Title: Engineers: Formal Management Training Requirements?

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Abstract: Technology based companies are constantly seeking ways to assure that engineering managers are successful both as an engineer and as a manager. Since most engineering managers start as engineers, it is interesting to ask "What makes an effective engineer also an effective manager?" With this project we attempt to answer a small part of this question with empirical analysis. One of the tools used was controlled analysis, with which we test the hypothesis that formal management training is required for an engineer to be an effective and successful manager.

ENGINEERS: FORMAL MANAGEMENT TRAINING REQUIREMENTS?

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EXECUTIVE SUMMARY

Technology based companies are constantly seeking ways to assure that engineering managers are successful both as an engineer and as a manager. Since most engineering managers start as engineers, it is interesting to ask "What makes an effective engineer also an effective manager?" The objective of this project is to answer a small part of this question with empirical analysis.

Surveys with sixty-six questions were sent to 91 middle and upper engineering managers in approximately 10 local companies. The survey was designed to address following three major issues:

- Effectiveness as a manager
- Enjoyment in the management position
- Mobility of current position

Three different methods were used to analyze the survey results:

- Tabulation of survey results without testing for significance
- Controlled correlation analysis
- Open-ended correlation analysis

The results from the analysis showed that significant correlations do exist for certain aspects of formal training and effective managers. However, it is difficult to say that formal training is a prerequisite to becoming an effective manager. Some of the advantages for obtaining formal training included "rounding out" of the technical background. One respondent reminded us that it is important to remember that formal training cannot replace necessary experiences; rather, they are interdependent and not mutually exclusive. He noted that to be an effective manager, "training is a

INTRODUCTION

The rate at which science and technology are developing presents an unparalleled challenge to technology-based companies. The companies that do not stay with the game face the danger of becoming obsolete. Companies that are able to stay on the fore front of technology have the best chance of succeeding. At first glance, one might suggest that the solution to managing technology would be to place more engineers in top management positions. While some of the most successful companies are led by managers with engineering background, it is likely that most of these engineering managers did not obtain their management skills from their engineering education [1].

One technology director of a leading electronics industry explained the problem in unambiguous terms when he said, "Once a new technology rolls over you, if you're not part of the steam roller, you're part of the road"[1].

Engineering firms are constantly seeking ways of assuring that engineering managers perform successfully in their roles. Since most engineering managers begin their careers as engineers, it is interesting to ask, What makes an effective engineer also an effective manager? There is no single recipe to the question. Some research studies [2] have even cast doubts on the notion of engineers as efficient, strategic managers. These studies suggest that engineers are more involved in and committed to activities related to their profession rather than to the organization and that they lack general management skills.

The purpose of this project is to answer a small part of this question by empirical analysis. One of the tools used was controlled analysis to test the hypothesis that formal management training is required for an engineer to be an effective and

successful manager. In addition, we seek to determine any correlations that may exist between formal training and engineering managers' responsibilities.

BACKGROUND

In an annual survey of chief executive officers of the 1,000 largest US companies done by Heidrick and Struggles, those with an engineering (or science) background have steadily increased from 7 percent in 1977 to 18 percent in 1987 [3]. The *Forbes* magazine listed over 20 percent of the Chief Executive Officers from the 322 industrial firms to have technical background. An even larger percentage of smaller high technology corporations are led by executives with engineering background. Since it is likely that this trend will continue, it is important to ensure that engineers and engineering managers be prepared to assume progressively heavier responsibility.

A study conducted by Morrison in 1986 [4] identified several qualities in which an engineering background was helpful for a manager. Engineers are logical, methodical, objective, and make unemotional decisions based on facts. They use their technical knowledge to check the validity of information and can analyze problems thoroughly. They are able to look beyond the immediate problems and ask good questions to explore alternative solutions to technical problems. Engineering managers can review and evaluate the work of their subordinates because they understand what their subordinates are doing. Being engineers themselves, they understand what motivate other engineers. They are in a better position to engage in future planning with appropriate consideration for technology and its relationship to cost effectiveness. With a technical background, managers can be more effective in technical discussions with customers. This background also increases the managers' credibility with their subordinates, customers, and superiors. As others attribute these qualities, abilities,

skills, and knowledge to the engineering managers, the managers are able to influence those who have these perception.

