HOW TO MOTIVATE ENGINEERS:

AN INTEGRATED MODEL

By

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TABLE OF CONTENTS

Chapter Page

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

In the technological world of today, the work of engineers, the progenitors and refiners of technology, assumes increasing importance. Improving the quality and quantity of engineering work, hence, the productivity of engineers, becomes an issue. One key to unlocking the full potential of productivity is motivation, "the process of arousing actions, sustaining, and regulating the pattern of activity", (Smith, 1990, p. 60). The present study is concerned with determining how engineers are motivated.

Background of the Problem

The increased reliance on technology, hence, the significance of the work that engineers perform coupled with the view that engineers are becoming increasingly demotivated and dissatisfied (Badawy, 1977) have concerned engineering professionals. Concern over the perceived loss of motivation among engineers has resulted in a plethora of studies to investigate what motivates engineers (Aronberg, 1985; Badawy, 1975; Stevens & Krochmal, 1977; Thamhain, 1983). However, even though engineering management professionals have written on the topic of motivation, no conclusive answers have been advanced. There still is confusion between needs, organizational support factors, job satisfiers, job dissatisfiers, and motivators.

Statement of the Problem

It is assumed that the dependence of organizations on engineering work is growing. The productivity of the organization's engineering work force is hence a matter of survival for the organization in the highly competitive business arena. One of the keys to productivity is motivation. However, motivation is not easy to define. Pinder states that "there have been almost as many definitions of motivation offered over the years as there have been thinkers who have considered the nature of human behavior" (p. 7). Steers and Porter define work motivation as "conditions which influence the arousal, directions, and maintenance of behavior relevant in work settings" (p. 14).

Psychologists have viewed motivation from a content or a process perspective. Engineering management professionals have tried to specifically determine what motivates engineers by conducting surveys. However, no research has yet attempted to model the process of engineering motivation in its entirety. How do the different factors such as needs, organizational support factors, or rewards interact to result in motivating engineers?

Purpose of the Study

The purpose of the study is to attempt to model the process of motivating engineers. The components of the model will be compiled from a review of the general psychology literature and the engineering management literature. This study will be taken as far as stating some of the issues and questions that need to be investigated to validate the proposed integrated model of motivating engineers. However, the validity of the model will not be actually tested in this study. Further research in the future can build upon the findings of this thesis to test the proposed model.

Outline of the Study

Chapter Two of this thesis constitutes a review of the literature on motivation. In the first major section, the following motivation theories will be reviewed: Needs Theories, Expectancy Theory, Equity Theory, Reinforcement Theory, and two integrated motivational theories. The second major section of this chapter consists of reviewing the engineering motivation literature.

Chapter Three presents an evaluation and critique of the engineering literature findings against the major motivation theories.

In Chapter Four, the proposed integrated model of motivating engineers and its components are presented.

Finally, Chapter Five provides the questions and issues that arise from the proposed integrated model and some recommendations for further research.

CHAPTER II

REVIEW OF THE LITERATURE

The following literature review presents theories and research relevant to the present study. This chapter is composed of three major sections. In the first section, a definition of motivation and its relationship to job performance are presented. In the second section, the major theories of motivation in the general psychology literature are summarized. Finally, in the third section, the work of engineering professionals who have researched the area of motivating engineers is introduced.

Definition of Motivation

In the following section, a definition of motivation and its relationship to job performance are presented.

Definition

The task of defining motivation is not an easy one. Pinder (1984) states that there has been almost as many definitions of motivation presented as there have been thinkers who have considered the nature of human behavior. Theorists have looked at motivation from different perspectives. Proponents of the content theories have tried to explain motivation by identifying the human needs that arouse, start, or initiate behavior. Proponents of the process theories have tried to explain motivation by looking at the thought processes through which humans give meaning to rewards and hence determine how they could be influenced. Proponents of reinforcement theory have looked at the impact of the environment in shaping human behavior through reinforcement.

Jones (1955), Vroom (1964), Steers and Porter (1975), and Locke, Shaw, Saari, and Latham (1981) tried to give an "absolute" definition of motivation (one that does not explain motivation based on any particular theory). They define work motivation as:

> . . . a set of energetic forces that originate both within as well as beyond an individual's being, to initiate work-related behavior, and to determine its form, direction, intensity, and duration (Quoted from Pinder, 1984, p. 8).

The force metaphor is central to this definition. It implies the existence of needs, drives, instincts, and external factors that lead to a specific behavior. The concept of force also implies that motivation levels vary between weak and strong under different circumstances, as well as at different times within the same individual. Pinder (1984) also states that "the idea of force suggests that motivation will manifest itself through effort" (p. 8).

The notion of direction in the definition of motivation emphasizes that it is not sufficient to consider the force or effort of work motivation. The goals toward which the work energy is focused have to also be taken into consideration to completely understand work motivation.

