub> H <sub>EF</sub>                  | H <sub>EM</sub> L <sub>EF</sub> | L <sub>EM</sub> H <sub>EF</sub> | L <sub>EM</sub> L <sub>EF</sub> |        |
| Nonsignificant                             | 2                                                | 7                               | 1                               | 13                              | 23     |
| Significant                                | 3                                                | 5                               | 2                               | 1                               | 11     |
| Totals                                     | 5                                                | 12                              | 3                               | 14                              | 34     |



preferred that the engineering manager attend local and national technical meetings on engineering (Item 1-47). However, only 12 percent of the managers responded that he "absolutely must" do this compared to 30 percent of the engineering faculty. (The modal response was "preferably should" for both groups.) The engineering managers were more positive, however, in terms of the manager pursuing an advanced degree in business management (Item 1-39). Thirty-four (34) percent of the managers believed that the engineering manager "preferably should" do this, while only 10 percent of the faculty shared this preference. (The modal response was "may or may not" in both instances.) Fifty-one (51) percent of the engineering managers were of the opinion that the engineering manager "preferably should" take graduate credit work in business management not necessarily for a degree, as compared to 26 percent of the faculty (Item 1-42). With regard to the engineering manager taking time off for sabbatical leave to pursue advanced degree work (Item 1-51), only 7 percent of the managers felt he should do this as compared to 28 percent of the engineering faculty. (The modal response to this item was "may or may not" for both samples.) The engineering managers, on the other hand, were of the opinion that the engineering manager should pursue advanced degree work simultaneously with job responsibilities (Item 1-52). Twenty-eight (28) percent of the managers responded thus

as compared to 6 percent of the engineering faculty. (The modal response in both instances was "may or may not.")

Another item in which the engineering managers and the engineering faculty differed significantly in their responses was Item 1-53. Thirty-five (35) percent of the managers believed that the engineering manager "preferably should" take advanced non-credit engineering courses compared to 22 percent of the faculty. (The modal response for both groups was "may or may not.") The engineering managers indicated a stronger preference for the engineering manager to take advanced non-credit business and management courses (Item 1-54). Fifty-three (53) percent of the managers responded that the engineering manager "preferably should" do this, whereas only 22 percent of the faculty felt this way. (The modal response of the engineering faculty to this item was "may or may not.") More engineering managers than engineering faculty preferred that the engineering manager become acquainted with the new technological ideas and associated terminology used in engineering (Item 1-56). Ninety-eight (98) percent of the managers expressed this preference compared to 84 percent of the engineering faculty. Finally, with regard to the engineering manager, keeping updated by attending lectures in the liberal arts and humanities (Item 1-60), 35 percent of the engineering managers felt that he "preferably should," as compared to 22 percent of the engineering faculty. (The modal response in both instances was "may or may not.")

Table 18 categorizes the disagreement between the engineering managers and the engineering faculty, and classifies the items according to consensus within each of the two samples. One of the eleven items showing that significant differences exist between engineering managers and the engineering faculty indicates low intraposition consensus for both samples. High intraposition consensus is revealed for three items which show significant differences. The null hypothesis can thus be rejected for three items when comparing the responses of the engineering managers and the engineering faculty, namely on items:

- (1-39) Pursue an advanced degree in business management;
- (1-42) Take graduate credit work in business management not necessarily for a degree; and
- (1-47) Attend local and national technical meetings on engineering.

Hypothesis 2a.--There is no significant difference in the expectations that immediate superiors and direct subordinates hold for the continuing education activities of the engineering manager.

The group mean and variance responses, as well as the level of significance of difference between the two groups for each of the thirty-four items concerning the continuing education activities of the engineering manager, are summarized in Table 15.

## Immediate Superiors--Direct Subordinates

The data revealed interposition consensus on twenty-four of the thirty-four items, as shown in Table 19. Additional analysis revealed high intraposition consensus for both groups on thirteen items, namely, 36, 37, 38, 40, 41, 42, 43, 51, 53, 54, 55, 58, and 68. Consensus on these items was positive for the following three items: take graduate credit work in business management, not necessarily for a degree; become familiar with the modern engineering curricula being offered in the leading colleges and universities; and, keep updated by attending lectures and seminars on business management. Neutral consensus between the immediate superiors and the direct subordinates was revealed for the following ten items: be active in a professional business or management society; pursue an advanced degree in engineering; pursue an advanced degree in mathematics or the basic sciences; take graduate credit work in engineering not necessarily for a degree; take graduate credit work in mathematics or basic sciences not necessarily for a degree; take time off for sabbatical leave to pursue advanced degree work; take advanced non-credit engineering courses; take advanced non-credit business and management courses; take advanced non-credit courses in basic sciences; and, keep updated by utilizing such sources of information as management consultants.

Table 19. Classification of thirty-four continuing education activity items according to consensus within each of the samples and according to significant degree of disagreement between two samples. (Immediate Superiors--Direct Subordinates.)

| Disagreement<br>Between the<br>Two Samples | High (H) or Low (L) Consensus Within Each Sample |                                 |                                 |                                 | Totals |
|--------------------------------------------|--------------------------------------------------|---------------------------------|---------------------------------|---------------------------------|--------|
|                                            | H <sub>IS</sub> H <sub>DS</sub>                  | H <sub>IS</sub> L <sub>DS</sub> | L <sub>IS</sub> H <sub>DS</sub> | L <sub>IS</sub> L <sub>DS</sub> |        |
| Nonsignificant                             | 13                                               | 3                               | 4                               | 4                               | 24     |
| Significant                                | 4                                                | 1                               | 1                               | 4                               | 10     |
| Totals                                     | 17                                               | 4                               | 5                               | 8                               | 34     |

Significant differences in expectations between the immediate superiors and the direct subordinates existed on ten (29 percent) of the thirty-four items. The immediate superiors expressed a more positive attitude than the direct subordinates for all but one of the ten items. With regard to the engineering manager pursuing an advanced degree in business management (Item 1-39), only 20 percent of the immediate superiors responded that the engineering manager "preferably should" do this, as compared to 35 percent of the direct subordinates. (The modal response to this item for both samples was "may or may not.") Forty (40) percent of the immediate superiors, however, felt that the engineering manager "preferably should" write and present technical and professional papers (Item 1-46), while only 24 percent of the direct subordinates shared this preference. (The modal response for this item for both samples was also "may or may not.") The immediate superiors also noted a stronger preference for engineering managers to attend local and national technical meetings on engineering (Item 1-47). Although the modal response of both groups to this item was "preferably should," 19 percent of the superiors believed that this was a mandatory activity of the engineering manager, compared to 9 percent of the direct subordinates. More immediate superiors than direct subordinates strongly preferred that the engineering manager subscribe to engineering or scientific journals

(Item 1-48). Forty-one (41) percent of the superiors were of the opinion that he "absolutely must" do this, compared to 26 percent of the subordinates. (In both instances, the modal response was "preferably should.")

In addition, a significant difference existed in expectations regarding the engineering manager attending engineering lectures and seminars (Item 1-57). Thirty-seven (37) percent of the immediate superiors shared the feeling that the engineering manager "absolutely must" do this, while 27 percent of the direct subordinates felt this way. (The modal response for both groups was "preferably should.") As for the engineering manager keeping updated by utilizing technical and trade journals (Item 1-61), the immediate superiors noted a much stronger preference than the direct subordinates. Fifty-four (54) percent of the superiors believed that the engineering manager "absolutely must" do this, compared to 33 percent of the subordinates. (The modal response for the subordinates was "preferably should.") Even though both the immediate superiors and the direct subordinates were of the opinion that the engineering manager should utilize technical abstracts and indexes (Item 1-62), 28 percent of the superiors felt that this was mandatory as compared to 17 percent of the subordinates. (The modal response in both instances was "preferably should.") Similar patterns occurred in the responses of the superiors and the subordinates for

Items (1-63) and (1-64). Twenty-seven (27) percent of the immediate superiors believed that the engineering manager "absolutely must" read technical books and reports, while 13 percent of the direct subordinates felt that this was mandatory. Likewise, 20 percent of the superiors were of the opinion that the engineering manager "absolutely must" read business reports, compared to 9 percent of the direct subordinates. (The modal response was "preferably should" for both groups.) Finally, a much stronger preference was noted by the immediate superiors for the engineering manager to keep updated by utilizing manufacturer's literature (Item 1-65). Fifty-four (54) percent of the superiors responded that the manager "preferably should" use this source of information, as compared to 35 percent of the subordinates. (The modal response of the subordinates was "may or may not.")

Table 19 categorizes the disagreement between the immediate superiors and the direct subordinates according to consensus within each of the two samples. Four of the ten items showing that significant differences exist between the immediate superiors and the direct subordinates indicate low intraposition consensus for both samples. High intraposition consensus is revealed for four items which show significant differences. The null hypothesis can thus be rejected for four items when comparing the responses of the immediate superiors and the direct subordinates, namely:



- (1-39) Pursue an advanced degree in business management;
- (1-47) Attend local and national technical meetings on engineering;
- (1-48) Subscribe to engineering or scientific journals; and
- (1-61) Keep updated by utilizing technical and trade journals.

### Areas of Differences

Analysis of the items on which there is significant agreement within the samples but significant disagreement between the samples will identify some possible areas of differences.

The engineering managers and their immediate superiors disagreed on three items for which there was substantial intraposition consensus. In response to Item 1-39, 34 percent of the engineering managers believed that the manager "preferably should" pursue an advanced degree in business management, while only 20 percent of their immediate superiors indicated such. (The modal response for both groups was "may or may not.") The engineering managers noted a much stronger preference for the engineering manager to take graduate credit work in business management, not necessarily for a degree (Item 1-42). Fifty-one (51) percent of the managers were of the opinion that the engineering manager "preferably should" do this, as compared to 38 percent of the superiors. Likewise, 53 percent of

the engineering managers felt that the manager "preferably should" take advanced non-credit business and management courses, whereas this same preference was shared by only 38 percent of the immediate superiors (Item 1-54). The modal responses of the immediate superiors to Items 1-12 and 1-54 were "may or may not."

Significant differences in expectations were noted between the engineering managers and their direct subordinates on two items, 1-54 and 1-61. The managers (53 percent) expressed a stronger opinion than the subordinates (35 percent) that the engineering manager "preferably should" take advanced non-credit business and management courses (Item 1-54). The modal response of the subordinates to this item was "may or may not." The engineering managers exhibited a more positive attitude than the subordinates that the engineering manager "absolutely must" utilize technical and trade journals to keep updated (Item 1-61). Fifty (50) percent of the engineering managers indicated that this activity was mandatory, as compared to 33 percent of the direct subordinates. The modal feeling of the subordinates was "preferably should."

The engineering managers disagreed with the engineering faculty on three items. On Item 1-39, thirty-four (34) percent of the managers were of the opinion that the engineering manager "preferably should" pursue an advanced degree in business management, whereas only 10 percent of

the faculty felt this way. (The modal response was "may or may not" for both groups.) Fifty-one (51) percent of the engineering managers also believed that the engineering manager "preferably should" take graduate credit work, not necessarily for a degree, as compared to 26 percent of the engineering faculty (Item 1-42). (The modal response for the engineering faculty was "may or may not.") The managers, however, were less positive than the faculty regarding the engineering manager attending local and national technical meetings on engineering (Item 1-47). Even though both samples preferred that the engineering manager do this, only 12 percent of the engineering managers felt that this activity was mandatory, while 30 percent of the engineering faculty believed that it was. (For both groups, the modal response was "preferably should.")

The immediate superiors and the direct subordinates disagreed on four items, namely, 39, 47, 48, and 61. With regard to the engineering manager pursuing an advanced degree in business management (Item 1-39), 20 percent of the immediate superiors felt that he "preferably should," as compared to 35 percent of the direct subordinates. (In both instances, the modal response was "may or may not.") A stronger preference was expressed by the immediate superiors for the engineering manager to attend local and national technical meetings on engineering (Item 1-47). Nineteen (19) percent of the superiors responded that he "absolutely

must" do this, whereas only 9 percent of the subordinates thought so. (The modal response for both groups was "preferably should.") More immediate superiors than direct subordinates preferred that the engineering manager subscribe to engineering or scientific journals (Item 1-48). Forty-one (41) percent of the superiors thought that this was mandatory, compared to 26 percent of the subordinates. (The modal response was "preferably should" for both groups.") Finally, fifty-four (54) percent of the superiors believed that the engineering manager "absolutely must" utilize technical and trade journals to keep updated (Item 1-61), while only 33 percent of the subordinates shared this strong an opinion. The modal response of the direct subordinates was that he "preferably should."

#### Areas of Ambiguity

Further analysis of the data discloses eighteen items which satisfy one or more of the criteria of ambiguity of response for all four samples. These criteria include: the tendency for all modal responses to fall in the neutral category; low consensus among the responses; and the occurrence of a bimodal distribution.

The modal responses fell in the "may or may not" category for the following fourteen items:

- (1-37) Pursue an advanced degree in engineering;
- (1-38) Pursue an advanced degree in mathematics or the basic sciences;

- (1-39) Pursue an advanced degree in business management;
- (1-40) Take graduate credit work in engineering, not necessarily for a degree;
- (1-41) Take graduate credit work in mathematics or basic sciences, not necessarily for a degree;
- (1-45) Acquire certification as Professional Engineer;
- (1-50) Take time off during regular working hours to pursue continuing education programs;
- (1-51) Take time off for sabbatical leave to pursue advanced degree work;
- (1-52) Pursue advanced degree work simultaneously with job responsibilities;
- (1-53) Take advanced non-credit engineering courses;
- (1-55) Take advanced non-credit courses in basic sciences;
- (1-60) Keep updated by attending lectures in the liberal arts and humanities;
- (1-67) Keep updated by utilizing engineering consultants; and
- (1-68) Keep updated by utilizing management consultants.

The following four items revealed low intraposition consensus for all four samples:

- (1-59) Keep updated by attending short technical refresher courses;
- (1-62) Keep updated by utilizing technical abstracts and indexes;
- (1-64) Keep updated by utilizing business reports; and
- (1-65) Keep updated by utilizing manufacturer's literature.

### Areas of Consensus

To conclude the macroscopic consensus analysis, attention will center around those items which most of the members of a given sample agree should be a continuing education activity of the engineering manager. Examination of these items in terms of intraposition consensus for all samples will provide a positive expression of the expectations which the majority of the members of a group hold for the engineering manager.

Looking first at the responses of the engineering managers, there are two activities which most of the members of the sample agree are mandatory for the engineering manager. Fifty-seven (57) percent of the managers responded that the engineering manager "absolutely must" become acquainted with the new technological ideas and associated terminology used in engineering (Item 1-56), and 50 percent of the engineering managers felt that he "absolutely must" keep updated by utilizing technical and trade journals (Item 1-61). In addition, positive consensus was noted for the following seven items listed according to modal frequencies ranging from 65.8 percent for Item 1-47 to 50.8 percent for Item 1-42:

(1-47) Attend local and national technical meetings on engineering;

(1-58) Keep updated by attending lectures and seminars on business and management;

- (1-43) Become familiar with the modern engineering curricula being offered in the leading colleges and universities;
- (1-66) Keep updated by utilizing business and management journals;
- (1-57) Keep updated by attending engineering lectures and seminars;
- (1-54) Take advanced non-credit business and management courses; and
- (1-42) Take graduate credit work in business management, not necessarily for a degree

For the immediate superiors, the majority were also in strong positive consensus on two items, 1-56 and 1-61. Fifty-three (53) percent of the superiors indicated that it was mandatory that the engineering manager become acquainted with the new technological ideas and associated terminology used in engineering (Item 1-56), and 54 percent responded that he "absolutely must" keep updated by utilizing technical and trade journals (Item 1-61). The data also revealed positive consensus for the following six items which ranged from 64.8 percent for Item 1-43 to 53.3 percent for Item 1-48:

- (1-43) Become familiar with the modern engineering curricula being offered in the leading colleges and universities;
- (1-47) Attend local and national technical meetings on engineering;
- (1-58) Keep updated by attending lectures and seminars on business management;
- (1-44) Become familiar with the modern trends in business and management curricula in the leading colleges and universities;

(1-57) Keep updated by attending engineering lectures and seminars; and

(1-48) Subscribe to engineering or scientific journals.

The engineering managers and the immediate superiors are in positive consensus on six items (56, 61, 43, 47, 57, 58) representing continuing education activities of the engineering manager.

The responses of the direct subordinates disclosed nine items for which positive consensus resulted. The modal frequencies ranged from 64.3 percent for Item 1-58 to 53.6 percent for Item 1-35:

(1-58) Keep updated by attending lectures and seminars on business management;

(1-43) Become familiar with the modern engineering curricula being offered in the leading colleges and universities;

(1-48) Subscribe to engineering or scientific journals;

(1-47) Attend local and national technical meetings on engineering;

(1-49) Subscribe to business and management journals;

(1-63) Keep updated by utilizing technical books and reports;

(1-66) Keep updated by utilizing business and management journals;

(1-61) Keep updated by utilizing technical and trade journals; and

(1-35) Be active in a professional engineering society.

Four of these items (43, 47, 58, 61) coincide with the expectations of the engineering managers and the immediate superiors, indicating that there is some basic agreement



on the continuing education activities of the engineering manager among all three samples.

The majority of the members of the engineering faculty agreed that the following three items should be expected from the engineering manager, with percentages ranging from 64.0 for Item 1-35 to 50.0 for Item 1-48:

- (1-35) Be active in a professional engineering society;
- (1-47) Attend local and national technical meetings on engineering; and
- (1-48) Subscribe to engineering or scientific journals.

Only Item 1-47 was common to the other three samples; however, Item 1-48 was common to the sample of immediate superiors and the sample of direct subordinates, but not to the sample of engineering managers.

Hypothesis 3.--There is no significant difference in the perceptions engineering managers have of their needs in certain subject areas and in the expectations held for them by their immediate superiors, direct subordinates, and engineering faculty; and

Hypothesis 3a.--There is no significant difference in the expectations that immediate superiors and direct subordinates hold concerning the needs of engineering managers in certain subject areas.

Seven major subject areas, with items as indicated, were investigated, namely:

|                                 |          |
|---------------------------------|----------|
| Mathematics, Physics, Chemistry | 11 items |
| Engineering                     | 14       |
| General Management              | 11       |
| Personnel Management            | 9        |
| Financial Management            | 5        |
| Marketing and Sales Management  | 6        |
| Communication Skills            | 10       |
|                                 | <hr/>    |
|                                 | 66       |

#### Mathematics, Physics, Chemistry

The mathematics, Physics, Chemistry area included the following eleven special subjects: calculus; differential equations; linear algebra; matrix theory; numerical analysis; partial differential equations; probability and statistics; vector calculus; nuclear physics; polymer chemistry; and solid state physics.

The engineering managers indicated a pronounced feeling that an "over-view only" was needed in seven of the subjects. In two subjects, calculus and probability and statistics, they were approximately equally divided between "working knowledge" and "over-view only"; and in two subjects, nuclear physics and polymer chemistry, they were equally divided between "over-view only" and doesn't really need."

The immediate superiors indicated a pronounced feeling that an "over-view only" was needed for seven of the subjects. They were approximately equally divided between "working knowledge" and "over-view only" on one subject, probability and statistics. They indicated a pronounced feeling for "doesn't really need" for three subjects--vector calculus, nuclear physics, and polymer chemistry.