An engineering background helps as well as hinders a manager's effectiveness. Major dilemmas in making the transition from engineer to manager are inherent in the differences between these two roles. When engineers make the transition into management, they are usually not very well prepared. The information on their new role, its breadth, organizational priorities, and established procedures are transmitted effectively. The primary criterion for promotion of engineers to management is that they are technically excellent. Having the technical excellence sometimes makes it difficult for them to "back off" and delegate the details to their subordinates. Another problem of technically excellent manager is that sometimes they have difficulty dealing with solving the problem by someone else's method. A comment made frequently is: "I know how to do it the right way". This reluctance to delegate is a critical and common problem among engineering managers. In fact, those who have been able to effectively delegate have recognized that their "right way" is not the only "right way" [4].

As we view the engineers as managers, we ask: "What are the characteristics of an effective manager?" Unfortunately, there is no one personality trait or set of qualities that can be used to discriminate leaders from non-leaders. Several studies by Gadeken [5] has summarized that leadership ability is tied to one's personality. Also management training can help make one's style mesh with organizational characteristics within the company. A good leader adjusts to the organization and the environment. Perhaps engineers tend to be too quantitative in their approach to becoming good managers, lacking sufficient understanding of the organization.

A comparison of management operations traits of those trained as engineers and those trained in management (managers) done by Brown in 1981 [6] offers some insights. Relative to engineers, the managers prefer acting through other people, are more socially oriented and outspoken, show more confidence, poise, and competitiveness. They are more comfortable with others. Those engineers who later obtain management training tend to show these same characteristics as managers. [6]

METHODS

Sociological Survey Design

Due to the time constrains, our survey will concentrate on middle and upper managers who have an engineering or science background. Through group discussions, we determined areas of importance for the technical manager relative to management training. The survey was designed in three sections to answer three major areas:

- Effectiveness as a manager
- Enjoyment in the management position
- Mobility of current position

The first section of the survey was designed to establish a consensus of expert opinion in the area of management training for the technical manager. The questions were very general and was not intended to exactly describe the individuals thoughts on the subject. The narrow response range (yes or no) required the respondent to intuitively sum the total reaction to the question and answer on the over-riding tendency. Viewing the data with regard to the summation of results and statistical analysis would be interesting and hopefully illustrating significant areas for continued work.

The second section of the survey, listing management skill areas, was taken in part from a previous survey [7]. In that survey, engineers were asked to rate the priority importance of a long list of management skill areas from which we selected nine of the top rated areas. This section as a whole, including importance, education, and skill, was our main focus for testing the hypothesis. It was designed to solicit the most objective responses possible with respect to the education-to-skill level correlation. This part of the survey design and analysis methodology was completed as a whole to objectively test our hypothesis.

The third section of the survey was designed to collect the population data. Majority of this section related to quantifiable profile information, but we also asked open ended questions concerning the persons job responsibilities and the pros and cons of management training. This section made the individual surveys more interesting to review and allowed analysis of demographic correlation.

Much of the survey design and survey was completed using guidances from Don Dillman's, *Mail and Telephone Surveys, The Total Design Method* [8]. The survey was designed so that it can be quick and easy for the respondents to complete. We used several people with significant experience in survey design, implementation, and analysis to help establish reasonable goals and methodology including (in chronological order of involvement): Dr. L. Hammer, PSU Psychology Department; Mr. G. Gilmore, Predoctorate PSU SSM; Dr. D. Frost, PSU Psychology Department; a number of engineers and managers to review the survey drafts; Dr. D. Kocaoglu, PSU EMP.

Dr. Frost recommended the two pole, (yes-no, rather than a wider range of answers), range because:

- The questions were very general (open to interpretation)
- A statistical analysis with at least 50 respondents
- A survey that required as little time as possible to complete

Dr. Frost's insight was very important because it broke through our academic approach with the practical reality of implementing the survey. Using a larger range was likely to produce an insignificant scattering of responses and a much less definitive result and it would certainly have taken longer for respondents to complete with a broader answer range.

The survey consisted of sixty six questions of which sixty where quantified for use in the analysis. Ninety-one survey forms were sent to middle and upper engineering managers in approximately 10 local companies. Seventy-seven managers responded to our request, for a 85% response. Of those responded to our survey, 69% held middle management positions and 23% held upper or top management positions. 87% had more than 10 years of work experience but only 30% has held a management position for more than 10 years. A copy of the survey form is included in Appendix A.

Correlations Analysis Method

The analysis was conducted in three independent forms followed with a synthesis of the results to draw together the results in a meaningful way. The intent was to extract as much information from the data as possible and then formulate in-depth conclusions.