The notion of duration is another factor in the definition of work motivation. It emphasizes that it is not enough to arouse the work energy, but it is also crucial to maintain this energy for the duration necessary to accomplish the work.

However, the most important feature of all in the definition of work motivation is the notion that motivation is an internal concept. Because it is not visible and not directly observable, it can only be assumed. This is the reason for the nonexistence of a unique, universally accepted theory that explains motivation. However, even though each theory explains motivation from a distinct perspective, they do not contradict each other but complement one another. Hence, the major insights from each theory will ultimately be drawn together into an integrated model to explain how engineers are motivated.

Motivation and Job Performance

Managers believe that the above definition of motivation implies that a highly motivated employee would necessarily perform well (Pinder, 1984). However, this is not always true. Performance is not only a function of motivation, but also a factor of the individual's ability to perform the job, and the organizational support provided to him/her in performing his/her job. Schermerhorn (1989) states that:

Performance = Ability x Support x Effort

Hence, when managers assume that poor job performance is the result of low motivation to work, they could be making a serious mistake. The poor performance could be simply that the employee lacks the ability to perform the task, or that he/she lacks the support to execute the assigned task.

Some psychologists (Dunette, 1972) have argued that ability is more important than motivation in job performance. However, even though there is no consensus on which factor is more important, there is agreement that both motivation and ability are necessary to achieve high job performance. Organizational support is the third element necessary to achieve high performance.

Theories of Motivation

The psychological literature categorizes the motivational theories into three broad categories: content, process, and reinforcement theories.

Content Theories

The content theories of motivation are concerned with the factors or needs that arouse motivated behavior.

> A need is ... sometimes provoked directly by internal processes of a certain kind ... but more frequently (when in a state of readiness) by the occurrence of one of a few commonly effective press (or features of the environment)... Thus, it manifests itself by leading the organism to search for or to avoid encountering, or when encountered, to attend to and respond to certain kinds of press... It may be weak or intense, momentary or enduring. But usually it persists and gives rise

> to a certain course of overt behavior (or fantasy) which ... changes the initiating circumstance in such a way as to bring about an end situation which stills (appeases and satisfies) the organism. (Murray, 1938, p. 123-124).

The content theories are Maslow's Hierarchy of Needs, Alderfer's ERG Theory, McClelland's Acquired Needs Theory, and Herzberg's Two Factor Theory.

Maslow's Hierarchy of Needs Theory

Maslow states that people in the workplace are motivated to perform by a desire to satisfy a set of internal needs. He divides those needs into five categories:

1- Physiological Needs: The basic, primary human needs such as need for air, food, sex, and shelter.

2- Safety Needs: The need for security, protection, and stability.

3- Social Needs: The need for love, affection, sense of belonging, such as friendship, companionship, and affection.

4- Esteem Needs: The need for the esteem of others: respect, prestige, recognition, self-esteem, and self-respect.

5- Self-Actualization Needs: The need to fulfill one's self to the highest of one's potential such as growth, achievement, and advancement.

Maslow's Theory is based on two principles:

1- People are wanting beings whose needs can influence their behavior. Only unsatisfied needs can influence behavior, satisfied needs are not motivators of behavior.

2- The five needs exist in a hierarchy of prepotency; a need at any level becomes activated once the next lower-level need has been satisfied.

Maslow's theory is often presented in the form of a pyramid in management books. However, I chose not to do so here as Pinder (1984) argues that the "staircase-like image" is an "oversimplification" of the theory.

> The image is often interpreted as if all of the forces motivating a person's behavior at a given time originate in one and only one need state, and that this total domination continues until satisfaction is experienced, at which time that need state somehow shuts off, or goes away, while the next set of needs immediately clicks on to take its place (Pinder, 1984, p. 48).

Maslow's theory has additional features that are not as widely known. First, Maslow recognized that even though the order in which the needs were mentioned is the most common, there are many differences among people in the relative prepotency of their needs. For instance, many people seem to place self-esteem ahead of love, seeking respect rather than affection from others. Second, not all behaviors result from the force provided by the basic needs; human behavior is much more complex. Third, needs are not necessarily conscious nor are they necessarily unconscious.

Alderfer's ERG Theory

In an attempt to build on Maslow's theory, Alderfer proposed a theory based on three needs: Existence, Relatedness, and Growth. These three needs are innate to human beings rather than learned, even though learning can strengthen them.

Existence Needs. They correspond closely to Maslow's physiological and safety needs. The substances required to satisfy these needs are concrete in nature and scarce; hence more satisfaction for one person will tend to result in lower satisfaction for another.

Relatedness Needs. They correspond to Maslow's social needs or love needs. They represent the desires for satisfying interpersonal relationships.