The direct subordinates indicated a pronounced feeling for "over-view only" for five subjects: calculus; differential equations; linear algebra; numerical analysis; and probability and statistics. They were approximately equally divided between "over-view only" and "doesn't really need" on three subjects--matrix theory, partial differential equations, and solid state physics. They indicated a pronounced feeling for "doesn't really need" for the three remaining subjects--vector calculus, nuclear physics, and polymer chemistry.

The engineering faculty indicated a pronounced feeling for "working knowledge" for two subjects, calculus and differential equations. They indicated a pronounced feeling for "over-view only" for the remaining nine subjects: linear algebra; matrix theory; numerical analysis; partial differential equations; probability and statistics; vector calculus; nuclear physics; polymer chemistry, and solid state physics.

The responses of the engineering managers, immediate superiors, direct subordinates, and engineering faculty are summarized in Table 20.

High intraposition consensus items for which no significant differences occurred, are enumerated for the respective groupings.

The engineering managers and immediate superiors showed such consensus for two items, 76 and 79. A positive-neutral\* trend was revealed for one subject, probability and statistics, whereas a more neutral-negative trend was shown for polymer chemistry.

The engineering managers and direct subordinates did not show high intraposition consensus for any items.

The engineering managers and engineering faculty showed such consensus for two items, 76 and 80. A positive-neutral trend was revealed for probability and statistics, whereas the trend was neutral for solid state physics.

The immediate superiors and direct subordinates showed high intraposition consensus for two items, 78 and 79. The trend was negative for both nuclear physics and polymer chemistry.

Significant difference items are now enumerated for the respective groupings.

In comparing engineering managers and immediate superiors, significant differences were revealed for three items, 77, 78, and 80. In Item 77, vector calculus, 58

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\*For convenience, the term neutral is used to refer to "over-view only."

Table 20. Group frequency, mean, and variance responses, and significance of difference between groups on sixty-six items concerning the needs of engineering managers in certain subject areas.

| Subject Areas                         | Sample | N   | Percentage Responses |     |     | Mean | Var. | Compared Samples | Chi-Square Test |
|---------------------------------------|--------|-----|----------------------|-----|-----|------|------|------------------|-----------------|
|                                       |        |     | AWK                  | AOV | DRN |      |      |                  |                 |
|                                       |        |     | 1                    | 2   | 3   |      |      |                  |                 |
| Section III                           |        |     |                      |     |     |      |      |                  |                 |
| MATHEMATICS, PHYSICS, CHEMISTRY       |        |     |                      |     |     |      |      |                  |                 |
| (1-70) Calculus                       | IS     | 122 | 36                   | 52  | 12  | 1.76 | .44  | EM-IS            | N.S.            |
|                                       | EM     | 199 | 46                   | 44  | 10  | 1.64 | .44  | EM-EF            | .005            |
|                                       | DS     | 168 | 39                   | 48  | 13  | 1.73 | .45  | EM-DS            | N.S.            |
|                                       | EF     | 50  | 64                   | 34  | 2   | 1.38 | .28* | IS-DS            | N.S.            |
| (1-71) Differential Equations         | IS     | 122 | 26                   | 56  | 18  | 1.92 | .44  | EM-IS            | N.S.            |
|                                       | EM     | 199 | 32                   | 54  | 14  | 1.83 | .44  | EM-EF            | .005            |
|                                       | DS     | 168 | 30                   | 47  | 23  | 1.93 | .53  | EM-DS            | N.S.            |
|                                       | EF     | 50  | 58                   | 40  | 2   | 1.44 | .29* | IS-DS            | N.S.            |
| (1-72) Linear Algebra                 | IS     | 121 | 29                   | 55  | 16  | 1.87 | .44  | EM-IS            | N.S.            |
|                                       | EM     | 199 | 31                   | 48  | 21  | 1.91 | .52  | EM-EF            | N.S.            |
|                                       | DS     | 168 | 26                   | 52  | 22  | 1.96 | .48  | EM-DS            | N.S.            |
|                                       | EF     | 50  | 34                   | 56  | 10  | 1.75 | .38  | IS-DS            | N.S.            |
| (1-73) Matrix theory                  | IS     | 122 | 14                   | 53  | 33  | 2.19 | .44  | EM-IS            | N.S.            |
|                                       | EM     | 199 | 9                    | 55  | 26  | 2.17 | .32* | EM-EF            | .005            |
|                                       | DS     | 168 | 9                    | 50  | 41  | 2.32 | .40  | EM-DS            | .01             |
|                                       | EF     | 50  | 20                   | 62  | 10  | 1.82 | .36  | IS-DS            | N.S.            |
| (1-74) Numerical Analysis             | IS     | 122 | 19                   | 61  | 20  | 2.00 | .40  | EM-IS            | N.S.            |
|                                       | EM     | 199 | 16                   | 67  | 17  | 2.02 | .32* | EM-EF            | .05             |
|                                       | DS     | 168 | 13                   | 58  | 29  | 2.15 | .40  | EM-DS            | .05             |
|                                       | EF     | 50  | 32                   | 58  | 10  | 1.78 | .38  | IS-DS            | N.S.            |
| (1-75) Partial differential equations | IS     | 122 | 13                   | 56  | 31  | 2.18 | .41  | EM-IS            | N.S.            |
|                                       | EM     | 199 | 9                    | 62  | 29  | 2.19 | .35  | EM-EF            | .05             |
|                                       | DS     | 168 | 11                   | 46  | 43  | 2.32 | .44  | EM-DS            | .01             |
|                                       | EF     | 50  | 10                   | 68  | 14  | 1.96 | .32* | IS-DS            | N.S.            |
| (1-76) Probability and statistics     | IS     | 122 | 47                   | 49  | 4   | 1.57 | .32* | EM-IS            | N.S.            |
|                                       | EM     | 199 | 47                   | 50  | 3   | 1.56 | .31* | EM-EF            | N.S.            |
|                                       | DS     | 168 | 35                   | 55  | 10  | 1.74 | .38  | EM-DS            | .01             |
|                                       | EF     | 50  | 30                   | 66  | 4   | 1.74 | .28* | IS-DS            | N.S.            |
| (1-77) Vector calculus                | IS     | 122 | 10                   | 39  | 51  | 2.40 | .46  | EM-IS            | .005            |
|                                       | EM     | 199 | 5                    | 58  | 37  | 2.31 | .32* | EM-EF            | .05             |
|                                       | DS     | 168 | 4                    | 42  | 54  | 2.49 | .35  | EM-DS            | .005            |
|                                       | EF     | 50  | 10                   | 72  | 18  | 2.08 | .28* | IS-DS            | N.S.            |
| (1-78) Nuclear physics                | IS     | 122 | 1                    | 34  | 65  | 2.63 | .27* | EM-IS            | .005            |
|                                       | EM     | 199 | 2                    | 53  | 45  | 2.43 | .29* | EM-EF            | .05             |
|                                       | DS     | 168 | 1                    | 30  | 69  | 2.68 | .23* | EM-DS            | .005            |
|                                       | EF     | 50  | 2                    | 74  | 24  | 2.22 | .21* | IS-DS            | N.S.            |
| (1-79) Polymer chemistry              | IS     | 122 | 2                    | 39  | 59  | 2.57 | .30* | EM-IS            | N.S.            |
|                                       | EM     | 199 | 2                    | 51  | 47  | 2.44 | .30* | EM-EF            | .05             |
|                                       | DS     | 168 | 3                    | 30  | 67  | 2.64 | .29* | EM-DS            | .005            |
|                                       | EF     | 50  | 2                    | 70  | 28  | 2.26 | .24* | IS-DS            | N.S.            |
| (1-80) Solid state physics            | IS     | 121 | 5                    | 53  | 42  | 2.37 | .34  | EM-IS            | .05             |
|                                       | EM     | 199 | 4                    | 67  | 29  | 2.26 | .26* | EM-EF            | N.S.            |
|                                       | DS     | 168 | 3                    | 46  | 51  | 2.47 | .32* | EM-DS            | .005            |
|                                       | EF     | 50  | 6                    | 78  | 16  | 2.10 | .21* | IS-DS            | N.S.            |
| ENGINEERING                           |        |     |                      |     |     |      |      |                  |                 |
| (2-6) Computer application            | IS     | 122 | 53                   | 46  | 1   | 1.48 | .27* | EM-IS            | N.S.            |
|                                       | EM     | 199 | 51                   | 47  | 2   | 1.51 | .29* | EM-EF            | N.S.            |
|                                       | DS     | 168 | 40                   | 56  | 4   | 1.63 | .30* | EM-DS            | N.S.            |
|                                       | EF     | 50  | 48                   | 52  | -   | 1.52 | .25* | IS-DS            | .05             |

\*Variance below median cutting point of .325, indicating high intraposition consensus.

Table 20. Continued.

| Subject Areas                | Sample | N   | Percentage Responses |          |          | Mean | Var. | Compared Samples | Chi-Square Test |
|------------------------------|--------|-----|----------------------|----------|----------|------|------|------------------|-----------------|
|                              |        |     | AWK<br>1             | AOV<br>2 | DRJ<br>3 |      |      |                  |                 |
| (2-7) Computer programming   | IS     | 122 | 14                   | 67       | 19       | 2.05 | .32* | EM-IS            | N.S.            |
|                              | EM     | 199 | 9                    | 71       | 20       | 2.11 | .28* | EM-EF            | N.S.            |
|                              | DS     | 168 | 7                    | 61       | 32       | 2.26 | .32* | EM-DS            | .05             |
|                              | EF     | 50  | 10                   | 72       | 18       | 2.08 | .28* | IS-DS            | .05             |
| (2-8) Materials science      | IS     | 122 | 27                   | 63       | 10       | 1.83 | .34  | EM-IS            | N.S.            |
|                              | EM     | 199 | 21                   | 73       | 6        | 1.86 | .25* | EM-EF            | N.S.            |
|                              | DS     | 168 | 17                   | 73       | 15       | 2.03 | .27* | EM-DS            | .01             |
|                              | EF     | 50  | 16                   | 70       | 14       | 1.98 | .30* | IS-DS            | .005            |
| (2-9) Quality control        | IS     | 122 | 30                   | 59       | 11       | 1.80 | .37  | EM-IS            | .05             |
|                              | EM     | 199 | 23                   | 72       | 5        | 1.83 | .25* | EM-EF            | N.S.            |
|                              | DS     | 168 | 14                   | 71       | 15       | 2.01 | .29* | EM-DS            | .005            |
|                              | EF     | 50  | 26                   | 66       | 8        | 1.82 | .31* | IS-DS            | .005            |
| (2-10) Reliability           | IS     | 122 | 46                   | 51       | 3        | 1.57 | .31* | EM-IS            | N.S.            |
|                              | EM     | 198 | 33                   | 64       | 3        | 1.70 | .27* | EM-EF            | N.S.            |
|                              | DS     | 168 | 33                   | 58       | 9        | 1.76 | .36  | EM-DS            | .05             |
|                              | EF     | 50  | 18                   | 75       | 6        | 1.88 | .23* | IS-DS            | .05             |
| (2-11) Systems theory        | IS     | 122 | 33                   | 64       | 4        | 1.71 | .29* | EM-IS            | N.S.            |
|                              | EM     | 199 | 30                   | 61       | 9        | 1.79 | .35  | EM-EF            | N.S.            |
|                              | DS     | 168 | 21                   | 63       | 16       | 1.94 | .37  | EM-DS            | N.S.            |
|                              | EF     | 49  | 20                   | 68       | 12       | 1.92 | .32* | IS-DS            | .005            |
| (2-12) Energy conversion     | IS     | 122 | 16                   | 61       | 23       | 2.07 | .40  | EM-IS            | N.S.            |
|                              | EM     | 199 | 13                   | 67       | 20       | 2.06 | .32* | EM-EF            | N.S.            |
|                              | DS     | 168 | 16                   | 57       | 27       | 2.11 | .42  | EM-DS            | N.S.            |
|                              | EF     | 50  | 20                   | 70       | 10       | 1.90 | .29* | IS-DS            | N.S.            |
| (2-13) Fluid dynamics        | IS     | 122 | 19                   | 57       | 24       | 2.06 | .44  | EM-IS            | N.S.            |
|                              | EM     | 199 | 14                   | 63       | 23       | 2.10 | .36  | EM-EF            | N.S.            |
|                              | DS     | 168 | 13                   | 58       | 29       | 2.16 | .40  | EM-DS            | N.S.            |
|                              | EF     | 50  | 18                   | 66       | 16       | 1.98 | .35  | IS-DS            | N.S.            |
| (2-14) Lubrication           | IS     | 122 | 20                   | 58       | 22       | 2.02 | .42  | EM-IS            | .01             |
|                              | EM     | 199 | 7                    | 68       | 25       | 2.18 | .30* | EM-EF            | N.S.            |
|                              | DS     | 168 | 10                   | 52       | 38       | 2.27 | .41  | EM-DS            | .01             |
|                              | EF     | 50  | 8                    | 64       | 28       | 2.20 | .32* | IS-DS            | .01             |
| (2-15) Mechanics of continua | IS     | 122 | 5                    | 52       | 42       | 2.35 | .36  | EM-IS            | .05             |
|                              | EM     | 198 | 1                    | 53       | 46       | 2.44 | .28* | EM-EF            | .005            |
|                              | DS     | 167 | 2                    | 39       | 59       | 2.57 | .28* | EM-DS            | .05             |
|                              | EF     | 50  | 12                   | 68       | 20       | 2.08 | .32* | IS-DS            | .01             |
| (2-16) Metallurgy            | IS     | 122 | 18                   | 64       | 18       | 2.00 | .36  | EM-IS            | N.S.            |
|                              | EM     | 199 | 12                   | 69       | 19       | 2.07 | .30* | EM-EF            | N.S.            |
|                              | DS     | 168 | 10                   | 64       | 26       | 2.15 | .35  | EM-DS            | N.S.            |
|                              | EF     | 50  | 14                   | 68       | 18       | 2.04 | .32* | IS-DS            | N.S.            |
| (2-17) Plasticity            | IS     | 122 | 9                    | 61       | 30       | 2.20 | .36  | EM-IS            | N.S.            |
|                              | EM     | 198 | 4                    | 65       | 31       | 2.28 | .27* | EM-EF            | N.S.            |
|                              | DS     | 167 | 4                    | 60       | 36       | 2.32 | .30* | EM-DS            | N.S.            |
|                              | EF     | 50  | 10                   | 66       | 24       | 2.14 | .32* | IS-DS            | N.S.            |
| (2-18) Stress analysis       | IS     | 122 | 30                   | 56       | 14       | 1.85 | .42  | EM-IS            | N.S.            |
|                              | EM     | 199 | 18                   | 65       | 17       | 1.98 | .35  | EM-EF            | N.S.            |
|                              | DS     | 167 | 18                   | 60       | 22       | 2.04 | .40  | EM-DS            | N.S.            |
|                              | EF     | 50  | 20                   | 66       | 14       | 1.94 | .35  | IS-DS            | .05             |
| (2-19) Vibration             | IS     | 122 | 26                   | 58       | 16       | 1.90 | .42  | EM-IS            | .05             |
|                              | EM     | 199 | 15                   | 71       | 14       | 1.99 | .29* | EM-EF            | N.S.            |
|                              | DS     | 168 | 12                   | 68       | 20       | 2.07 | .31* | EM-DS            | N.S.            |
|                              | EF     | 50  | 16                   | 66       | 18       | 2.02 | .59  | IS-DS            | .05             |

Table 20. Continued.

| Subject Areas                                                         | Sample | N   | Percentage Responses |          |          | Mean | Var. | Compared Samples | Chi-Square Test |
|-----------------------------------------------------------------------|--------|-----|----------------------|----------|----------|------|------|------------------|-----------------|
|                                                                       |        |     | AWK<br>1             | AOV<br>2 | DRN<br>3 |      |      |                  |                 |
| GENERAL MANAGEMENT                                                    |        |     |                      |          |          |      |      |                  |                 |
| (2-20) Organization theory                                            | IS     | 121 | 56                   | 41       | 3        | 1.47 | .31* | EM-IS            | N.S.            |
|                                                                       | EM     | 198 | 56                   | 42       | 2        | 1.46 | .29* | EM-EF            | .005            |
|                                                                       | DS     | 166 | 65                   | 32       | 3        | 1.38 | .30* | EM-DS            | N.S.            |
|                                                                       | EF     | 48  | 29                   | 65       | 6        | 1.77 | .31* | IS-DS            | N.S.            |
| (2-21) Business law                                                   | IS     | 120 | 9                    | 58       | 33       | 2.23 | .36  | EM-IS            | N.S.            |
|                                                                       | EM     | 198 | 11                   | 68       | 21       | 2.10 | .31* | EM-EF            | N.S.            |
|                                                                       | DS     | 168 | 11                   | 64       | 25       | 2.14 | .34  | EM-DS            | N.S.            |
|                                                                       | EF     | 49  | 22                   | 57       | 21       | 1.98 | .44  | IS-DS            | N.S.            |
| (2-22) Decision theory                                                | IS     | 120 | 49                   | 45       | 6        | 1.57 | .36  | EM-IS            | N.S.            |
|                                                                       | EM     | 197 | 52                   | 44       | 4        | 1.53 | .35  | EM-EF            | .05             |
|                                                                       | DS     | 168 | 48                   | 46       | 6        | 1.58 | .36  | EM-DS            | N.S.            |
|                                                                       | EF     | 48  | 33                   | 54       | 13       | 1.79 | .42  | IS-DS            | N.S.            |
| (2-23) Research and development                                       | IS     | 121 | 47                   | 48       | 5        | 1.58 | .35  | EM-IS            | N.S.            |
|                                                                       | EM     | 197 | 39                   | 59       | 2        | 1.63 | .27* | EM-EF            | N.S.            |
|                                                                       | DS     | 168 | 48                   | 49       | 3        | 1.56 | .32* | EM-DS            | N.S.            |
|                                                                       | EF     | 48  | 40                   | 54       | 6        | 1.67 | .36  | IS-DS            | N.S.            |
| (2-24) Simulation methods                                             | IS     | 120 | 31                   | 66       | 3        | 1.73 | .27* | EM-IS            | N.S.            |
|                                                                       | EM     | 196 | 27                   | 65       | 8        | 1.82 | .32* | EM-EF            | N.S.            |
|                                                                       | DS     | 168 | 17                   | 69       | 14       | 1.98 | .31* | EM-DS            | .05             |
|                                                                       | EF     | 47  | 21                   | 70       | 9        | 1.87 | .29* | IS-DS            | .001            |
| (2-25) Data processing                                                | IS     | 120 | 18                   | 76       | 6        | 1.89 | .23* | EM-IS            | N.S.            |
|                                                                       | EM     | 197 | 15                   | 73       | 12       | 1.97 | .27* | EM-EF            | .01             |
|                                                                       | DS     | 168 | 8                    | 71       | 21       | 2.13 | .28* | EM-DS            | .05             |
|                                                                       | EF     | 48  | 31                   | 67       | 2        | 1.71 | .25* | IS-DS            | .001            |
| (2-26) Business ethics                                                | IS     | 120 | 47                   | 45       | 8        | 1.62 | .41  | EM-IS            | N.S.            |
|                                                                       | EM     | 198 | 48                   | 49       | 3        | 1.54 | .30* | EM-EF            | N.S.            |
|                                                                       | DS     | 168 | 50                   | 42       | 8        | 1.59 | .41  | EM-DS            | .05             |
|                                                                       | EF     | 48  | 52                   | 42       | 6        | 1.54 | .38  | IS-DS            | N.S.            |
| (2-27) Principles and functions of management                         | IS     | 120 | 68                   | 29       | 3        | 1.34 | .28* | EM-IS            | N.S.            |
|                                                                       | EM     | 198 | 76                   | 22       | 2        | 1.25 | .22* | EM-EF            | .05             |
|                                                                       | DS     | 168 | 73                   | 26       | 1        | 1.29 | .23* | EM-DS            | N.S.            |
|                                                                       | EF     | 47  | 55                   | 43       | 2        | 1.47 | .30* | IS-DS            | N.S.            |
| (2-28) Understanding individual and group behavior in work situations | IS     | 121 | 69                   | 29       | 2        | 1.34 | .28* | EM-IS            | N.S.            |
|                                                                       | EM     | 198 | 70                   | 28       | 2        | 1.31 | .25* | EM-EF            | .05             |
|                                                                       | DS     | 168 | 72                   | 26       | 2        | 1.30 | .25* | EM-DS            | N.S.            |
|                                                                       | EF     | 48  | 50                   | 48       | 2        | 1.52 | .30* | IS-DS            | N.S.            |
| (2-29) Business policy                                                | IS     | 120 | 51                   | 39       | 10       | 1.59 | .45  | EM-IS            | N.S.            |
|                                                                       | EM     | 198 | 49                   | 46       | 5        | 1.55 | .34  | EM-EF            | N.S.            |
|                                                                       | DS     | 168 | 52                   | 43       | 5        | 1.54 | .36  | EM-DS            | N.S.            |
|                                                                       | EF     | 48  | 33                   | 56       | 11       | 1.77 | .40  | IS-DS            | N.S.            |
| (2-30) Production control                                             | IS     | 120 | 15                   | 65       | 20       | 2.05 | .35  | EM-IS            | N.S.            |
|                                                                       | EM     | 198 | 11                   | 72       | 17       | 2.06 | .28* | EM-EF            | .005            |
|                                                                       | DS     | 167 | 11                   | 67       | 22       | 2.10 | .32* | EM-DS            | N.S.            |
|                                                                       | EF     | 48  | 31                   | 63       | 6        | 1.75 | .31* | IS-DS            | N.S.            |
| PERSONNEL MANAGEMENT                                                  |        |     |                      |          |          |      |      |                  |                 |
| (2-31) Personnel administration                                       | IS     | 121 | 58                   | 39       | 3        | 1.45 | .31* | EM-IS            | N.S.            |
|                                                                       | EM     | 199 | 55                   | 42       | 3        | 1.49 | .32* | EM-EF            | N.S.            |
|                                                                       | DS     | 168 | 58                   | 38       | 4        | 1.46 | .32* | EM-DS            | N.S.            |
|                                                                       | EF     | 48  | 65                   | 31       | 4        | 1.40 | .32* | IS-DS            | N.S.            |
| (2-32) Human relations skills                                         | IS     | 121 | 75                   | 24       | 1        | 1.26 | .21* | EM-IS            | N.S.            |
|                                                                       | EM     | 199 | 70                   | 29       | 1        | 1.31 | .24* | EM-EF            | N.S.            |
|                                                                       | DS     | 168 | 64                   | 33       | 3        | 1.38 | .28* | EM-DS            | N.S.            |
|                                                                       | EF     | 48  | 63                   | 35       | 2        | 1.40 | .29* | IS-DS            | N.S.            |