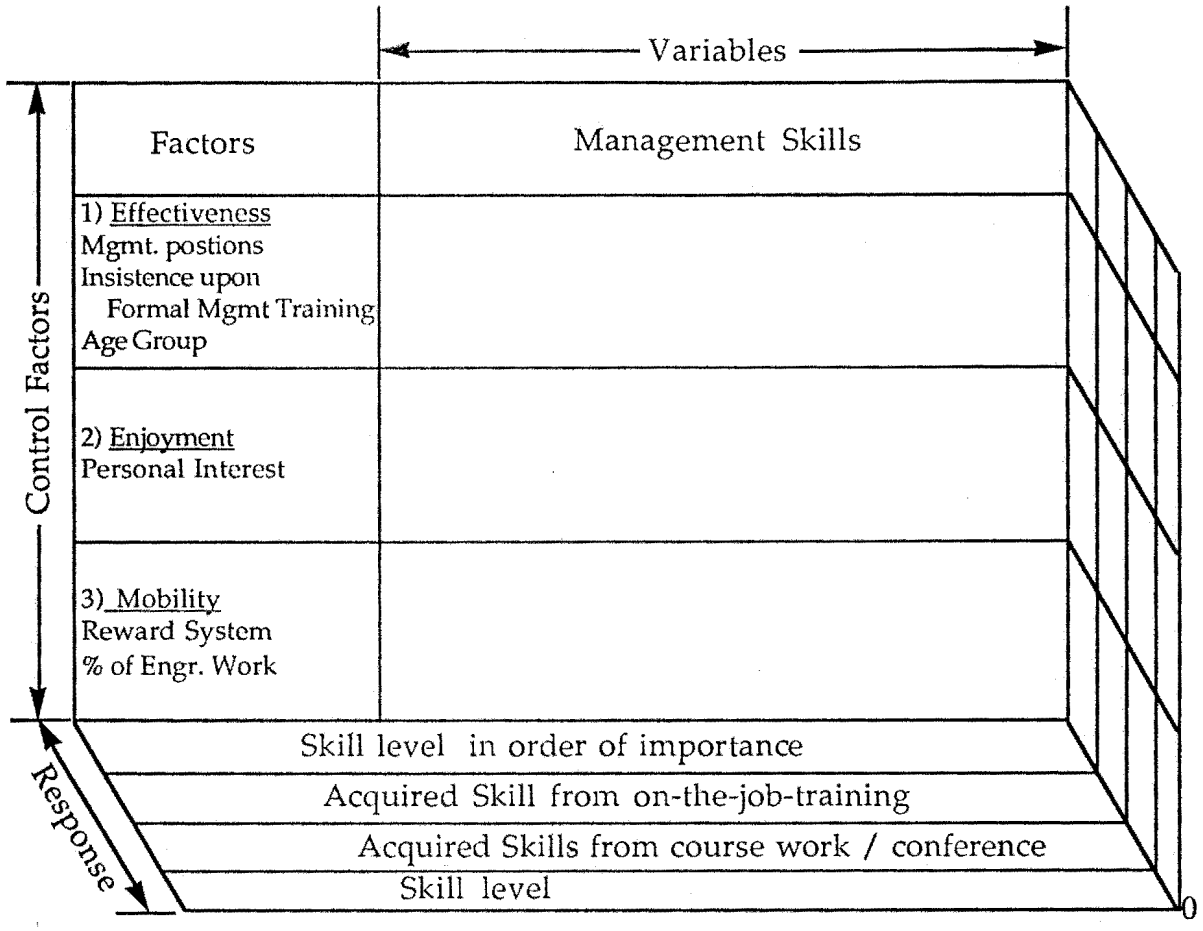
In the first approach the survey results were tabulated without testing for significance. This was the most simple and unscientific of the tests, but certainly the most important with its use in the correlation analysis as the basic benchmark of results.

In the second approach a controlled correlation analysis was used to test the hypothesis. This analysis was done to determine the relationship between 3 controlled factors (effectiveness, enjoyment and mobility) and 9 variables (project management, supervision, written communication, personnel management, marketing, labor relations, strategic planning and accounting) in 4 categories using the Spearman's Rank Correlation method. The 4 categories are :

- skill level in order of importance as perceived by the respondent
- acquired skills from on-the-job-training
- acquired skills from course work/conference
- skill level of respondent

Appendix B shows detailed information on the Spearman's Rank Correlations Method.

This method of analysis can be graphically represented by the figure below :



In the third approach an open-ended correlation analysis was conducted with the purpose of discovering characterizations and tendencies in our surveyed population. The correlation matrix in Appendix C shows the 95% significant Spearman Rank Correlation Coefficients and the asterisk identify the uncorrelated to the same significance. Our group did not trust the significance of secondary correlations so only direct correlations were used. Many interesting tendencies are evident in the response correlations with many illuminating the central theme of engineers and management training.