Table 20. Continued.

| Subject Areas                                | Sample | N   | Percentage Responses |          |          | Mean | Var. | Compared Samples | Chi-Square Test |
|----------------------------------------------|--------|-----|----------------------|----------|----------|------|------|------------------|-----------------|
|                                              |        |     | AWK<br>1             | AOV<br>2 | DRN<br>3 |      |      |                  |                 |
| (2-33) Job evaluation                        | IS     | 121 | 65                   | 32       | 3        | 1.38 | .30* | EM-IS            | N.S.            |
|                                              | EM     | 199 | 71                   | 26       | 3        | 1.31 | .27* | EM-EF            | N.S.            |
|                                              | DS     | 168 | 75                   | 24       | 1        | 1.26 | .22* | EM-DS            | N.S.            |
|                                              | EF     | 47  | 55                   | 38       | 7        | 1.51 | .38  | IS-DS            | N.S.            |
| (2-34) Industrial relations                  | IS     | 121 | 25                   | 59       | 16       | 1.92 | .41  | EM-IS            | .05             |
|                                              | EM     | 198 | 26                   | 67       | 7        | 1.82 | .30* | EM-EF            | N.S.            |
|                                              | DS     | 160 | 21                   | 66       | 13       | 1.91 | .34  | EM-DS            | N.S.            |
|                                              | EF     | 47  | 34                   | 64       | 2        | 1.68 | .27* | IS-DS            | N.S.            |
| (2-35) Performance review and appraisal      | IS     | 121 | 85                   | 15       | -        | 1.15 | .13* | EM-IS            | N.S.            |
|                                              | EM     | 199 | 91                   | 8        | 1        | 1.10 | .09* | EM-EF            | .005            |
|                                              | DS     | 168 | 87                   | 12       | 1        | 1.13 | .13* | EM-DS            | N.S.            |
|                                              | EF     | 47  | 66                   | 32       | 2        | 1.36 | .28* | IS-DS            | N.S.            |
| (2-36) Personnel selection and assessment    | IS     | 121 | 82                   | 17       | 1        | 1.19 | .17* | EM-IS            | N.S.            |
|                                              | EM     | 199 | 84                   | 14       | 2        | 1.17 | .18* | EM-EF            | .005            |
|                                              | DS     | 168 | 85                   | 14       | 1        | 1.16 | .16* | EM-DS            | N.S.            |
|                                              | EF     | 48  | 63                   | 37       | -        | 1.38 | .24* | IS-DS            | N.S.            |
| (2-37) Supervisory training                  | IS     | 121 | 61                   | 34       | 5        | 1.44 | .35  | EM-IS            | N.S.            |
|                                              | EM     | 199 | 63                   | 34       | 3        | 1.39 | .29* | EM-EF            | .05             |
|                                              | DS     | 168 | 64                   | 34       | 2        | 1.39 | .29* | EM-DS            | N.S.            |
|                                              | EF     | 47  | 43                   | 55       | 2        | 1.60 | .29* | IS-DS            | N.S.            |
| (2-38) Techniques of guidance and counseling | IS     | 121 | 61                   | 34       | 5        | 1.44 | .35  | EM-IS            | N.S.            |
|                                              | EM     | 199 | 52                   | 44       | 4        | 1.52 | .34  | EM-EF            | .005            |
|                                              | DS     | 168 | 49                   | 47       | 4        | 1.56 | .35  | EM-DS            | N.S.            |
|                                              | EF     | 47  | 26                   | 60       | 14       | 1.89 | .40  | IS-DS            | N.S.            |
| (2-39) Training methods and techniques       | IS     | 121 | 35                   | 58       | 7        | 1.73 | .35  | EM-IS            | N.S.            |
|                                              | EM     | 199 | 36                   | 58       | 6        | 1.70 | .34  | EM-EF            | N.S.            |
|                                              | DS     | 168 | 35                   | 55       | 10       | 1.75 | .40  | EM-DS            | N.S.            |
|                                              | EF     | 47  | 36                   | 53       | 11       | 1.74 | .41  | IS-DS            | N.S.            |
| FINANCIAL MANAGEMENT                         |        |     |                      |          |          |      |      |                  |                 |
| (2-40) Capital budgeting                     | IS     | 120 | 43                   | 49       | 8        | 1.64 | .38  | EM-IS            | N.S.            |
|                                              | EM     | 198 | 47                   | 46       | 7        | 1.60 | .38  | EM-EF            | N.S.            |
|                                              | DS     | 168 | 45                   | 48       | 7        | 1.61 | .37  | EM-DS            | N.S.            |
|                                              | EF     | 47  | 36                   | 55       | 9        | 1.72 | .38  | IS-DS            | N.S.            |
| (2-41) Cost accounting procedures            | IS     | 120 | 23                   | 65       | 12       | 1.90 | .35  | EM-IS            | N.S.            |
|                                              | EM     | 198 | 23                   | 67       | 10       | 1.87 | .31* | EM-EF            | N.S.            |
|                                              | DS     | 168 | 20                   | 67       | 13       | 1.93 | .32  | EM-DS            | N.S.            |
|                                              | EF     | 47  | 23                   | 66       | 11       | 1.87 | .34  | IS-DS            | N.S.            |
| (2-42) Financial planning and forecasting    | IS     | 120 | 46                   | 43       | 11       | 1.65 | .45  | EM-IS            | N.S.            |
|                                              | EM     | 198 | 43                   | 52       | 5        | 1.63 | .35  | EM-EF            | N.S.            |
|                                              | DS     | 168 | 39                   | 51       | 10       | 1.71 | .41  | EM-DS            | N.S.            |
|                                              | EF     | 47  | 28                   | 68       | 4        | 1.77 | .27* | IS-DS            | N.S.            |
| (2-43) Fundamentals of financial management  | IS     | 120 | 28                   | 60       | 12       | 1.83 | .37  | EM-IS            | N.S.            |
|                                              | EM     | 198 | 33                   | 63       | 4        | 1.72 | .29* | EM-EF            | N.S.            |
|                                              | DS     | 168 | 29                   | 60       | 11       | 1.83 | .38  | EM-DS            | .05             |
|                                              | EF     | 47  | 38                   | 55       | 7        | 1.68 | .35  | IS-DS            | N.S.            |
| (2-44) Economics                             | IS     | 120 | 33                   | 55       | 12       | 1.80 | .41  | EM-IS            | .05             |
|                                              | EM     | 198 | 28                   | 67       | 5        | 1.78 | .28* | EM-EF            | N.S.            |
|                                              | DS     | 168 | 27                   | 61       | 12       | 1.85 | .37  | EM-DS            | N.S.            |
|                                              | EF     | 47  | 41                   | 53       | 6        | 1.66 | .36  | IS-DS            | N.S.            |
| (2-45) Advertising and sales promotion       | IS     | 120 | 4                    | 51       | 45       | 2.41 | .32* | EM-IS            | N.S.            |
|                                              | EM     | 198 | 3                    | 61       | 36       | 2.32 | .29* | EM-EF            | N.S.            |
|                                              | DS     | 168 | 5                    | 54       | 40       | 2.35 | .34  | EM-DS            | N.S.            |
|                                              | EF     | 47  | 10                   | 60       | 30       | 2.19 | .37  | IS-DS            | N.S.            |
| (2-46) Consumer surveys                      | IS     | 120 | 11                   | 56       | 33       | 2.22 | .40  | EM-IS            | N.S.            |
|                                              | EM     | 198 | 12                   | 57       | 31       | 2.20 | .40  | EM-EF            | N.S.            |
|                                              | DS     | 168 | 6                    | 55       | 39       | 2.33 | .34  | EM-DS            | N.S.            |
|                                              | EF     | 47  | 9                    | 68       | 23       | 2.15 | .30* | IS-DS            | N.S.            |



Table 20. Continued.

| Subject Areas                                   | Sample | N   | Percentage Responses |          |          | Mean | Var. | Compared Samples | Chi-Square Test |
|-------------------------------------------------|--------|-----|----------------------|----------|----------|------|------|------------------|-----------------|
|                                                 |        |     | AWK<br>1             | AOV<br>2 | DRN<br>3 |      |      |                  |                 |
| (2-47) Fundamentals of marketing                | IS     | 120 | 12                   | 56       | 32       | 2.19 | .41  | EM-IS            | N.S.            |
|                                                 | EM     | 198 | 11                   | 65       | 24       | 2.12 | .34  | EM-EF            | N.S.            |
|                                                 | DS     | 168 | 10                   | 55       | 35       | 2.24 | .40  | EM-DS            | N.S.            |
|                                                 | EF     | 47  | 13                   | 66       | 21       | 2.09 | .34  | IS-DS            | N.S.            |
| (2-48) Market forecasting                       | IS     | 121 | 12                   | 50       | 38       | 2.26 | .44  | EM-IS            | .01             |
|                                                 | EM     | 197 | 8                    | 68       | 24       | 2.16 | .30* | EM-EF            | N.S.            |
|                                                 | DS     | 168 | 8                    | 54       | 38       | 2.29 | .37  | EM-DS            | .05             |
|                                                 | EF     | 47  | 6                    | 68       | 26       | 2.19 | .29* | IS-DS            | N.S.            |
| (2-49) Market research                          | IS     | 121 | 7                    | 55       | 38       | 2.31 | .35  | EM-IS            | .05             |
|                                                 | EM     | 197 | 7                    | 70       | 23       | 2.15 | .28* | EM-EF            | N.S.            |
|                                                 | DS     | 168 | 6                    | 54       | 40       | 2.34 | .35  | EM-DS            | .005            |
|                                                 | EF     | 47  | 8                    | 66       | 26       | 2.17 | .31* | IS-DS            | N.S.            |
| (2-50) Public relations                         | IS     | 121 | 9                    | 55       | 36       | 2.26 | .40  | EM-IS            | .005            |
|                                                 | EM     | 197 | 13                   | 71       | 16       | 2.02 | .29* | EM-EF            | N.S.            |
|                                                 | DS     | 168 | 11                   | 63       | 26       | 2.15 | .36  | EM-DS            | .05             |
|                                                 | EF     | 47  | 19                   | 68       | 13       | 1.94 | .32* | IS-DS            | N.S.            |
| COMMUNICATION SKILLS                            |        |     |                      |          |          |      |      |                  |                 |
| (2-51) Business letter writing                  | IS     | 120 | 83                   | 15       | 2        | 1.20 | .21* | EM-IS            | N.S.            |
|                                                 | EM     | 198 | 86                   | 13       | 1        | 1.15 | .14* | EM-EF            | N.S.            |
|                                                 | DS     | 168 | 84                   | 15       | 1        | 1.16 | .14* | EM-DS            | N.S.            |
|                                                 | EF     | 50  | 84                   | 12       | 4        | 1.20 | .24* | IS-DS            | N.S.            |
| (2-52) English composition                      | IS     | 120 | 77                   | 22       | 1        | 1.24 | .20* | EM-IS            | N.S.            |
|                                                 | EM     | 199 | 79                   | 20       | 1        | 1.23 | .20* | EM-EF            | N.S.            |
|                                                 | DS     | 168 | 75                   | 24       | 1        | 1.26 | .22* | EM-DS            | N.S.            |
|                                                 | EF     | 50  | 72                   | 24       | 4        | 1.32 | .30* | IS-DS            | N.S.            |
| (2-53) Conference leadership                    | IS     | 121 | 83                   | 16       | 1        | 1.18 | .17* | EM-IS            | N.S.            |
|                                                 | EM     | 199 | 87                   | 12       | 1        | 1.14 | .14* | EM-EF            | .005            |
|                                                 | DS     | 168 | 85                   | 14       | 1        | 1.17 | .16* | EM-DS            | N.S.            |
|                                                 | EF     | 49  | 67                   | 31       | 2        | 1.35 | .27* | IS-DS            | N.S.            |
| (2-54) Effective communication in organizations | IS     | 121 | 90                   | 10       | -        | 1.10 | .09* | EM-IS            | N.S.            |
|                                                 | EM     | 199 | 90                   | 9        | 1        | 1.10 | .10* | EM-EF            | N.S.            |
|                                                 | DS     | 168 | 89                   | 10       | 1        | 1.12 | .13* | EM-DS            | N.S.            |
|                                                 | EF     | 49  | 80                   | 18       | 2        | 1.22 | .22* | IS-DS            | N.S.            |
| (2-55) Engineering graphics                     | IS     | 120 | 48                   | 50       | 2        | 1.53 | .28  | EM-IS            | N.S.            |
|                                                 | EM     | 198 | 43                   | 52       | 5        | 1.62 | .34  | EM-EF            | .005            |
|                                                 | DS     | 168 | 39                   | 54       | 7        | 1.68 | .36  | EM-DS            | N.S.            |
|                                                 | EF     | 49  | 16                   | 57       | 27       | 2.10 | .42  | IS-DS            | .05             |
| (2-56) Interviewing skills                      | IS     | 120 | 65                   | 34       | 1        | 1.36 | .25* | EM-IS            | N.S.            |
|                                                 | EM     | 199 | 66                   | 31       | 3        | 1.36 | .28* | EM-EF            | .005            |
|                                                 | DS     | 168 | 59                   | 38       | 3        | 1.45 | .32* | EM-DS            | N.S.            |
|                                                 | EF     | 49  | 33                   | 61       | 6        | 1.73 | .32* | IS-DS            | N.S.            |
| (2-57) Listening skills                         | IS     | 120 | 81                   | 19       | -        | 1.19 | .16* | EM-IS            | N.S.            |
|                                                 | EM     | 199 | 78                   | 21       | 1        | 1.24 | .21* | EM-EF            | N.S.            |
|                                                 | DS     | 168 | 75                   | 23       | 2        | 1.28 | .25* | EM-DS            | N.S.            |
|                                                 | EF     | 49  | 67                   | 33       | -        | 1.33 | .22* | IS-DS            | N.S.            |
| (2-58) Public speaking                          | IS     | 120 | 68                   | 31       | 1        | 1.33 | .24* | EM-IS            | N.S.            |
|                                                 | EM     | 199 | 77                   | 22       | 1        | 1.24 | .20* | EM-EF            | .01             |
|                                                 | DS     | 168 | 68                   | 32       | -        | 1.32 | .22* | EM-DS            | .05             |
|                                                 | EF     | 50  | 60                   | 34       | 6        | 1.46 | .37  | IS-DS            | N.S.            |
| (2-59) Rapid reading                            | IS     | 120 | 66                   | 30       | 4        | 1.38 | .32* | EM-IS            | N.S.            |
|                                                 | EM     | 199 | 65                   | 27       | 8        | 1.42 | .40  | EM-EF            | N.S.            |
|                                                 | DS     | 168 | 52                   | 38       | 10       | 1.59 | .46  | EM-DS            | .05             |
|                                                 | EF     | 49  | 55                   | 39       | 6        | 1.51 | .38  | IS-DS            | .05             |
| (2-60) Technical report writing                 | IS     | 120 | 71                   | 28       | 1        | 1.30 | .23* | EM-IS            | N.S.            |
|                                                 | EM     | 199 | 69                   | 28       | 3        | 1.34 | .28* | EM-EF            | N.S.            |
|                                                 | DS     | 168 | 55                   | 41       | 4        | 1.49 | .34* | EM-DS            | .05             |
|                                                 | EF     | 50  | 74                   | 24       | 2        | 1.28 | .25* | IS-DS            | .05             |

percent of the engineering managers indicated a need for "over-view only" as compared to 39 percent of the immediate superiors. (The modal response for immediate superiors was "doesn't really need.") In Item 78, nuclear physics, 53 percent of the engineering managers indicated a need for "over-view only" as compared to 34 percent of the immediate superiors. (The modal response for immediate superiors was "doesn't really need.") In Item 80, solid state physics, 67 percent of the engineering managers indicated a need for "over-view only" as compared to 53 percent of the immediate superiors.

Table 21 categorizes the eleven items according to disagreement between the engineering managers and their immediate superiors, and according to consensus within each sample. High intraposition consensus is revealed for one of the three items which showed a significant difference. In comparing engineering managers and immediate superiors, the null hypothesis can be rejected for this one item:

(1-78) nuclear physics.

In comparing engineering managers and direct subordinates, significant differences were revealed for eight items, 73, 74, 75, 76, 77, 78, 79, and 80.

In Item 73, matrix theory, 65 percent of the engineering managers indicated a need for "over-view only" as compared to 50 percent of the direct subordinates. In

Table 21. Classification of eleven mathematics, physics, chemistry items according to consensus within each of the samples and according to significant degree of disagreement between two samples. (Engineering Managers--Immediate Superiors.)

| Disagreement<br>Between the<br>Two Samples | High (H) or Low (L) Consensus Within Each Sample |                                 |                                 |                                 | Totals        |
|--------------------------------------------|--------------------------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------|
|                                            | H <sub>EM</sub> H <sub>IS</sub>                  | H <sub>EM</sub> L <sub>IS</sub> | L <sub>EM</sub> H <sub>IS</sub> | L <sub>EM</sub> L <sub>IS</sub> |               |
| Nonsignificant                             | 2                                                | 2                               | -                               | 4                               | 8             |
| Significant                                | 1                                                | 2                               | -                               | -                               | 3             |
|                                            | <u>      </u>                                    | <u>      </u>                   | <u>      </u>                   | <u>      </u>                   | <u>      </u> |
| Totals                                     | 3                                                | 4                               | -                               | 4                               | 11            |

Table 22. Classification of eleven mathematics, physics, chemistry items according to consensus within each of the samples and according to significant degree of disagreement between two samples. (Engineering Managers--Direct Subordinates.)

| Disagreement<br>Between the<br>Two Samples | High (H) or Low (L) Consensus Within Each Sample |                                 |                                 |                                 | Totals        |
|--------------------------------------------|--------------------------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------|
|                                            | H <sub>EM</sub> H <sub>DS</sub>                  | H <sub>EM</sub> L <sub>DS</sub> | L <sub>EM</sub> H <sub>DS</sub> | L <sub>EM</sub> L <sub>DS</sub> |               |
| Nonsignificant                             | -                                                | -                               | -                               | 3                               | 3             |
| Significant                                | 3                                                | 4                               | -                               | 1                               | 8             |
|                                            | <u>      </u>                                    | <u>      </u>                   | <u>      </u>                   | <u>      </u>                   | <u>      </u> |
| Totals                                     | 3                                                | 4                               | -                               | 4                               | 11            |

Item 74, numerical analysis, 67 percent of the engineering managers expressed a need for "over-view only" as compared to 58 percent of the direct subordinates. In Item 75, partial differential equations, 62 percent of the engineering managers indicated a need for "over-view only" as compared to 46 percent of the direct subordinates. In Item 76, probability and statistics, 50 percent of the engineering managers expressed a need for "over-view only" as compared to 55 percent of the direct subordinates. In Item 77, vector calculus, 58 percent of the managers indicated a need for "over-view only" as compared to 42 percent of the subordinates. (The modal response for the subordinates was "doesn't really need.") In Item 78, nuclear physics, 53 percent of the managers expressed a need for "over-view only" as compared to 30 percent of the subordinates. (The modal response for the subordinates was "doesn't really need.") In Item 79, polymer chemistry, 51 percent of the managers indicated a need for "over-view only" as compared to 30 percent of the subordinates. (The modal response for the subordinates was "doesn't really need.") In Item 80, solid state physics, 67 percent of the managers expressed a need for "over-view only" as compared to 46 percent of the subordinates. (The modal response for the subordinates was "doesn't really need.")

Table 22 classifies the eleven items according to disagreement between the engineering managers and the direct subordinates, and according to consensus within each sample.

High intraposition consensus is revealed for three of the eight items which showed a significant difference. In comparing engineering managers with direct subordinates, the null hypothesis can be rejected for the three items:

- (1-78) nuclear physics;
- (1-79) polymer chemistry; and
- (1-80) solid state physics.

In comparing engineering managers and engineering faculty, significant differences were revealed for eight items, 70, 71, 73, 74, 75, 77, 78, and 79.

In Item 70, calculus, 46 percent of the engineering managers expressed a need for a "working knowledge" as compared to 64 percent of the engineering faculty. In Item 71, differential equations, 54 percent of the managers indicated a need for "over-view only" as compared to 40 percent of the faculty. (The modal response for the faculty was "working knowledge.") In Item 73, matrix theory, 65 percent of the managers expressed a need for "over-view only" as compared to 62 percent of the faculty, but 26 percent of the managers indicated "doesn't really need" whereas 28 percent of the faculty indicated "working knowledge." In Item 74, numerical analysis, 67 percent of the managers indicated a need for "over-view only" as compared to 58 percent of the faculty. In Item 75, partial differential equations, 62 percent of the managers expressed a need for "over-view only" as compared to 68

percent of the faculty, but 29 percent of the managers indicated "doesn't really need" whereas the balance of the faculty was approximately equally divided between "working knowledge" and "doesn't really need." In Item 77, vector calculus, 58 percent of the managers indicated a need for "over-view only" as compared to 72 percent of the faculty. In Item 78, nuclear physics, 53 percent of the managers expressed a need for "over-view only" as compared to 74 percent of the faculty. In Item 79, polymer chemistry, 51 percent of the managers indicated a need for "over-view only" as compared to 70 percent of the faculty.

Table 23 classifies the eleven items according to disagreement between the engineering managers and the engineering faculty, and according to consensus within each sample. High intraposition consensus is revealed for three of the eight items which showed a significant difference. In comparing engineering managers and engineering faculty, the null hypothesis can thus be rejected for the three items:

- (1-77) vector calculus;
- (1-78) nuclear physics; and
- (1-79) polymer chemistry.

In comparing immediate superiors and direct subordinates, there were no items which revealed a significant difference between these two groups. The eleven items are classified in Table 24.

Table 23. Classification of eleven mathematics, physics, chemistry items according to consensus within each of the samples and according to significant degree of disagreement between two samples. (Engineering Managers--Engineering Faculty.)

| Disagreement<br>Between the<br>Two Samples | High (H) or Low (L) Consensus Within Each Sample |                                 |                                 |                                 | Totals    |
|--------------------------------------------|--------------------------------------------------|---------------------------------|---------------------------------|---------------------------------|-----------|
|                                            | H <sub>EM</sub> H <sub>EF</sub>                  | H <sub>EM</sub> L <sub>EF</sub> | L <sub>EM</sub> H <sub>EF</sub> | L <sub>EM</sub> L <sub>EF</sub> |           |
| Nonsignificant                             | 2                                                | -                               | -                               | 1                               | 3         |
| Significant                                | 3                                                | 2                               | 3                               | -                               | 8         |
|                                            | <u>5</u>                                         | <u>2</u>                        | <u>3</u>                        | <u>1</u>                        | <u>11</u> |
| Totals                                     | 5                                                | 2                               | 3                               | 1                               | 11        |

Table 24. Classification of eleven mathematics, physics, chemistry items according to consensus within each of the samples and according to significant degree of disagreement between two samples. (Immediate Superiors--Direct Subordinates.)

| Disagreement<br>Between the<br>Two Samples | High (H) or Low (L) Consensus Within Each Sample |                                 |                                 |                                 | Totals    |
|--------------------------------------------|--------------------------------------------------|---------------------------------|---------------------------------|---------------------------------|-----------|
|                                            | H <sub>IS</sub> H <sub>DS</sub>                  | H <sub>IS</sub> L <sub>DS</sub> | L <sub>IS</sub> H <sub>DS</sub> | L <sub>IS</sub> L <sub>DS</sub> |           |
| Nonsignificant                             | 2                                                | 1                               | 1                               | 7                               | 11        |
| Significant                                | -                                                | -                               | -                               | -                               | -         |
|                                            | <u>2</u>                                         | <u>1</u>                        | <u>1</u>                        | <u>7</u>                        | <u>11</u> |
| Totals                                     | 2                                                | 1                               | 1                               | 7                               | 11        |

## Engineering

The engineering area included the following fourteen special subjects: computer application; computer programming; materials science; quality control; reliability; systems theory; energy conversion; fluid dynamics; lubrication; mechanics of continua; metallurgy; plasticity; stress analysis; and vibration.

The engineering managers indicated a pronounced feeling that an "over-view only" was needed in twelve of the subjects. In one subject, computer application, they were approximately equally divided between "working knowledge" and "over-view only," and in one subject, mechanics of continua, they were somewhat equally divided between "over-view only" and "doesn't really need."

The immediate superiors indicated a pronounced feeling that an "over-view only" was needed for eleven of the subjects. They were approximately equally divided between "working knowledge" and "over-view only" on two subjects, computer application and reliability; whereas they were approximately equally divided between "over-view only" and "doesn't really need" on one subject, mechanics of continua.

The direct subordinates indicated a pronounced feeling for "over-view only" for thirteen subjects. In the remaining subject, mechanics of continua, they indicated a pronounced feeling for "doesn't really need."



The engineering faculty indicated a pronounced feeling that an "over-view only" was needed for thirteen of the subjects: computer programming; materials science; quality control; reliability; systems theory; energy conversion; fluid dynamics; lubrication; mechanics of continua; metallurgy; plasticity; stress analysis; and vibration. For the remaining subject, computer application, they were approximately equally divided between "working knowledge" and "over-view only."

The responses of the engineering managers, immediate superiors, direct subordinates, and engineering faculty are summarized in Table 20.

High intraposition consensus items for which no significant differences occurred, are presented for the respective groupings.

The engineering managers and immediate superiors showed such consensus for three items, 6, 7, and 10. A positive-neutral trend was revealed for one subject, computer application and reliability; whereas a neutral trend was shown for computer programming.

The engineering managers and direct subordinates showed high intraposition consensus for three items, 6, 17, and 19. A positive-neutral trend was revealed for one subject, computer application. A neutral feeling was shown for two subjects, plasticity and vibration.

The engineering managers and the engineering faculty showed such consensus for nine items, 6, 7, 8, 9, 10, 12, 14, 16, and 17. A positive-neutral trend was revealed for one subject, computer application. A neutral response was shown for eight subjects, computer programming, materials science, quality control, reliability, energy conversion, lubrication, metallurgy, and plasticity. The positive-neutral trend expressed for computer application was common to all three groupings.

The immediate superiors and the direct subordinates did not show high intraposition consensus for any items.

Significant difference items are now enumerated for the respective groupings.

In comparing engineering managers and immediate superiors, significant differences were revealed for four items, 9, 14, 15, and 19. In Item 9, quality control, 72 percent of the engineering managers indicated a need for "over-view only" as compared to 59 percent of the immediate superiors. In Item 14, lubrication, 68 percent of the engineering managers indicated a need for "over-view only" as compared to 58 percent of the superiors. In Item 15, mechanics of continua, the modal response of "over-view only" was slightly higher for the engineering managers than for the immediate superiors, and 46 percent of the managers indicated "doesn't really need" as compared to 42 percent of the superiors. In Item 19, vibration, 71 percent of

the engineering managers expressed a need for "over-view only" as compared to 58 percent of the immediate superiors.

Table 25 categorizes the fourteen items according to disagreement between the engineering managers and their immediate superiors, and according to consensus within each sample. However, none of the four items with a significant difference showed high intraposition consensus.

In comparing engineering managers and direct subordinates, significant differences were revealed for six items, 7, 8, 9, 10, 14, and 15.

In Item 7, computer programming, 71 percent of the engineering managers indicated a need for "over-view only" as compared to 61 percent of the direct subordinates. In Item 8, materials science, the modal response of "over-view only" was 73 percent for both groups, but 21 percent of the managers expressed a need for "working knowledge" whereas the balance of the direct subordinates was evenly divided between "working knowledge" and "doesn't really need." In Item 9, quality control, 72 percent of the engineering managers indicated a need for "over-view only" as compared to 71 percent of the direct subordinates, but 23 percent of the managers responded "working knowledge" whereas the balance of the subordinates was equally divided between "working knowledge" and "doesn't really need." In Item 10, reliability, 64 percent of the engineering managers expressed a need for "over-view only" as compared

Table 25. Classification of fourteen engineering items according to consensus within each of the samples and according to significant degree of disagreement between two samples. (Engineering Managers--Immediate Superiors.)

| Disagreement<br>Between the<br>Two Samples | High (H) or Low (L) Consensus Within Each Sample |                                 |                                 |                                 | Totals |
|--------------------------------------------|--------------------------------------------------|---------------------------------|---------------------------------|---------------------------------|--------|
|                                            | H <sub>EM</sub> H <sub>IS</sub>                  | H <sub>EM</sub> L <sub>IS</sub> | L <sub>EM</sub> H <sub>IS</sub> | L <sub>EM</sub> L <sub>IS</sub> |        |
| Nonsignificant                             | 3                                                | 4                               | 1                               | 2                               | 10     |
| Significant                                | -                                                | 4                               | -                               | -                               | 4      |
|                                            | -                                                | -                               | -                               | -                               | -      |
| Totals                                     | 3                                                | 8                               | 1                               | 2                               | 14     |

Table 26. Classification of fourteen engineering items according to consensus within each of the samples and according to significant degree of disagreement between two samples. (Engineering Managers--Direct Subordinates.)

| Disagreement<br>Between the<br>Two Samples | High (H) or Low (L) Consensus Within Each Sample |                                 |                                 |                                 | Totals |
|--------------------------------------------|--------------------------------------------------|---------------------------------|---------------------------------|---------------------------------|--------|
|                                            | H <sub>EM</sub> H <sub>DS</sub>                  | H <sub>EM</sub> L <sub>DS</sub> | L <sub>EM</sub> H <sub>DS</sub> | L <sub>EM</sub> L <sub>DS</sub> |        |
| Nonsignificant                             | 3                                                | 2                               | -                               | 3                               | 8      |
| Significant                                | 4                                                | 2                               | -                               | -                               | 6      |
|                                            | -                                                | -                               | -                               | -                               | -      |
| Totals                                     | 7                                                | 4                               | -                               | 3                               | 14     |

to 58 percent of the direct subordinates. In Item 14, lubrication, 68 percent of the managers indicated a need for "over-view only" as compared to 52 percent of the subordinates. In Item 15, mechanics of continua, 53 percent of the engineering managers expressed a need for "over-view only" as compared to 39 percent of the direct subordinates. (The modal response for the subordinates was "doesn't really need.")

Table 26 classifies the fourteen items according to disagreement between the engineering managers and the direct subordinates, and according to consensus within each sample. High intraposition consensus is revealed for four of the six items which showed a significant difference. In comparing engineering managers with direct subordinates, the null hypothesis can be rejected for the four items:

- (2-7) Computer programming;
- (2-8) Materials science;
- (2-9) Quality control; and
- (2-15) Mechanics of continua.

In comparing engineering managers and engineering faculty, a significant difference was revealed for one item, 15. In Item 15, mechanics of continua, 53 percent of the engineering managers expressed a need for "over-view only" as compared to 68 percent of the engineering faculty.

Table 27 classifies the fourteen items according to disagreement between the engineering managers and the

Table 27. Classification of fourteen engineering items according to consensus within each of the samples and according to significant degree of disagreement between two samples. (Engineering Managers--Engineering Faculty.)

| Disagreement<br>Between the<br>Two Samples | High (H) or Low (L) Consensus Within Each Sample |                                 |                                 |                                 | Totals    |
|--------------------------------------------|--------------------------------------------------|---------------------------------|---------------------------------|---------------------------------|-----------|
|                                            | H <sub>EM</sub> H <sub>EF</sub>                  | H <sub>EM</sub> L <sub>EF</sub> | L <sub>EM</sub> H <sub>EF</sub> | L <sub>EM</sub> L <sub>EF</sub> |           |
| Nonsignificant                             | 9                                                | 1                               | 1                               | 2                               | 13        |
| Significant                                | 1                                                | -                               | -                               | -                               | 1         |
|                                            | <u>10</u>                                        | <u>1</u>                        | <u>1</u>                        | <u>2</u>                        | <u>14</u> |
| Totals                                     |                                                  |                                 |                                 |                                 |           |

Table 28. Classification of fourteen engineering items according to consensus within each of the samples and according to significant degree of disagreement between two samples. (Immediate Superiors--Direct Subordinates.)

| Disagreement<br>Between the<br>Two Samples | High (H) or Low (L) Consensus Within Each Sample |                                 |                                 |                                 | Totals    |
|--------------------------------------------|--------------------------------------------------|---------------------------------|---------------------------------|---------------------------------|-----------|
|                                            | H <sub>IS</sub> H <sub>DS</sub>                  | H <sub>IS</sub> L <sub>DS</sub> | L <sub>IS</sub> H <sub>DS</sub> | L <sub>IS</sub> L <sub>DS</sub> |           |
| Nonsignificant                             | -                                                | -                               | 1                               | 3                               | 4         |
| Significant                                | 2                                                | 2                               | 4                               | 2                               | 10        |
|                                            | <u>2</u>                                         | <u>2</u>                        | <u>5</u>                        | <u>5</u>                        | <u>14</u> |
| Totals                                     |                                                  |                                 |                                 |                                 |           |

engineering faculty, and according to consensus within each sample. High intraposition consensus is revealed for Item 15 which showed a significant difference. Therefore, in comparing engineering managers and engineering faculty, the null hypothesis can be rejected for one item:

(2-15) Mechanics of continua.

In comparing immediate superiors and direct subordinates, significant differences were revealed for ten items, 6, 7, 8, 9, 10, 11, 14, 15, 18, and 19.

In Item 6, computer application, 53 percent of the immediate superiors expressed a need for "working knowledge" as compared to 40 percent of the direct subordinates. (The modal response of the subordinates was "over-view only.") In Item 7, computer programming, 67 percent of the superiors indicated a need for "over-view only" as compared to 61 percent of the subordinates, but the balance of the superiors was approximately equally divided between "working knowledge" and "doesn't really need" whereas 32 percent of the subordinates indicated "doesn't really need." In Item 8, materials science, 63 percent of the immediate superiors expressed a need for "over-view only" as compared to 73 percent of the direct subordinates. In Item 9, quality control, 59 percent of the superiors indicated "over-view only" as compared to 71 percent of the subordinates. In Item 10, reliability, 51 percent of the immediate superiors responded "over-view only" as compared

to 58 percent of the direct subordinates. In Item 11, systems theory, the modal response of "over-view only" was 63 percent for both groups, but 33 percent of the superiors expressed a need for "working knowledge" whereas the balance of the direct subordinates was somewhat evenly divided between "working knowledge" and "doesn't really need." In Item 14, lubrication, 58 percent of the immediate superiors indicated "over-view only" as compared to 52 percent of the direct subordinates, but the balance of the superiors was almost equally divided between "working knowledge" and "doesn't really need" whereas 38 percent of the subordinates indicated "doesn't really need." In Item 15, mechanics of continua, 52 percent of the immediate superiors expressed a need for "over-view only" as compared to 39 percent of the direct subordinates. (The modal response of the subordinates was "doesn't really need.") In Item 18, stress analysis, 56 percent of the superiors indicated "over-view only" as compared to 60 percent of the subordinates, but 30 percent of the subordinates responded "working knowledge" whereas the balance of the subordinates was almost equally divided between "working knowledge" and "doesn't really need." On Item 19, vibration, 58 percent of the immediate superiors indicated "over-view only" as compared to 68 percent of the direct subordinates.