RESULTS

Survey of Engineering Managers

Included in the survey questions was a list of 9 subjects which the respondents were asked to rank in order of importance from their stand point as engineering managers. Written communication was ranked most important followed by project management, strategic planning, personnel management and supervision. Other significant results of the survey include:

- 87% of respondents did not perceive others with exclusively business degrees as having an advantage over them
- 69% of respondents indicated that they would advance into their technical field if given an opportunity
- Almost all the respondents have enjoyed the challenges of business management. Only 32% indicated that money was a major factor in determining their management career path
- Only 24% of respondents indicated that a management degree was a major consideration in promotion to a management position, while 43% indicated that management training is a prerequisite for upper management
- Almost all the respondents indicated that they would encourage their subordinates to take management courses and agreed that a company should offer formal management training to those advancing to a technical management position

- 65% of respondents indicated that they would seek management training at their own time and expense while 90% would do it if it did not required personal time or money
- 57% of respondents indicated that they spend more than 40% of their time on "engineering work"

Appendix D includes the raw survey results.

Results from the Correlations Analysis

The controlled correlation analysis yielded interesting, but not entirely conclusive results. The points of correlation with above 90% significance were very few and did not show any substantial trends toward varifying our hypothesis. The points that shed light on our total analysis was the correlation between, "insistence upon formal management training," and having high, "project management skills." We found both project management and management training to be of importance to the engineers we surveyed. Results from the Spearman Correlation Rank Method is included in the Appendix B.

The open-ended correlation analysis showed a number of trends that led to our central conclusions. Analysis of certain questions and their trends (all 95% significant) showed relative correlations.

Tracking a yes answer to Question two [Do you possess the most effective management skills?], the response tendency was to see increased effectiveness and mobility with management training, increased rewards in management, high labor relations job experience, and high supervisory skills. These responses did not correlate over all with

the high education and skill blocks that one would expect from the "Most effective manager," but rather we see the limited view of management as supervision.

Tracking a yes answer to question seventeen [Is management training a pre-requisite for upper management position?], the tendency was to see increased performance after training and with additional education in personnel management. This response correlates with personnel performance and education and begins to indicate the engineers' idea that management is people related and not business related.

Tracking a yes answer to question six [Have you enjoyed the challenge of adding business management skills to your technical background?], the tendency was to have a high importance in project management and high job experience in personnel management.

From these three examples one can conclude that the engineer may be more project and personnel focused, but there is also a strong tendency to enjoy business management. On question six [Have you enjoyed adding business management skills to your technical background?], the response was a resounding 95% yes.

Our assumption of nonnormal data and the use of nonparametric correlation analysis was confirmed in the correlation array (see Appendix B). The second section of the survey had significant correlations within each block of questions (importance to itself, skill to itself, etc.). This indicates that each person had his own range of answers that was consistent only for that person.

In this same section of the survey, an extremely consistent trend for each skill area (PM1 to PM4 to PM2, etc.) was observed. This trend was almost entirely unbroken with

most of the brakes showing correlations at 90% significance. One exception to this trend was the sets of "on-the-job acquired skill" to "course work acquired skill" which were confounded and near zero correlation. This shows the extreme internal consistency of answers given by the surveyed engineers. In this set of correlations the level of correlations for marketing was unusually high considering the unmatched ranges of the various parts of this section.

One additional area of significant correlation worth mentioning is the correlation of the [Significant salary increase period], as compared to the areas of education and skill with regard to personnel issues. All six data points were correlated to 95% except education in [Industrial/Labor Relations], which was 90% significant. This trend indicates that having extensive background in personnel management areas might make salary increases less frequent.

Additional Comments

The survey form specifically solicited any additional comments that the respondents wished to convey. Approximately 40 percent of the returned survey commented on the advantages and the disadvantages in obtaining formal management training. A complete listing of comments are available in the Appendix E.

The following is a summary of advantages in obtaining formal training:

- Gain insight into to how to manage right
- Greater benefit to the job performances and organization in the long run
- Management training is one of the necessary experiences
- Increase management effectiveness, including motivation, communication, supervision, performance of the people, commitment to the organizational goals
- Understanding the need for management

to the survey question concerning the pros & cons of formal management training it is clear that the key is an integration of education, responsibility and increasing authority to form the astute business engineer.

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