Table 28 categorizes the fourteen items according to disagreement between the immediate superiors and the direct subordinates, and according to consensus within each sample. High intraposition consensus is revealed for two of the ten items which showed a significant difference. In comparing immediate superiors with direct subordinates, the null hypothesis can be rejected for the two items:

(2-6) Computer application; and

(2-7) Computer programming.

#### Management

The four management areas have been combined to include the following thirty-one special subjects: organization theory; business law; decision theory; research and development; simulation methods; data processing; business ethics; principles and functions of management; understanding individual and group behavior in work situations; business policy; production control; personnel administration; human relations skills; job evaluation; industrial relations; performance review and appraisal; personnel selection and assessment; supervisory training; techniques of guidance and counseling; training methods and techniques; capital budgeting; cost accounting procedures; financial planning and forecasting; fundamentals of financial management; economics; advertising and sales promotion;

consumer surveys; fundamentals of marketing; market forecasting; market research; and public relations.

The engineering managers indicated a pronounced feeling that a "working knowledge" was needed in nine of the subjects. In six subjects they were approximately equally divided between "working knowledge" and "over-view only"; and in sixteen of the subjects the engineering managers expressed a pronounced feeling that an "over-view only" was needed.

The immediate superiors indicated a pronounced feeling that a "working knowledge" was needed for eleven of the subjects. In five subjects they were approximately equally divided between "working knowledge" and "over-view only"; and in fourteen of the subjects they expressed a pronounced feeling that an "over-view only" was needed. In one subject, advertising and sales promotion, the immediate superiors were almost equally divided between "over-view only" and "doesn't really need."

The direct subordinates indicated a pronounced feeling that a "working knowledge" was needed for nine of the subjects. In six subjects they were almost evenly divided between "working knowledge" and "over-view only"; and in sixteen of the subjects the direct subordinates expressed a pronounced feeling that an "over-view only" was needed.

The engineering faculty indicated a pronounced feeling for "working knowledge" for six subjects: principles and functions of management; personnel administration; human relations skills; job evaluation; performance review and appraisal; and personnel selection and assessment. They were approximately equally divided between "working knowledge" and "over-view only" on two subjects: business ethics; and understanding individual and group behavior in work situations. On twenty-three of the subjects, the engineering faculty responded "over-view only." These items were: organization theory; business law; decision theory; research and development, simulation methods; data processing; business policy; production control; industrial relations; supervisory training; techniques of guidance and counseling; training methods and techniques; capital budgeting; cost accounting procedures; financial planning and forecasting; fundamentals of financial management; economics; advertising and sales promotion; consumer surveys; fundamentals of marketing; market forecasting; market research; and public relations.

The responses of the engineering managers, immediate superiors, direct subordinates, and engineering faculty are summarized in Table 20.

High intraposition consensus items for which no significant differences occurred, are enumerated for the respective groupings.

The engineering managers and immediate superiors showed such consensus for eleven items, 20, 24, 25, 27, 28, 31, 32, 33, 35, 36, and 45. A positive trend was revealed for six subjects: principles and functions of management; understanding individual and group behavior in work situations; human relations skills; job evaluation; performance review and appraisal; and personnel selection and assessment. A positive-neutral trend was revealed for two subjects, organization theory and personnel administration; whereas a neutral trend was indicated for two subjects, simulation methods and data processing. A neutral-negative trend was revealed for advertising and sales promotion.

The engineering managers and direct subordinates revealed high intraposition consensus for twelve items, 20, 23, 27, 28, 30, 31, 32, 33, 35, 36, 37, and 41. A positive trend was shown for seven subjects: principles and functions of management; understanding individual and group behavior in work situations; human relations skills; job evaluation; performance review and appraisal; personnel selection and assessment; and supervisory training. A positive-neutral trend was indicated for three subjects, organization theory, research and development, and personnel administration, whereas a neutral trend was indicated for two items, production control and cost accounting procedures. The feeling expressed for the eight subjects underlined was common to the previous grouping as well.

The engineering managers and the engineering faculty showed such concensus for six items, 24, 31, 32, 48, 49, and 50. A positive trend was revealed for human relations skills and a positive-neutral trend was revealed for personnel administration. A neutral trend was indicated for four subjects: simulation methods; market forecasting; market research; and public relations. The feeling expressed for the two subjects underlined was common to all three groupings.

The immediate superiors and direct subordinates showed high intraposition consensus for eight items, 20, 27, 28, 31, 32, 33, 35, and 36. A positive trend was revealed for six subjects: principles and functions of management; understanding individual and group behavior in work situations; human relations skills; job evaluation; performance review and appraisal; and personnel selection and assessment. A positive-neutral trend was indicated for two subjects, organization theory and personnel administration.

Significant difference items are now enumerated for the respective groupings.

In comparing engineering managers and immediate superiors, significant differences were revealed for five items, 34, 44, 48, 49, and 50. In Item 34, industrial relations, 67 percent of the engineering managers indicated a need for "over-view only" as compared to 59 percent of

the immediate superiors. In Item 44, economics, 67 percent of the managers responded "over-view only" as compared to 55 percent of the superiors. In Item 48, market forecasting, 68 percent of the engineering managers expressed a need for "over-view only" as compared to 50 percent of the immediate superiors. In Items 49 and 50, market research and public relations, approximately 70 percent of the engineering managers indicated a need for "over-view only" on each item as compared to 55 percent of the immediate superiors.

Table 29 categorizes the thirty-one items according to disagreement between the engineering managers and their immediate superiors, and according to consensus within each sample. However, none of the five items with a significant difference showed high intraposition consensus.

In comparing engineering managers and direct subordinates, significant differences were revealed for seven items, 24, 25, 26, 43, 48, 49, and 50.

In Item 24, simulation methods, 65 percent of the engineering managers indicated "over-view only" as compared to 69 percent of the direct subordinates, but 27 percent of the managers expressed a need for "working knowledge" whereas the balance of the subordinates was approximately equally divided between "working knowledge" and "doesn't really need." In Item 25, data processing, 73 percent

Table 29. Classification of thirty-one management items according to consensus within each of the samples and according to significant degree of disagreement between two samples. (Engineering Managers--Immediate Superiors.)

| Disagreement<br>Between the<br>Two Samples | High (H) or Low (L) Consensus Within Each Sample |                                 |                                 |                                 | Totals    |
|--------------------------------------------|--------------------------------------------------|---------------------------------|---------------------------------|---------------------------------|-----------|
|                                            | H <sub>EM</sub> H <sub>IS</sub>                  | H <sub>EM</sub> L <sub>IS</sub> | L <sub>EM</sub> H <sub>IS</sub> | L <sub>EM</sub> L <sub>IS</sub> |           |
| Nonsignificant                             | 11                                               | 7                               | -                               | 8                               | 26        |
| Significant                                | -                                                | 5                               | -                               | -                               | 5         |
|                                            | <u>11</u>                                        | <u>12</u>                       | <u>-</u>                        | <u>-</u>                        | <u>31</u> |
| Totals                                     | 11                                               | 12                              | -                               | 8                               | 31        |

Table 30. Classification of thirty-one management items according to consensus within each of the samples and according to significant degree of disagreement between two samples. (Engineering Managers--Direct Subordinates.)

| Disagreement<br>Between the<br>Two Samples | High (H) or Low (L) Consensus Within Each Sample |                                 |                                 |                                 | Totals    |
|--------------------------------------------|--------------------------------------------------|---------------------------------|---------------------------------|---------------------------------|-----------|
|                                            | H <sub>EM</sub> H <sub>DS</sub>                  | H <sub>EM</sub> L <sub>DS</sub> | L <sub>EM</sub> H <sub>DS</sub> | L <sub>EM</sub> L <sub>DS</sub> |           |
| Nonsignificant                             | 12                                               | 4                               | -                               | 8                               | 24        |
| Significant                                | 2                                                | 5                               | -                               | -                               | 7         |
|                                            | <u>14</u>                                        | <u>9</u>                        | <u>-</u>                        | <u>-</u>                        | <u>31</u> |
| Totals                                     | 14                                               | 9                               | -                               | 8                               | 31        |

of the engineering managers responded "over-view only" as compared to 71 percent of the direct subordinates, but the balance of the managers was approximately equally divided between "working knowledge" and "doesn't really need."

In Item 25, data processing, 73 percent of the engineering managers responded "over-view only" as compared to 71 percent of the direct subordinates, but the balance of the managers was approximately evenly divided between "working knowledge" and "doesn't really need" whereas 21 percent of the subordinates indicated "doesn't really need." In Item 26, business ethics, 49 percent of the engineering managers expressed a need for "over-view only" as compared to 42 percent of the direct subordinates. (The modal response of the subordinates was "working knowledge.") In Item 43, fundamentals of financial management, the modal response of "over-view only" was slightly higher for the engineering managers than for the direct subordinates, and 33 percent of the managers indicated "working knowledge" as compared to 29 percent of the subordinates. In Items 48 and 49, market forecasting and market research, approximately 70 percent of the engineering managers expressed a need for "over-view only" on each item as compared to 54 percent of the direct subordinates. In Item 50, public relations, 71 percent of the engineering managers responded "over-view only" as compared to 63 percent of the direct subordinates, but the balance of the managers was



approximately evenly divided between "working knowledge" and "doesn't really need" whereas 26 percent of the subordinates indicated "doesn't really need."

Table 30 classifies the thirty-one items according to disagreement between the engineering managers and the direct subordinates, and according to consensus within each sample. High intraposition consensus is revealed for two of the seven items which showed a significant difference. In comparing engineering managers with direct subordinates, the null hypothesis can be rejected for the two items:

(2-24) simulation methods; and

(2-25) data processing.

In comparing engineering managers and engineering faculty, significant differences were revealed for ten items, 20, 22, 25, 27, 28, 30, 35, 36, 37, and 38.

In Item 20, organization theory, 56 percent of the engineering managers indicated a need for "working knowledge" as compared to 29 percent of the engineering faculty. (The modal response of the faculty was "over-view only.") In Item 22, decision theory, 52 percent of the managers expressed a need for "working knowledge" as compared to 33 percent of the faculty. (The modal response of the engineering faculty was "over-view only.") In Item 25, data processing, 73 percent of the engineering managers responded "over-view only" as compared to 67 percent of

the engineering faculty, but the balance of the managers was almost equally divided between "working knowledge" and "over-view only" whereas 31 percent of the faculty indicated "working knowledge." In Item 27, principles and functions of management, 76 percent of the engineering managers indicated a need for "working knowledge" as compared to 55 percent of the engineering faculty. In Item 28, understanding individual and group behavior in work situations, 70 percent of the managers expressed a need for "working knowledge" as compared to 50 percent of the faculty. In Item 30, production control, 72 percent of the engineering managers indicated a need for "over-view only" as compared to 63 percent of the engineering faculty, but the balance of the managers were more or less evenly divided between "working knowledge" and "over-view only" whereas 31 percent of the faculty responded "working knowledge." In Item 35, performance review and appraisal, 91 percent of the engineering managers indicated a need for "working knowledge" as compared to 66 percent of the engineering faculty. In Item 36, personnel selection and assessment, 84 percent of the managers responded "working knowledge" as compared to 63 percent of the faculty. In Item 37, supervisory training, 63 percent of the engineering managers expressed a need for "working knowledge" as compared to 43 percent of the engineering faculty. (The modal response of the faculty was "over-view only.") Finally, in Item 38,

techniques of guidance and counseling, 52 percent of the engineering managers indicated a need for "working knowledge" as compared to only 26 percent of the engineering faculty. (The modal response of the faculty was "over-view only.")

Table 31 classifies the thirty-one items according to disagreement between the engineering managers and the engineering faculty, and according to consensus within each sample. High intraposition consensus is revealed for eight of the ten items which showed a significant difference. In comparing the engineering managers and engineering faculty, the null hypothesis can thus be rejected for the eight items:

- (2-20) organization theory;
- (2-25) data processing;
- (2-27) principles and functions of management;
- (2-28) understanding individual and group behavior in work situations;
- (2-30) production control;
- (2-35) performance review and appraisal;
- (2-36) personnel selection and assessment; and
- (2-37) supervisory training.

In comparing the immediate superiors and direct subordinates, significant differences were revealed for two items, 24 and 25. In Item 24, simulation methods, 66 percent of the immediate superiors indicated a need for "over-view only" as compared to 69 percent of the

Table 31. Classification of thirty-one management items according to consensus within each of the samples and according to significant degree of disagreement between two samples. (Engineering Managers--Engineering Faculty.)

| Disagreement<br>Between the<br>Two Samples | High (H) or Low (L) Consensus Within Each Sample |                                 |                                 |                                 | Totals |
|--------------------------------------------|--------------------------------------------------|---------------------------------|---------------------------------|---------------------------------|--------|
|                                            | H <sub>EM</sub> H <sub>EF</sub>                  | H <sub>EM</sub> L <sub>EF</sub> | L <sub>EM</sub> H <sub>EF</sub> | L <sub>EM</sub> L <sub>EF</sub> |        |
| Nonsignificant                             | 6                                                | 9                               | 1                               | 5                               | 21     |
| Significant                                | 8                                                | -                               | 1                               | 1                               | 10     |
| Totals                                     | 14                                               | 9                               | 2                               | 6                               | 31     |

Table 32. Classification of thirty-one management items according to consensus within each of the samples and according to significant degree of disagreement between two samples. (Immediate Superiors--Direct Subordinates.)

| Disagreement<br>Between the<br>Two Samples | High (H) or Low (L) Consensus Within Each Sample |                                 |                                 |                                 | Totals |
|--------------------------------------------|--------------------------------------------------|---------------------------------|---------------------------------|---------------------------------|--------|
|                                            | H <sub>IS</sub> H <sub>DS</sub>                  | H <sub>IS</sub> L <sub>DS</sub> | L <sub>IS</sub> H <sub>DS</sub> | L <sub>IS</sub> L <sub>DS</sub> |        |
| Nonsignificant                             | 8                                                | 1                               | 4                               | 16                              | 29     |
| Significant                                | 2                                                | -                               | -                               | -                               | 2      |
| Totals                                     | 10                                               | 1                               | 4                               | 16                              | 31     |

direct subordinates, but 31 percent of the superiors indicated "working knowledge" whereas the balance of the subordinates was almost evenly divided between "working knowledge" and "doesn't really need." In Item 25, data processing, 76 percent of the immediate superiors responded "over-view only" as compared to 71 percent of the subordinates, but 18 percent of the superiors indicated "working knowledge" whereas 21 percent of the subordinates responded "doesn't really need."

Table 32 categorizes the thirty-one items according to disagreement between the immediate superiors and the direct subordinates, and according to consensus within each sample. High intraposition consensus is revealed for both items which showed a significant difference. In comparing immediate superiors and direct subordinates, the null hypothesis can thus be rejected for the two items:

- (2-24) simulation methods; and
- (2-25) data processing.

#### Communication Skills

The Communication Skills area included the following ten subjects: business letter writing; English composition; conference leadership; effective communication in organizations; engineering graphics; interviewing skills; listening skills; public speaking; rapid reading; and technical report writing.

The engineering managers indicated a pronounced feeling that a "working knowledge" was needed in nine of the ten subjects. In the other subject, engineering graphics, they were approximately evenly divided between "working knowledge" and "over-view only."

The immediate superiors also indicated a pronounced feeling that a "working knowledge" was needed in nine of the ten subjects. In the other subject, engineering graphics, they were evenly divided between "working knowledge" and "over-view only."

The direct subordinates likewise indicated a pronounced feeling that a "working knowledge" was needed in nine of the ten subjects. In engineering graphics, they indicated that an "over-view only" was needed.

The engineering faculty indicated a pronounced feeling that a "working knowledge" was needed in eight of the ten subjects. They indicated a pronounced feeling that an "over-view only" was needed in the other two subjects, engineering graphics, and interviewing skills.

The responses of the engineering managers, immediate superiors, direct subordinates, and engineering faculty are summarized in Table 20.

High intraposition consensus items for which no significant difference occurred are enumerated for the respective groupings.

The engineering managers and immediate superiors showed such consensus for eight of the ten items, 51, 52, 53, 54, 56, 57, 58, and 60. A positive trend was revealed for all eight items, namely: business letter writing; English composition; conference leadership; effective communication in organizations; interviewing skills; listening skills; public speaking; and technical report writing.

The engineering managers and direct subordinates showed high intraposition consensus for six items, 51, 52, 53, 54, 56, and 57. A positive trend was revealed for all six items, namely: business letter writing; English composition; conference leadership; effective communication in organizations; interviewing skills; and listening skills. These six subjects were common to the previous grouping as well.

The engineering managers and the engineering faculty showed high intraposition consensus for five of the ten items, 51, 52, 54, 57, and 60. The trend was positive for all five items, namely: business letter writing; English composition; effective communication in organizations; listening skills; and technical report writing. Four subjects, business letter writing; English composition; effective communication in organizations; and listening skills, were common to all three groupings.

The immediate superiors and direct subordinates showed high intraposition consensus for seven items, 51,

52, 53, 54, 56, 57, and 58. The trend was positive for all seven items, namely: business letter writing; English composition; conference leadership; effective communication in organizations; interviewing skills; listening skills; and public speaking.

Significant difference items are now enumerated for the respective groupings.

In comparing engineering managers and immediate superiors, there were no items which revealed a significant difference between these two groups. The ten items are classified in Table 33.

In comparing engineering managers and direct subordinates, significant differences were revealed for three items, 58, 59, and 60. In Item 58, public speaking, 77 percent of the engineering managers indicated a need for "working knowledge" as compared to 68 percent of the direct subordinates. In Item 59, rapid reading, 65 percent of the managers expressed a need for "working knowledge" as compared to 52 percent of the subordinates. In Item 60, technical report writing, 69 percent of the managers indicated a need for "working knowledge" as compared to 55 percent of the subordinates.

Table 34 classifies the ten items according to disagreement between engineering managers and direct subordinates, and according to consensus within each sample. High intraposition consensus is revealed for one of the three



Table 33. Classification of ten communication skills items according to consensus within each of the samples and according to significant degree of disagreement between two samples. (Engineering Managers--Immediate Superiors.)

| Disagreement<br>Between the<br>Two Samples | High (H) or Low (L) Consensus Within Each Sample |                                 |                                 |                                 | Totals |
|--------------------------------------------|--------------------------------------------------|---------------------------------|---------------------------------|---------------------------------|--------|
|                                            | H <sub>EM</sub> H <sub>IS</sub>                  | H <sub>EM</sub> L <sub>IS</sub> | L <sub>EM</sub> H <sub>IS</sub> | L <sub>EM</sub> L <sub>IS</sub> |        |
| Nonsignificant                             | 8                                                | -                               | 2                               | -                               | 10     |
| Significant                                | -                                                | -                               | -                               | -                               | -      |
| Totals                                     | 8                                                | -                               | 2                               | -                               | 10     |

Table 34. Classification of ten communication skills items according to consensus within each of the samples and according to significant degree of disagreement between two samples. (Engineering Managers--Direct Subordinates.)

| Disagreement<br>Between the<br>Two Samples | High (H) or Low (L) Consensus Within Each Sample |                                 |                                 |                                 | Totals |
|--------------------------------------------|--------------------------------------------------|---------------------------------|---------------------------------|---------------------------------|--------|
|                                            | H <sub>EM</sub> H <sub>DS</sub>                  | H <sub>EM</sub> L <sub>DS</sub> | L <sub>EM</sub> H <sub>DS</sub> | L <sub>EM</sub> L <sub>DS</sub> |        |
| Nonsignificant                             | 6                                                | -                               | -                               | 1                               | 7      |
| Significant                                | 1                                                | 1                               | -                               | 1                               | 3      |
| Totals                                     | 7                                                | 1                               | -                               | 2                               | 10     |

items which showed a significant difference. Thus, in comparing engineering managers with direct subordinates, the null hypothesis can be rejected for this one item:

(2-58) public speaking.

In comparing engineering managers and engineering faculty, significant differences were revealed for four items, 53, 55, 56, and 58. In Item 53, conference leadership, 87 percent of the engineering managers indicated a need for "working knowledge" as compared to 67 percent of engineering faculty. In Item 55, engineering graphics, 52 percent of the managers expressed a need for "over-view only" as compared to 57 percent of the engineering faculty, but 43 percent of the managers indicated a need for "working knowledge" whereas 27 percent of the faculty indicated "doesn't really need." In Item 56, interviewing skills, 66 percent of the engineering managers indicated a need for "working knowledge" as compared to 33 percent of the engineering faculty. (The modal response for the engineering faculty was "over-view only.") In Item 58, public speaking, 77 percent of the managers expressed a need for "working knowledge" as compared to 60 percent of the faculty.

Table 35 classifies the ten items according to disagreement between engineering managers and engineering faculty, and according to consensus within each sample. High intraposition consensus is revealed for two of the four items which showed a significant difference. Thus,

Table 35. Classification of ten communication skills items according to consensus within each of the samples and according to significant degree of disagreement between two samples. (Engineering Managers--Engineering Faculty.)

| Disagreement<br>Between the<br>Two Samples | High (H) or Low (L) Consensus Within Each Sample |                                 |                                 |                                 | Totals    |
|--------------------------------------------|--------------------------------------------------|---------------------------------|---------------------------------|---------------------------------|-----------|
|                                            | H <sub>EM</sub> H <sub>EF</sub>                  | H <sub>EM</sub> L <sub>EF</sub> | L <sub>EM</sub> H <sub>EF</sub> | L <sub>EM</sub> L <sub>EF</sub> |           |
| Nonsignificant                             | 5                                                | -                               | -                               | 1                               | 6         |
| Significant                                | 2                                                | 1                               | -                               | 1                               | 4         |
|                                            | <u>7</u>                                         | <u>1</u>                        | <u>-</u>                        | <u>2</u>                        | <u>10</u> |
| Totals                                     | 7                                                | 1                               | -                               | 2                               | 10        |

Table 36. Classification of ten communication skills items according to consensus within each of the samples and according to significant degree of disagreement between two samples. (Immediate Superiors--Direct Subordinates.)

| Disagreement<br>Between the<br>Two Samples | High (H) or Low (L) Consensus Within Each Sample |                                 |                                 |                                 | Totals    |
|--------------------------------------------|--------------------------------------------------|---------------------------------|---------------------------------|---------------------------------|-----------|
|                                            | H <sub>IS</sub> H <sub>DS</sub>                  | H <sub>IS</sub> L <sub>DS</sub> | L <sub>IS</sub> H <sub>DS</sub> | L <sub>IS</sub> L <sub>DS</sub> |           |
| Nonsignificant                             | 7                                                | -                               | -                               | -                               | 7         |
| Significant                                | -                                                | 3                               | -                               | -                               | 3         |
|                                            | <u>7</u>                                         | <u>3</u>                        | <u>-</u>                        | <u>-</u>                        | <u>10</u> |
| Totals                                     | 7                                                | 3                               | -                               | -                               | 10        |

in comparing engineering managers and engineering faculty, the null hypothesis can be rejected for the two items:

(2-53) conference leadership; and

(2-56) interviewing skills.

In comparing the immediate superiors and the direct subordinates, significant differences were revealed for three items, 55, 59, and 60. In Item 55, engineering graphics, the modal response for "over-view only" was approximately equal for both groups, but 48 percent of the immediate superiors expressed a need for "working knowledge" as compared to 39 percent of the direct subordinates. In Item 59, rapid reading, 66 percent of the superiors indicated a need for "working knowledge" as compared to 52 percent of the subordinates. In Item 60, technical report writing, 71 percent of the superiors expressed a need for "working knowledge" as compared to 55 percent of the subordinates.

Table 36 classifies the ten items according to disagreement between the immediate superiors and the direct subordinates, and according to consensus within each sample. None of the three items, which revealed significant differences, showed high intraposition consensus.

## CHAPTER VI

### SUMMARY AND CONCLUSIONS

#### Purpose of the Study

The main purpose of this study is to investigate the relationships among the perceptions engineering managers have of their role and their continuing education requirements, and among the expectations held for them by their immediate superiors, direct subordinates, and by engineering faculty outside of the organization.

More specifically the study will:

1. Examine the relationships among the perceptions engineering managers have of their job functions and among the expectations held for them by their immediate superiors, direct subordinates, and by engineering faculty outside of the organization.
2. Examine the relationships among the perceptions engineering managers have of their continuing education activities, and among the expectations held for them by their immediate superiors, direct subordinates, and by engineering faculty outside of the organization.
3. Examine the relationships among the perceptions engineering managers have of their subject area needs, and

among the expectations held for them by their immediate superiors, direct subordinates, and by engineering faculty outside of the organization.

### Summary

#### Section I-Job Functions

##### Intraposition Consensus for Individual Groups

Examination of the job function items in terms of consensus within each of the four role-definer groups gives an expression of the job expectations which the majority of the members of a group hold for the Engineering Manager. The engineering managers indicated a feeling of "absolutely must" for 11 of the 29 job function items (7, 9, 10, 11, 15, 18, 19, 20, 25, 27, 32). The immediate superiors indicated this same feeling for 13 items (6, 7, 9, 10, 11, 15, 18, 19, 20, 21, 25, 27, 32), with 11 items common to both groups. The direct subordinates indicated a feeling of "absolutely must" for 8 items (9, 11, 15, 18, 20, 25, 27, 32) with all 8 items common to the two previous groups. The engineering faculty expressed such a feeling for 11 items (8, 9, 10, 11, 18, 19, 20, 24, 25, 27, 32). Seven of these items (9, 11, 18, 20, 25, 27, 32) were common to the three previous groups. The items were: delegate authority; motivate employees to achieve objectives; represent engineering in management

decisions; assess problems and progress; keep abreast of the current state of the art of management; familiarize himself in general with the work of those engineers reporting to him; and evaluate work being done by his engineers.

The engineering managers indicated a feeling of "preferably should" for 3 of the 29 job function items (22, 24, 30). The immediate superiors indicated the same feeling for the same 3 items. The direct subordinates indicated a feeling of "preferably should" for 4 items (21, 22, 24, 30). The engineering faculty indicated such a feeling for 3 items (14, 21, 30). Item 30 was common to the four groups: be available for consultation with his engineers as much as possible.

The engineering managers, immediate superiors, and direct subordinates expressed a negative feeling for 1 item (28): familiarize himself in detail with the work of those engineers reporting to him.

#### Intraposition and Interposition Consensus for Compared Groups

Hypothesis 1.--There is no significant difference in the perception engineering managers have of their job functions and in the expectations held for them by their immediate superiors, direct subordinates, and by engineering faculty.

Hypothesis 1a.--There is no significant difference in the expectations that immediate superiors and direct subordinates hold for the job functions of the engineering manager.

High intraposition consensus for items with no significant difference (interposition consensus) was found for:

- 14 items in comparing EM-IS;
- 10 items in comparing EM-DS;
- 9 items in comparing EM-EF; and
- 8 items in comparing IS-DS.

The null hypothesis can thus be accepted for these items. The items are summarized in the following array with the prevailing trend indicated in each instance. The following four items (9, 24, 27, 30) were common to the three primary groupings, involving engineering managers: delegate authority; keep abreast of the current state of the art of engineering; familiarize himself in general with the work of those engineers reporting to him; and be available for consultation with his engineers as much as possible.

| <u>Job Functions</u>                             | <u>EM-IS</u> | <u>EM-DS</u> | <u>EM-EF</u> | <u>IS-DS</u> |
|--------------------------------------------------|--------------|--------------|--------------|--------------|
| (1-7) Determine departmental or unit objectives. | pos.         |              |              |              |
| (1-9) Delegate authority.                        | pos.         | pos.         | pos.         | pos.         |
| (1-10) Coordinate the efforts of subordinates.   | pos.         |              | pos.         |              |



|        | <u>Job Functions</u>                                                              | <u>EM-IS</u> | <u>EM-DS</u> | <u>EM-EF</u> | <u>IS-DS</u> |
|--------|-----------------------------------------------------------------------------------|--------------|--------------|--------------|--------------|
| (1-11) | Motivate employees to achieve objectives.                                         | pos.         |              | pos.         |              |
| (1-15) | Facilitate communication on all levels.                                           | pos.         | pos.         |              | pos.         |
| (1-18) | Represent engineering in management decisions.                                    |              | pos.         | pos.         | pos.         |
| (1-19) | Justify and "sell" projects, ideas and plans to higher management.                | pos.         |              | pos.         |              |
| (1-20) | Assess problems and progress.                                                     | pos.         |              | pos.         |              |
| (1-22) | Encourage his engineers to justify and "sell" projects, ideas and plans to him.   | pos.         | pos.         |              | pos.         |
| (1-24) | Keep abreast of the current state of the art of engineering.                      | pos.         | pos.         | pos.         | pos.         |
| (1-25) | Keep abreast of the current state of the art of management.                       | pos.         | pos.         |              | pos.         |
| (1-27) | Familiarize himself in general with the work of those engineers reporting to him. | pos.         | pos.         | pos.         | pos.         |
| (1-28) | Familiarize himself in detail with the work of those engineers reporting to him.  | neg.         | neg.         |              | neg.         |
| (1-30) | Be available for consultation with his engineers as much as possible.             | pos.         | pos.         | pos.         |              |
| (1-32) | Evaluate the work being done by his engineers.                                    | pos.         | pos.         |              |              |

High intraposition consensus for items with a significant difference was found for:

- 1 item in comparing EM-IS;
- 2 items in comparing EM-DS;
- 2 items in comparing EM-EF; and
- 4 items in comparing IS-DS.

The null hypothesis can thus be rejected for these items. The items are summarized in the following array with the level of significance indicated in each instance. There were no items common to the three primary groupings involving engineering managers.

| <u>Job Functions</u>                                                         | <u>EM-IS</u> | <u>EM-DS</u> | <u>EM-EF</u> | <u>IS-DS</u> |
|------------------------------------------------------------------------------|--------------|--------------|--------------|--------------|
| (1-11) Motivate employees to achieve objectives.                             |              | .005         |              | .001         |
| (1-18) Represent engineering in management decisions.                        | .05          |              |              |              |
| (1-20) Assess problems and progress.                                         |              | .01          |              | .001         |
| (1-21) Ask penetrating questions to provide insight.                         |              |              |              | .01          |
| (1-25) Keep abreast of the current state of the art of management.           |              |              | .05          |              |
| (1-30) Be available for consultation with his engineers as much as possible. |              |              |              | .05          |
| (1-32) Evaluate work being done by his engineers.                            |              |              | .05          |              |

## Section II-Continuing Education Activities

### Intraposition Consensus for Individual Groups

Examination of the continuing education activities items in terms of consensus within each of the four role-definer groups gives an expression of the continuing education activities which the majority of the members of a group hold for the engineering manager. The engineering managers indicated a positive consensus for 8 of the 34 continuing education activities items (43, 47, 54, 56, 57, 58, 61, 66). The immediate superiors indicated this same feeling for 9 items (42, 43, 44, 47, 48, 56, 57, 58, 61), with 6 items (43, 47, 56, 57, 58, 61) common to both groups. The direct subordinates indicated a positive consensus for 9 items (35, 43, 47, 48, 49, 58, 61, 63, 66), with 4 items (43, 47, 58, 61) common to the two previous groups. The engineering faculty expressed such a feeling for 3 items (35, 47, 48). Item 47, attend local and national technical meetings on engineering was common to the three previous groups.

### Intraposition and Interposition Consensus for Compared Groups

Hypothesis 2.--There is no significant difference in the perceptions engineering managers have of their continuing education activities and in the expectations held

for them by their immediate superiors, direct subordinates, and by engineering faculty.

Hypothesis 2a.--There is no significant difference in the expectations that immediate superiors and direct subordinates hold for the continuing education activities of the engineering manager.

High intraposition consensus for items with no significant difference was found for:

11 items in comparing EM-IS;

11 items in comparing EM-DS;

2 items in comparing EM-EF; and

13 items in comparing IS-DS.

The null hypothesis can thus be accepted for these items. The items are summarized in the following array with the prevailing trend indicated in each instance. The following two items (38, 41) were common to the three primary groupings involving engineering managers: pursue an advanced degree in mathematics or the basic sciences; and take graduate credit work in mathematics or basic sciences, not necessarily for degree.

| <u>Continuing Education</u><br><u>Activities</u>                  | <u>EM-IS</u> | <u>EM-DS</u> | <u>EM-EF</u> | <u>IS-DS</u> |
|-------------------------------------------------------------------|--------------|--------------|--------------|--------------|
| (1-36) Be active in a professional business or management society | neut.        | neut.        |              | neut.        |
| (1-37) Pursue an advanced degree in engineering.                  | neut.        | neut.        |              | neut.        |

| <u>Continuing Education</u><br><u>Activities</u> |                                                                                                               | <u>EM-IS</u> | <u>EM-DS</u> | <u>EM-EF</u> | <u>IS-DS</u> |
|--------------------------------------------------|---------------------------------------------------------------------------------------------------------------|--------------|--------------|--------------|--------------|
| (1-38)                                           | Pursue an advanced degree in mathematics or the basic sciences.                                               | neut.        | neut.        | neut.        | neut.        |
| (1-39)                                           | Pursue an advanced degree in business management.                                                             |              | neut.        |              |              |
| (1-40)                                           | Take graduate credit work in engineering, not necessarily for degree.                                         |              |              |              | neut.        |
| (1-41)                                           | Take graduate credit work in mathematics or basic sciences, not necessarily for degree.                       | neut.        | neut.        | neut.        | neut.        |
| (1-42)                                           | Take graduate credit work in business management, not necessarily for degree.                                 |              | pos.         |              | neut.        |
| (1-43)                                           | Become familiar with the modern engineering curricula being offered in the leading colleges and universities. | pos.         | pos.         |              | pos.         |
| (1-47)                                           | Attend local and national technical meetings on engineering.                                                  | pos.         | pos.         |              |              |
| (1-51)                                           | Take time off for sabbatical leave to pursue advanced degree work.                                            | neut.        | neut.        |              | neut.        |
| (1-53)                                           | Take advanced non-credit engineering courses.                                                                 |              |              |              | neut.        |
| (1-54)                                           | Take advanced non-credit business and management courses.                                                     |              |              |              | neut.        |
| (1-55)                                           | Take advanced non-credit courses in basic sciences.                                                           |              |              |              | neut.        |

| <u>Continuing Education</u><br><u>Activities</u> |                                                                                                    | <u>EM-IS</u> | <u>EM-DS</u> | <u>EM-EF</u> | <u>IS-DS</u> |
|--------------------------------------------------|----------------------------------------------------------------------------------------------------|--------------|--------------|--------------|--------------|
| (1-56)                                           | Become acquainted with the new technological ideas and associated terminology used in engineering. | pos.         |              |              |              |
| (1-57)                                           | Attend engineering lectures and seminars.                                                          | pos.         |              |              |              |
| (1-58)                                           | Attend lectures and seminars on business management.                                               | pos.         | pos.         |              | pos.         |
| (1-61)                                           | Utilize technical and trade journals.                                                              | pos.         |              |              |              |
| (1-66)                                           | Utilize business and management journals.                                                          |              | pos.         |              |              |
| (1-68)                                           | Utilize management consultants.                                                                    |              |              |              | neut.        |

High intraposition consensus for items with a significant difference was found for:

- 3 items in comparing EM-IS;
- 2 items in comparing EM-DS;
- 3 items in comparing EM-EF; and
- 4 items in comparing IS-DS.

The null hypothesis can thus be rejected for these items. The items are summarized in the following array with the level of significance indicated in each instance. There were no items common to the three primary groupings involving engineering managers.

| <u>Continuing Education<br/>Activities</u> |                                                                               | <u>EM-IS</u> | <u>EM-DS</u> | <u>EM-EF</u> | <u>IS-DS</u> |
|--------------------------------------------|-------------------------------------------------------------------------------|--------------|--------------|--------------|--------------|
| (1-39)                                     | Pursue an advanced degree in business management.                             | .05          |              | .001         | .05          |
| (1-42)                                     | Take graduate credit work in business management, not necessarily for degree. | .05          |              | .001         |              |
| (1-47)                                     | Attend local and national technical meetings on engineering.                  |              |              | .005         | .05          |
| (1-48)                                     | Subscribe to engineering or scientific journals.                              |              |              |              | .05          |
| (1-54)                                     | Take advanced non-credit business and management courses.                     | .005         | .005         |              |              |
| (1-61)                                     | Utilize technical and trade journals.                                         |              | .01          |              | .005         |

### Section III-Subject Areas

Hypothesis 3.--There is no significant difference in the perceptions engineering managers have of their needs in certain subject areas and in the expectations held for them by their immediate superiors, direct subordinates, and engineering faculty; and

Hypothesis 3a.--There is no significant difference in the expectations that immediate superiors and direct subordinates hold concerning the needs of engineering managers in certain subject areas.

(Mathematics, Physics, Chemistry)

Intraposition Consensus for Individual Groups.--

Examination of the mathematics, physics, and chemistry items in terms of consensus within each of the four role-definer groups gives an expression of the subject area needs which the majority of the members of a group hold for the Engineering Manager.

The engineering managers were evenly distributed between "working knowledge" and "over-view only" for one item (76). They indicated a pronounced feeling for "over-view only" for 4 items (73, 74, 77, 80). They were evenly divided between "over-view only" and "doesn't really need" for two items (78, 79).

The immediate superiors were evenly divided between "working knowledge" and "over-view only" on one item (76). They expressed a pronounced feeling for "doesn't really need" for two items (78, 79).

There were no items involving "working knowledge" for the direct subordinates. However, the subordinates were evenly divided between "over-view only" and "doesn't really need" for one item (80). They expressed a pronounced feeling for "doesn't really need" for two items (78, 79).

The engineering faculty indicated a pronounced feeling for "working knowledge" on 2 items (70, 71), and a



pronounced feeling for "over-view only" on 6 items (75, 76, 77, 78, 79, 80).

There were no items common to all four groups.

Intraposiion and Interposition Consensus for Compared Groups.--High intraposition consensus for items with no significant difference was found for:

2 items in comparing EM-IS;

0 items in comparing EM-DS;

2 items in comparing EM-EF; and

2 items in comparing IS-DS.

The null hypothesis can thus be accepted for these items.

The items are summarized in the following array with the prevailing trend in each instance. There were no items common to the three primary groupings involving engineering managers.

| <u>Subject Areas</u>              | <u>EM-IS</u> | <u>EM-DS</u> | <u>EM-EF</u> | <u>IS-DS</u> |
|-----------------------------------|--------------|--------------|--------------|--------------|
| (1-76) Probability and statistics | awk-ov       |              | awk-ov       |              |
| (1-78) Nuclear physics            |              |              |              | drn          |
| (1-79) Polymer chemistry          | ov-drn       |              |              | drn          |
| (1-80) Solid state physics        |              |              | ov           |              |

High intraposition consensus for items with a significant difference was found for:

1 item in comparing EM-IS;

3 items in comparing EM-DS

3 items in comparing EM-EF; and

0 items in comparing IS-DS.

The null hypothesis can thus be rejected for these items. The items are summarized in the following array with the level of significance indicated in each instance. Item 78, nuclear physics, was common to the three primary groupings involving engineering managers.

| <u>Subject Areas</u>       | <u>EM-IS</u> | <u>EM-DS</u> | <u>EM-EF</u> | <u>IS-DS</u> |
|----------------------------|--------------|--------------|--------------|--------------|
| (1-77) Vector calculus     |              |              | .05          |              |
| (1-78) Nuclear physics     | .01          | .01          | .05          |              |
| (1-79) Polymer chemistry   |              | .005         | .05          |              |
| (1-80) Solid state physics |              | .005         |              |              |

(Engineering)

#### Intraposition Consensus for Individual Groups.--

Examination of the engineering items in terms of consensus within each of the four role-definer groups gives an expression of the engineering subject area needs which the majority of the members of a group hold for the Engineering Manager.

The engineering managers were evenly distributed between "working knowledge" and "over-view only" for Item 6. They indicated a pronounced feeling for "over-view only" for 9 items (7, 8, 9, 10, 12, 14, 16, 17, 19). They were evenly divided between "over-view only" and "doesn't really need" on one item (15).

The immediate superiors were evenly divided between "working knowledge" and "over-view only" on two items (6, 10). They expressed a pronounced feeling for "over-view only" for 2 items (7, 11).

The direct subordinates expressed a pronounced feeling for "over-view only" for 6 items (6, 7, 8, 9, 17, 19). They expressed a pronounced feeling for "doesn't really need" for one item (15).

The engineering faculty were evenly divided between "working knowledge" and "over-view only" on Item 6. They indicated a pronounced feeling for "over-view only" for 10 items (7, 8, 9, 10, 11, 12, 14, 15, 16, 17).

The feeling expressed for computer programming (Item 7) was common to all four groups.

Intraposition and Interposition Consensus for Compared Groups.--High intraposition consensus for items with no significant difference was found for:

- 3 items in comparing EM-IS;
- 3 items in comparing EM-DS;
- 9 items in comparing EM-EF; and
- 0 items in comparing IS-DS.

The null hypothesis can thus be accepted for these items. The items are summarized in the following array with the prevailing trend indicated in each instance. Item 6, computer application, was common to the three primary groupings involving engineering managers.



|        | <u>Subject Areas</u> | <u>EM-IS</u> | <u>EM-DS</u> | <u>EM-EF</u> | <u>IS-DS</u> |
|--------|----------------------|--------------|--------------|--------------|--------------|
| (2-6)  | Computer application | awk-ov       | ov           | awk-ov       |              |
| (2-7)  | Computer programming | ov           |              | ov           |              |
| (2-8)  | Materials science    |              |              | ov           |              |
| (2-9)  | Quality control      |              |              | ov           |              |
| (2-10) | Reliability          | awk-ov       |              | ov           |              |
| (2-12) | Energy conversion    |              |              | ov           |              |
| (2-14) | Lubrication          |              |              | ov           |              |
| (2-16) | Metallurgy           |              |              | ov           |              |
| (2-17) | Plasticity           |              | ov           | ov           |              |
| (2-19) | Vibration            |              | ov           |              |              |

High intraposition consensus for items with a significant difference was found for:

- 0 items in comparing EM-IS;
- 4 items in comparing EM-DS;
- 1 item in comparing EM-EF; and
- 2 items in comparing IS-DS.

The null hypothesis can thus be rejected for these items. The items are summarized in the following array with the level of significance indicated in each instance. There were no items common to the three primary groupings involving engineering managers.

| <u>Subject Areas</u>         | <u>EM-IS</u> | <u>EM-DS</u> | <u>EM-EF</u> | <u>IS-DS</u> |
|------------------------------|--------------|--------------|--------------|--------------|
| (2-6) Computer application   |              |              |              | .05          |
| (2-7) Computer programming   |              | .05          |              | .05          |
| (2-8) Materials science      |              | .01          |              |              |
| (2-9) Quality control        |              | .005         |              |              |
| (2-15) Mechanics of continua |              | .05          | .005         |              |

(Management)

Intraposition Consensus for Individual Groups.--

Examination of the management items in terms of consensus within each of the four role-definer groups gives an expression of the management subject area needs which the majority of the members of a group hold for the Engineering Manager.

The engineering managers indicated a pronounced feeling for "working knowledge" for 9 items (20, 27, 28, 31, 32, 33, 35, 36, 37). They were evenly distributed between "working knowledge" and "over-view only" for one item (26), and expressed a pronounced feeling for "over-view only" for 13 items (21, 23, 24, 25, 30, 34, 41, 43, 44, 45, 48, 49, 50).

The immediate superiors indicated a pronounced feeling for "working knowledge" for 8 items (20, 27, 28, 31, 32, 33, 35, 36). They expressed a pronounced feeling for "over-view only" for 2 items (24, 25). They were evenly divided between "over-view only" and "doesn't really need" for one item (45).

The direct subordinates indicated a pronounced feeling for "working knowledge" for 9 items (20, 27, 28, 31, 32, 33, 35, 36, 37). They were equally divided between "working knowledge" and "over-view only" for one item (23, and expressed a feeling of "over-view only" for 4 items (24, 25, 30, 41).

The engineering faculty expressed a pronounced feeling for "working knowledge" for 5 items (27, 31, 32, 35, 36), and were evenly distributed between "working knowledge" and "over-view only" for one item (28). The faculty indicated a pronounced feeling for "over-view only" for 10 items (20, 24, 25, 30, 37, 42, 46, 48, 49, 50).

The feeling expressed for 7 items (24, 25, 27, 31, 32, 35, 36) was common to all four groups. These items were: simulation methods; data processing; principles and functions of management; personnel administration, human relations skills; performance review and appraisal; and personnel selection and assessment.

Intraposition and Interposition Consensus for Compared Groups.--High intraposition consensus for items with no significant difference was found for:

- 11 items in comparing EM-IS;
- 12 items in comparing EM-DS;
- 6 items in comparing EM-EF; and
- 8 items in comparing IS-DS.

The null hypothesis can thus be accepted for these items. The items are summarized in the following array with the prevailing trend indicated in each instance. The following two items (31, 32) were common to the three primary groupings involving engineering managers: personnel administration and human relations skills.

| <u>Subject Areas</u>                                                   | <u>EM-IS</u> | <u>EM-DS</u> | <u>EM-EF</u> | <u>IS-DS</u> |
|------------------------------------------------------------------------|--------------|--------------|--------------|--------------|
| (2-20) Organization theory                                             | awk          | awk          |              | awk          |
| (2-23) Research and development                                        |              | awk-ov       |              |              |
| (2-24) Simulation methods                                              | ov           |              | ov           |              |
| (2-25) Data processing                                                 | ov           |              |              |              |
| (2-27) Principles and functions of management                          | awk          | awk          |              | awk          |
| (2-28) Understanding individual and group behavior in work situations. | awk          | awk          |              | awk          |
| (2-30) Production control                                              |              | ov           |              |              |
| (2-31) Personnel administration                                        | awk          | awk          | awk          | awk          |
| (2-32) Human relations skills                                          | awk          | awk          | awk          | awk          |
| (2-33) Job evaluation                                                  | awk          | awk          |              | awk          |
| (2-35) Performance review and appraisal                                | awk          | awk          |              | awk          |
| (2-36) Personnel selection and assessment                              | awk          | awk          |              | awk          |
| (2-37) Supervisory training                                            |              | awk          |              |              |
| (2-41) Cost accounting procedures                                      |              | ov           |              |              |



| <u>Subject Areas</u>                   | <u>EM-IS</u> | <u>EM-DS</u> | <u>EM-EF</u> | <u>IS-DS</u> |
|----------------------------------------|--------------|--------------|--------------|--------------|
| (2-45) Advertising and sales promotion | ov-drn       |              |              |              |
| (2-48) Market forecasting              |              |              | ov           |              |
| (2-49) Market research                 |              |              | ov           |              |
| (2-50) Public relations                |              |              | ov           |              |

High intraposition consensus for items with a significant difference was found for:

- 0 items in comparing EM-IS;
- 2 items in comparing EM-DS;
- 8 items in comparing EM-EF;
- 2 items in comparing IS-DS.

The null hypothesis can thus be rejected for these items. The items are summarized in the following array with the level of significance indicated in each instance. There were no items common to the three primary groupings involving engineering managers.

| <u>Subject Areas</u>                                                  | <u>EM-IS</u> | <u>EM-DS</u> | <u>EM-EF</u> | <u>IS-DS</u> |
|-----------------------------------------------------------------------|--------------|--------------|--------------|--------------|
| (2-20) Organization theory                                            |              |              | .005         |              |
| (2-24) Simulation methods                                             |              | .05          |              | .001         |
| (2-25) Data processing                                                |              | .05          | .01          | .001         |
| (2-27) Principles and functions of management                         |              |              | .05          |              |
| (2-28) Understanding individual and group behavior in work situations |              |              | .05          |              |
| (2-30) Production control                                             |              |              | .005         |              |

| <u>Subject Areas</u>                      | <u>EM-IS</u> | <u>EM-DS</u> | <u>EM-EF</u> | <u>IS-DS</u> |
|-------------------------------------------|--------------|--------------|--------------|--------------|
| (2-35) Performance review and appraisal   |              |              | .005         |              |
| (2-36) Personnel selection and assessment |              |              | .005         |              |
| (2-37) Supervisory training               |              |              | .05          |              |

(Communication Skills)

Intraposition Consensus for Individual Groups.--

Examination of the communication skills items in terms of consensus within each of the four role-definer groups gives an expression of the communication skills subject area needs which the majority of the members of a group hold for the Engineering Manager.

The engineering managers indicated a pronounced feeling for "working knowledge" for 8 items (51, 52, 53, 54, 56, 57, 58, 60).

The immediate superiors expressed a pronounced feeling for "working knowledge" for 9 items (51, 52, 53, 54, 56, 57, 58, 59, 60), and were evenly divided between "working knowledge" and "over-view only" on Item 55.

The direct subordinates expressed a feeling for "working knowledge" for 7 items (51, 52, 53, 54, 56, 57, 58).

The engineering faculty indicated a feeling for "working knowledge" for 6 items (51, 52, 53, 54, 57, 60), and expressed a feeling for "over-view only" for 1 item (56).



The feeling expressed for 5 items (51, 52, 53, 54, 57) was common to all four groups. These items were: business letter writing; English composition; conference leadership; effective communication in organizations; and listening skills.

Intraposition and Interposition Consensus for Compared Groups.--High intraposition consensus for items with no significant difference was found for:

- 8 items in comparing EM-IS;
- 6 items in comparing EM-DS;
- 5 items in comparing EM-EF; and
- 7 items in comparing IS-DS.

The null hypothesis can thus be accepted for these items. The items are summarized in the following array with the prevailing trend indicated in each instance. The following four items (51, 52, 54, 57) were common to the three primary groupings involving engineering managers: business letter writing; English composition; effective communication in organizations; and listening skills.

| <u>Subject Areas</u>                                | <u>EM-IS</u> | <u>EM-DS</u> | <u>EM-EF</u> | <u>IS-DS</u> |
|-----------------------------------------------------|--------------|--------------|--------------|--------------|
| (2-51) Business letter writing                      | awk          | awk          | awk          | awk          |
| (2-52) English composition                          | awk          | awk          | awk          | awk          |
| (2-53) Conference leadership                        | awk          | awk          |              | awk          |
| (2-54) Effective communications<br>in organizations | awk          | awk          | awk          | awk          |

| <u>Subject Areas</u>            | <u>EM-IS</u> | <u>EM-DS</u> | <u>EM-EF</u> | <u>IS-DS</u> |
|---------------------------------|--------------|--------------|--------------|--------------|
| (2-56) Interviewing skills      | awk          | awk          |              | awk          |
| (2-57) Listening skills         | awk          | awk          | awk          | awk          |
| (2-58) Public speaking          | awk          |              |              | awk          |
| (2-60) Technical report writing | awk          |              | awk          |              |

High intraposition consensus for items with a significant difference was found for:

- 0 items in comparing EM-IS;
- 1 item in comparing EM-DS;
- 2 items in comparing EM-EF; and
- 0 items in comparing IS-DS.

The null hypothesis can thus be rejected for these items. The items are summarized in the following array with the level of significance indicated in each instance. There were no items common to the three primary groupings involving engineering managers.

| <u>Subject Areas</u>         | <u>EM-IS</u> | <u>EM-DS</u> | <u>EM-EF</u> | <u>IS-DS</u> |
|------------------------------|--------------|--------------|--------------|--------------|
| (2-53) Conference leadership |              |              | .005         |              |
| (2-56) Interviewing skills   |              |              | .005         |              |
| (2-58) Public speaking       |              | .01          |              |              |

## Conclusions

### Section I - Job Functions

#### Intraposition Consensus for Individual Groups

1. The immediate superiors indicated a strong positive feeling on more job-function items than any of the other groups.

2. The direct subordinates indicated a strong positive feeling on fewer job-function items than any of the other groups.

3. There was common agreement among all four groups on seven of the twenty-nine items, namely:

- (1-9) delegate authority;
- (1-11) motivate employees to achieve objectives;
- (1-18) represent engineering in management decisions;
- (1-20) assess problems and progress;
- (1-25) keep abreast of the current state of the art of management;
- (1-27) familiarize himself in general with the work of those engineers reporting to him; and
- (1-32) evaluate work being done by his engineers.

#### Intraposition and Interposition Consensus for Compared Groups

1. A higher degree of agreement exists between the engineering managers and their immediate superiors concerning



the role of the engineering manager than between any other groups.

2. A lesser degree of agreement exists between the engineering managers and the engineering faculty concerning the role of the engineering manager than between the engineering manager and any other groups. However, four items (9, 24, 27, 30) were common to the three primary groupings: delegate authority; keep abreast of the current state of the art of engineering; familiarize himself in general with the work of those engineers reporting to him; and be available for consultation with his engineers as much as possible.

3. There were relatively few items in which the groups showed high intraposition consensus with a significant difference, and there were no items common to the three primary groupings.

## Section II - Continuing Education Activities

### Intraposition Consensus for Individual Groups

1. The engineering managers, immediate superiors, and direct subordinates, as individual groups, were essentially in agreement on the continuing-education items.

2. The engineering faculty indicated agreement on fewer continuing-education items than the other groups.

3. There was common agreement among all four groups on one of the thirty-four items, namely:



- (1-47) attend local and national technical meetings on engineering.

Intraposition and Interposition  
Consensus for Compared Groups

1. The engineering managers, immediate superiors, and direct subordinates, when compared, were essentially in agreement on the continuing-education activities of the engineering manager.

2. There was very little agreement between the engineering managers and the engineering faculty on the continuing-education activities of the engineering manager. However, two items (38, 41) were common to the three primary groupings: pursue an advanced degree in mathematics or the basic sciences; and take graduate credit work in mathematics or basic sciences, not necessarily for degree.

3. There were relatively few items in which the groups showed high intraposition consensus with a significant difference, and there were no items common to the three primary groupings.

Section III - Subject Areas

(Mathematics, Physics, Chemistry)

Intraposition Consensus  
for Individual Groups

1. The engineering faculty indicated a need for more mathematics, physics, chemistry subjects for the engineering manager than any of the other groups.

2. The direct subordinates did not indicate a need for any of the eleven subjects for the engineering manager, and the immediate superiors indicated a need for only one subject.

#### Intraposition and Interposition Consensus for Compared Groups

1. There was very little agreement among the compared groups concerning the mathematics, physics, chemistry subject needs of the engineering manager. In fact, there was no agreement between the managers and subordinates.

2. There were relatively few items in which the groups showed high intraposition consensus with a significant difference. In fact, there were no such items in comparing the superiors and subordinates. However, there was one item, (1-78), nuclear physics, which was common to the three primary groupings.

(Engineering)

#### Intraposition Consensus for Individual Groups

1. There was high agreement by both the engineering managers and the engineering faculty, as individual groups, concerning the need of the engineering manager for the engineering subjects.

2. There was relatively low agreement by both the immediate superiors and the direct subordinates, as individual

groups, concerning the need of the engineering manager for these subjects.

3. There was common agreement among all four groups on one of the fourteen items, namely:

(2-7) computer programming.

#### Intraposition and Interposition Consensus for Compared Groups

1. A much higher degree of agreement existed between engineering managers and engineering faculty concerning engineering subjects than between engineering managers and the other groups. In fact, there were no such items on which the superiors and subordinates agreed. There were no items common to the three primary groupings.

2. There were relatively few items on which the compared groups showed high intraposition consensus with a significant difference. In fact, there were no significant differences in comparing the engineering managers and their immediate superiors.

(Management)

#### Intraposition Consensus for Individual Groups

1. There was high agreement among the engineering managers and relatively low agreement among the immediate superiors concerning the need of the engineering manager for the management subjects.



2. There was moderate agreement by both the direct subordinates and the engineering faculty, as individual groups, concerning the need of the engineering manager for the management subjects.

3. There was common agreement among all four groups on seven of the thirty-one items, namely:

- (2-24) simulation methods;
- (2-25) data processing;
- (2-27) principles and functions of management;
- (2-31) personnel administration;
- (2-32) human relations skills;
- (2-35) performance review and appraisal; and
- (2-36) personnel selection and assessment.

#### Intraposition and Interposition Consensus for Compared Groups

1. A higher degree of agreement existed in comparing engineering managers with both superiors and subordinates than existed in comparing managers and faculty. There was moderate agreement between the superiors and subordinates. Two items, (2-31 and 2-32), were common to the three primary groupings: personnel administration, and human relations skills.

2. In comparing engineering managers and engineering faculty, there were more items (8) with high intraposition consensus and a significant difference than for any of the other groupings. There were no such items in comparing engineering managers and superiors.

## (Communication Skills)

Intraposition Consensus  
for Individual Groups

1. There was uniform agreement among the four individual groups on the need of the engineering manager for the communication skills subjects.

2. There was common agreement among the four groups on five of the ten items, namely:

- (2-51) business letter writing;
- (2-52) English composition;
- (2-53) conference leadership;
- (2-54) effective communication in organizations;  
and
- (2-57) listening skills.

Intraposition and Interposition  
Consensus for Compared Groups

1. A higher degree of agreement existed in comparing engineering managers with superiors than existed in comparing any of the other groups. Four items, (2-51), (2-52), (2-54), and (2-57) were common to the three primary groupings: business letter writing; English composition; effective communication in organizations; and listening skills.

2. There were relatively few items (3) in which the compared groups showed high intraposition consensus with

a significant difference. In fact, there were no significant differences in comparing managers and superiors, or in comparing superiors and subordinates.

### General Conclusion

As a general conclusion of the entire study:

1. The engineering managers showed the highest degree of consensus of the four individual groups;
2. The engineering managers and the immediate superiors showed the highest degree of consensus of the compared groups; and
3. The engineering managers and the immediate superiors showed the lowest number of significant differences of the compared groups.

### Recommendations

1. The lack of a strong feeling on the part of the direct subordinates concerning the job functions of the engineering manager might be a cause for concern, inasmuch as the direct subordinate is a potential candidate for movement into the position of engineering manager.

2. The relatively low degree of consensus between the engineering managers and the engineering faculty, concerning the role of the engineering manager, indicates a need for an interchange of managers and faculty in an effort to promote a mutual understanding between these two groups.

3. The lack of positive feeling on the part of the engineering faculty, concerning the continuing education activities of the engineering manager, warrants additional study.

4. The lack of consensus between the engineering managers and the engineering faculty, concerning the continuing education activities of the engineering manager, indicates a need for more dialogue between the two groups in order to reconcile the differences in opinions as recognized by the study.

5. The absence of strong feeling on the part of the immediate superiors and direct subordinates, as individual groups, along with the relatively low agreement of all of the compared groups concerning the mathematics, physics, chemistry subjects needed by the engineering manager, warrant further study.

6. The lack of strong feeling on the part of the immediate superiors and the direct subordinates, as individual groups, concerning the engineering subjects needed by the engineering manager, along with the relatively low consensus in comparing these groups with each other and with the engineering managers should be investigated.

7. The strong feeling on the part of the engineering managers, as a group, and the relatively high agreement between both engineering managers and immediate superiors and between engineering managers and direct



subordinates, concerning the management subjects needed by the engineering manager should be taken into account by the university, industry, and the professional societies in terms of curriculum development and continuing education program planning.

8. The strong feeling on the part of all four groups, concerning the communication skills subjects needed by the engineering manager, along with the high consensus of all of the compared groups must also be considered by the university, industry, and the professional societies in terms of curriculum development and continuing education program planning.

### Implications

Certain implications, over and beyond the study, warrant mentioning.

The lack of common agreement in the continuing education area on the part of the four individual groups in the study, as well as on the part of the compared groups, implies that much greater interaction is urgently needed. In particular, this was pointed up by the very limited agreement on the part of the faculty, as a group, concerning the continuing education activities of the engineering manager, and the very low agreement between the managers and the faculty on these items. An interchange, in terms of positions, of managers and faculty would lead

to better understanding of the needs of the engineering managers. The views of industry, in this regard, must be respected in order to meet their needs effectively.

The attendance of engineering managers at continuing education programs designed to meet their needs should be encouraged. Such programs would also provide insight to both superiors and subordinates if given an opportunity to attend periodically. These programs, multi-discipline in nature, should be designed to promote continuous learning on the part of the participants.

The relatively low agreement concerning the subject needs of the engineering manager in mathematics, physics, chemistry, and engineering on the part of the immediate superiors and the direct subordinates, as individual groups and when compared with each other, indicates that these subjects are more appropriate to the subordinate than to the manager. It also raises the question as to the need for these subjects in the managerial role.

The strong consensus of the engineering managers, as a group, and the relatively high agreement between managers and superiors and between managers and subordinates, concerning the management subject needs of the engineering manager, suggest that the management subject area is a criterion for advancement. The lack of consensus along with a high number of significant differences between the managers and the faculty on the management subjects suggest a

natural emphasis on the part of the engineering faculty toward the engineering discipline, or lack of sensitivity to the management needs of the engineering manager. Additional evidence is needed in order to arrive at a judgment.

The strong feeling on the part of all four groups concerning the communication skills subjects needed by the engineering managers, along with the high consensus of all the compared groups, suggest that effective communication skills can be enhanced through courses in the communication skills area. However, one subject of particular interest in the communication skills area is engineering graphics. The managers and their superiors indicated a stronger need for engineering graphics than was indicated by the subordinates and the faculty. This trend follows the current thinking that the computer and other devices are having a pronounced effect on the subject.

Finally, the faculties of the various colleges in the university must make a concerted effort to better understand the role of the engineering manager and his educational requirements, not only in terms of formal graduate and undergraduate programs within the university, but also with respect to his life-long educational needs.

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## APPENDIX A

### Open-ended Interview Schedule



## Open-ended Interview Schedule

## Questions

1. In your opinion, what are the job functions and responsibilities of the Engineering Manager?
2. In your opinion, what are the continuing education needs, activities, and professional responsibilities of the Engineering Manager?
3. In your opinion, what are the subject area needs of the Engineering Manager?

★

## APPENDIX B

### Engineering Manager Questionnaire

**Continuing Education Service/College of Engineering  
Michigan State University  
East Lansing, Michigan**

To help the University provide more effective programs in advanced engineering education, particularly for managers of engineering, we are conducting a research study to determine the continuing education needs, activities and responsibilities of the manager of engineering with respect to his professional development. In this study a "*Manager of Engineering*" refers to an engineer in a managerial or supervisory position at the first line of engineering management, responsible for directing the work of engineers or scientific personnel.

To insure confidential treatment of your reply, the questionnaire should be returned directly to the university in the self-addressed envelope. No names of individuals or firms will be identified in the text of the study. The success of this research effort is totally dependent on your co-operation. In appreciation of your participation, a summary of the results will be made available. Thank you very much for your help.

## Section I

*Instructions: The following items represent the views of a number of practicing engineering managers who have tried to describe their jobs as managers of a department or unit. Your answers to the following statements should provide a more comprehensive understanding of the job of the ideal manager or supervisor of engineering. We want to draw upon your knowledge and experience as a manager of engineering to determine more specifically what the functions and responsibilities of the manager are and what he needs to accomplish his job with maximum effectiveness.*

*Directions: Using the following scale, please indicate your feelings concerning each item. Circle one of the five numbers in the left column which most accurately describes the particular job activity of the Engineering Manager.*

|  | Absolutely must | Preferably should | May or may not | Preferably should not | Absolutely must not |                                                                      |
|--|-----------------|-------------------|----------------|-----------------------|---------------------|----------------------------------------------------------------------|
|  | 1               | 2                 | 3              | 4                     | 5                   |                                                                      |
|  | 1               | 2                 | 3              | 4                     | 5                   | (1- 6) Plan departmental or unit operations.                         |
|  | 1               | 2                 | 3              | 4                     | 5                   | (1- 7) Determine departmental or unit objectives.                    |
|  | 1               | 2                 | 3              | 4                     | 5                   | (1- 8) Organize resources for carrying out plans.                    |
|  | 1               | 2                 | 3              | 4                     | 5                   | (1- 9) Delegate authority.                                           |
|  | 1               | 2                 | 3              | 4                     | 5                   | (1-10) Coordinate the efforts of subordinates.                       |
|  | 1               | 2                 | 3              | 4                     | 5                   | (1-11) Motivate employees to achieve objectives.                     |
|  | 1               | 2                 | 3              | 4                     | 5                   | (1-12) Make decisions concerning the technical work of subordinates. |
|  | 1               | 2                 | 3              | 4                     | 5                   | (1-13) Direct employees toward established objectives.               |
|  | 1               | 2                 | 3              | 4                     | 5                   | (1-14) Rely on specialists for technical decisions.                  |
|  | 1               | 2                 | 3              | 4                     | 5                   | (1-15) Facilitate communication on all levels.                       |
|  | 1               | 2                 | 3              | 4                     | 5                   | (1-16) Manage engineers, not work alongside them.                    |
|  | 1               | 2                 | 3              | 4                     | 5                   | (1-17) Create and propose new ideas in engineering.                  |
|  | 1               | 2                 | 3              | 4                     | 5                   | (1-18) Represent engineering in management decisions.                |

*The job of the ideal manager  
of engineering is to:*

## APPENDIX C

### Sample Postcard

1 Absolutely must  
2 Preferably should  
3 May or may not  
4 Preferably should not  
5 Absolutely must not

*The ideal manager of  
engineering needs to:*

- 1 2 3 4 5 (1-46) Write and present technical and professional papers.
- 1 2 3 4 5 (1-47) Attend local and national technical meetings on engineering.
- 1 2 3 4 5 (1-48) Subscribe to engineering or scientific journals.
- 1 2 3 4 5 (1-49) Subscribe to business and management journals.
- 1 2 3 4 5 (1-50) Take time off during regular working hours to pursue continuing education programs.
- 1 2 3 4 5 (1-51) Take time off for sabbatical leave to pursue advanced degree work.
- 1 2 3 4 5 (1-52) Pursue advanced degree work simultaneously with job responsibilities.
- 1 2 3 4 5 (1-53) Take advanced non-credit engineering courses.
- 1 2 3 4 5 (1-54) Take advanced non-credit business and management courses.
- 1 2 3 4 5 (1-55) Take advanced non-credit courses in basic sciences.
- 1 2 3 4 5 (1-56) Become acquainted with the new technological ideas and associated terminology used in engineering.

*Keep updated by attending such activities as:*

- 1 2 3 4 5 (1-57) Engineering lectures and seminars.
- 1 2 3 4 5 (1-58) Lectures and seminars on business management.
- 1 2 3 4 5 (1-59) Short technical refresher courses.
- 1 2 3 4 5 (1-60) Lectures in the liberal arts and humanities.

|   |                       |
|---|-----------------------|
| 1 | Absolutely must       |
| 2 | Preferably should     |
| 3 | May or may not        |
| 4 | Preferably should not |
| 5 | Absolutely must not   |

*Keep updated by utilizing such sources of information as:*

- |   |   |   |   |   |                                                   |
|---|---|---|---|---|---------------------------------------------------|
| 1 | 2 | 3 | 4 | 5 | (1-61) Technical and trade journals.              |
| 1 | 2 | 3 | 4 | 5 | (1-62) Technical abstracts and indexes.           |
| 1 | 2 | 3 | 4 | 5 | (1-63) Technical books and reports.               |
| 1 | 2 | 3 | 4 | 5 | (1-64) Business reports (marketing, sales, etc.). |
| 1 | 2 | 3 | 4 | 5 | (1-65) Manufacturer's literature.                 |
| 1 | 2 | 3 | 4 | 5 | (1-66) Business and management journals.          |
| 1 | 2 | 3 | 4 | 5 | (1-67) Engineering consultants.                   |
| 1 | 2 | 3 | 4 | 5 | (1-68) Management consultants.                    |
| 1 | 2 | 3 | 4 | 5 | (1-69) Other_____.                                |

### Section III

*Instructions: In this section are listed specific technical and non-technical subjects. Please indicate the extent of knowledge that you feel the manager of engineering should have concerning each subject.*

*Directions: Using the following scale, please indicate your feelings concerning each item by circling one of the three numbers in the left column.*

*To what extent should the ideal  
manager of engineering  
know each subject?*

- 1 Acquire a working knowledge of
- 2 Acquire an over-view only
- 3 Doesn't really need

#### MATHEMATICS, PHYSICS, CHEMISTRY

- 1 2 3 (1-70) Calculus
- 1 2 3 (1-71) Differential equations
- 1 2 3 (1-72) Linear algebra
- 1 2 3 (1-73) Matrix theory
- 1 2 3 (1-74) Numerical analysis
- 1 2 3 (1-75) Partial differential equations
- 1 2 3 (1-76) Probability and statistics
- 1 2 3 (1-77) Vector calculus
- 1 2 3 (1-78) Nuclear physics
- 1 2 3 (1-79) Polymer chemistry
- 1 2 3 (1-80) Solid state physics

#### ENGINEERING

- 1 2 3 (2- 6) Computer application
- 1 2 3 (2- 7) Computer programming
- 1 2 3 (2- 8) Materials Science
- 1 2 3 (2- 9) Quality control



*To what extent should the ideal  
manager of engineering  
know each subject?*

- 1 Acquire a working knowledge of
- 2 Acquire an over-view only
- 3 Doesn't really need

1 2 3 (2-10) Reliability

1 2 3 (2-11) Systems theory

1 2 3 (2-12) Energy conversion

1 2 3 (2-13) Fluid dynamics

1 2 3 (2-14) Lubrication

1 2 3 (2-15) Mechanics of continua

1 2 3 (2-16) Metallurgy

1 2 3 (2-17) Plasticity

1 2 3 (2-18) Stress analysis

1 2 3 (2-19) Vibration

**GENERAL MANAGEMENT**

1 2 3 (2-20) Organization theory

1 2 3 (2-21) Business law

1 2 3 (2-22) Decision theory

1 2 3 (2-23) Research & Development

1 2 3 (2-24) Simulation methods

1 2 3 (2-25) Data processing

1 2 3 (2-26) Business ethics

1 2 3 (2-27) Principles and functions of management

1 2 3 (2-28) Understanding individual and group behavior in work situations

1 2 3 (2-29) Business policy

1 2 3 (2-30) Production control

*To what extent should the ideal  
manager of engineering  
know each subject?*

- 1 Acquire a working knowledge of
- 2 Acquire an over-view only
- 3 Doesn't really need

#### PERSONNEL MANAGEMENT

- 1 2 3 (2-31) Personnel administration
- 1 2 3 (2-32) Human relations skills
- 1 2 3 (2-33) Job evaluation
- 1 2 3 (2-34) Industrial relations
- 1 2 3 (2-35) Performance review and appraisal
- 1 2 3 (2-36) Personnel selection and assessment
- 1 2 3 (2-37) Supervisory training
- 1 2 3 (2-38) Techniques of guidance and counseling
- 1 2 3 (2-39) Training methods and techniques

#### FINANCIAL MANAGEMENT

- 1 2 3 (2-40) Capital Budgeting
- 1 2 3 (2-41) Cost accounting procedures
- 1 2 3 (2-42) Financial planning and forecasting
- 1 2 3 (2-43) Fundamentals of financial management
- 1 2 3 (2-44) Economics

#### MARKETING AND SALES MANAGEMENT

- 1 2 3 (2-45) Advertising and sales promotion
- 1 2 3 (2-46) Consumer surveys
- 1 2 3 (2-47) Fundamentals of marketing

*To what extent should the ideal  
manager of engineering  
know each subject?*

- 1 Acquire a working knowledge of
- 2 Acquire an over-view only
- 3 Doesn't really need

1 2 3 (2-48) Market forecasting

1 2 3 (2-49) Market research

1 2 3 (2-50) Public relations

**COMMUNICATION SKILLS**

1 2 3 (2-51) Business letter writing

1 2 3 (2-52) English composition

1 2 3 (2-53) Conference leadership

1 2 3 (2-54) Effective communication in organizations

1 2 3 (2-55) Engineering graphics

1 2 3 (2-56) Interviewing skills

1 2 3 (2-57) Listening skills

1 2 3 (2-58) Public speaking

1 2 3 (2-59) Rapid reading

1 2 3 (2-60) Technical report writing

## Section IV

*Instructions: Some statistical information would be of direct value in this research study. Please circle the number preceding the appropriate answer. This information will be treated with the strictest confidence.*

(2-61) *How old are you?*

- |                  |               |                 |
|------------------|---------------|-----------------|
| 1 under 25 years | 4 35-39 years | 7 51-55 years   |
| 2 25-29 years    | 5 40-44 years | 8 over 55 years |
| 3 30-34 years    | 6 45-50 years |                 |

(2-62) *What is the highest level of formal education you have attained?*

- |                        |                     |                   |
|------------------------|---------------------|-------------------|
| 1 High school          | 3 Bachelor's degree | 5 Doctoral degree |
| 2 1-3 years of college | 4 Master's degree   |                   |

(2-63) *How long has it been since you received your highest degree in engineering?*

- |                   |               |                 |
|-------------------|---------------|-----------------|
| 1 5 years or less | 3 11-15 years | 5 21-25 years   |
| 2 6-10 years      | 4 16-20 years | 6 over 25 years |

(2-64) *Please indicate the number of years you have been with your present company.*

- |                 |               |                 |
|-----------------|---------------|-----------------|
| 1 under 2 years | 3 6-10 years  | 5 16-20 years   |
| 2 2-5 years     | 4 11-15 years | 6 over 20 years |

(2-65) *How long have you been in your present position (level) in the company?*

- |                 |               |                 |
|-----------------|---------------|-----------------|
| 1 under 2 years | 3 6-10 years  | 5 16-20 years   |
| 2 2-5 years     | 4 11-15 years | 6 over 20 years |

(2-66) *How many professional engineering personnel are employed by your company?*

- |         |           |             |
|---------|-----------|-------------|
| 1 1-10  | 3 51-100  | 5 501-1000  |
| 2 11-50 | 4 101-500 | 6 over 1000 |

(2-67) *How many professional engineering personnel are under your supervision?*

- |        |         |               |
|--------|---------|---------------|
| 1 none | 3 6-10  | 5 51-99       |
| 2 1-5  | 4 11-50 | 6 100 or more |

(2-68) How would you classify your company among the following industry groups?

- |                 |                         |
|-----------------|-------------------------|
| 1 Manufacturing | 3 Service               |
| 2 Utility       | 4 Other (specify) _____ |

(2-69) Functionally, how would you classify your particular operation (department or unit) in relation to the rest of the organization?

- |              |                          |
|--------------|--------------------------|
| 1 Service    | 4 Design and Development |
| 2 Research   | 5 Marketing              |
| 3 Production | 6 Other (specify) _____  |

(2-70) Are you currently enrolled for another degree?

- |       |      |
|-------|------|
| 1 yes | 2 no |
|-------|------|

(2-71) If not enrolled, do you plan to enroll for another degree?

- |       |      |
|-------|------|
| 1 yes | 2 no |
|-------|------|

(2-72) If "yes" for either of the two preceding items, circle a number for the appropriate area and a number for the appropriate level:

- | (area)                  | (level)            |
|-------------------------|--------------------|
| 1 Engineering           | 5 Additional B. S. |
| 2 Business              | 6 Masters          |
| 3 Sciences              | 7 Doctorate        |
| 4 Other (specify) _____ | 8 Post doctoral    |

(2-74) If you had your education to do over again, would you go on to graduate work? (circle one)

- |                                                                      |
|----------------------------------------------------------------------|
| 1 No, would not go on to graduate work.                              |
| 2 Yes, would take graduate work in engineering.                      |
| 3 Yes, would take graduate work in mathematics or physical sciences. |
| 4 Yes, would take graduate work in business administration.          |
| 5 Yes, other (specify) _____                                         |

(2-75) From which State did you receive your highest degree in engineering?

- |                     |                         |
|---------------------|-------------------------|
| 1 State of Michigan | 2 Other (specify) _____ |
|---------------------|-------------------------|

OPTIONAL ITEMS:

Your name: \_\_\_\_\_

Your exact job title: \_\_\_\_\_

Your company's name: \_\_\_\_\_





## APPENDIX D

### Sample Cover Letter



We are conducting a study to determine the continuing education needs, activities and responsibilities of the manager of engineering with respect to his professional development.

It is hoped that the information from such a study will not only be helpful to the University, but will also be of value to those in industry and the professional societies involved in the planning of effective programs in advanced engineering education.

In order to carry out this study, we need your help. Please complete the enclosed questionnaire and return it to us in the self-addressed, stamped envelope provided.

We appreciate your cooperation and help in this project.

Sincerely,

Dr. Floyd G. Parker  
Assistant Director  
Continuing Education Service

Charles A. McKee  
Project Director

CAM:sjm

## **APPENDIX D**

### **Sample Cover Letter**

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