Growth Needs. They are similar to Maslow's needs for self-esteem and self-actualization, but not identical. The self-actualization needs in Maslow's theory consist of the fulfillment of innate potential (which may have a unique form for a given individual), while Alderfer's growth needs consist of desires to successfully investigate, explore, and master one's environment. The growth needs are desires for continued psychological growth and development.

Alderfer's ERG theory does not have the notion of hierarchy, thus it does not assume that lower-level needs must be satisfied before higher-level needs become activated. In addition, Alderfer's theory has a unique "frustration-regression" principle, whereby an already satisfied lower-level need becomes reactivated when a higher-level need cannot be satisfied.

McClelland's Acquired Needs Theory

Contrary to Maslow and Alderfer, McClelland's needs are learned not innate. McClelland states that those needs are learned from experiences in which certain cues in the environment are paired with positive or negative consequences. McClelland's three needs are:

Need for Achievement. This need represents the desire to do something better or more efficiently, to solve problems, or to master complex tasks. It is learned when opportunities to excel are associated with positive rewards. According to McClelland, people with high need for achievement have three characteristics. First, they prefer tasks with moderate levels of difficulty where they perceive that they have a fifty fifty chance of being able to perform the task. Second, they prefer tasks in which success depends upon their own efforts, not on luck. Third, these people demand feedback and knowledge about their success and failures to a far greater extent than people who are low in achievement motivation.

Need for Power. This need represents the desire to control other people, influence their behavior, and/or be responsible for them.

Need for Affiliation. This need represents the desire to establish and maintain friendly and warm relations with other people. It is essentially the same as Maslow's social need and Alderfer's relatedness need.

Herzberg's Two-Factor Theory

Frederick Herzberg studied job satisfaction and dissatisfaction and tried to determine the factors that cause them. He collected his data by asking accountants and engineers, one at a time, to think of an occasion when they felt "exceptionally good" or "exceptionally bad" about their jobs. After analysis of the data, Herzberg and his colleagues found out that the factors that cause positive attitudes toward a person's job are different from the factors that generate negative job related attitudes. This concept of job satisfaction and job dissatisfaction being independent from one another (not the opposite dimensions on the same continuum) was revolutionary at that time.

Hygiene Factors. Herzberg states that the factors that cause job dissatisfaction are most often associated with the job context (they relate to the work setting rather than to the nature of the job). He called these factors hygiene factors. Examples of these factors are company policy and administration, supervision, relationship with superior, work conditions, salary, relationship with peers, relationship with subordinates, status, and security. These factors only affect job dissatisfaction; improving them leads to less or no job dissatisfaction, but it will not cause job satisfaction nor better performance.

Satisfier/ Motivator Factors. Herzberg called the factors that cause job satisfaction, satisfier or motivator factors. Satisfier factors are part of the job's content (they constitute what the job actually is). Example of these factors are achievement, recognition, challenging work, varied work, interesting work, responsibility, advancement, and growth. Hence, if managers want to improve an employee's job satisfaction, they should focus on the satisfier/motivator factors, and shift away from the hygiene factors. In the study, salary was mentioned among the factors that lead to satisfaction and also among the factors that cause dissatisfaction. Despite this ambivalence, Herzberg classified it as a hygiene factor because it was related to more stories of long-term negative attitude shifts than to long-term positive shifts.

Process Theories

These theories address the "thought process through which individuals give meaning to rewards and allow them to influence their behavior" (Schermerhorn, 1989, p. 358).

Expectancy Theory

Expectancy theory states that work motivation is determined by the individual's beliefs regarding effort-performance relationships and the desirability of the outcomes associated with the performance. Motivation is related to expectancy, instrumentality, and valence. Expectancy is the "person's belief that working hard will enable various levels of task performance to be achieved" (Schermerhorn, 1989, p. 364). For example, a person's expectancy is low when he/she feels that he/she cannot achieve the necessary performance level set by his/her manager.

Instrumentality is the "person's belief that various work-related outcomes will occur as a result of task performance" (Schermerhorn, 1989, p. 364). For instance, a person's instrumentality is high when he/she is confident that a high level of task performance will result in the desired reward.

Valence is the "value that the individual assigns to these work-related outcomes" (Schermerhorn, 1989, p. 364). An outcome is positively valent for a person if he/she would prefer having it to not having it (for example promotion). An outcome is negatively valent if the person prefers not having it than having it (for example fatigue, stress, and layoff). A person's valence about a work related outcome is the person's expectation of receiving the work-related outcome, not the real valence the person actually derives from the outcome. Since beliefs about work are based on the individual's perceptions of the surrounding environment, the creation of an environment that is perceived positively by the employees is crucial.

Implications on Expectancy. Managers can influence expectancy by assigning personnel to jobs for which they are trained and which they are capable of performing. In addition, the manager should support the employee's work efforts by making sure that machinery and equipment are in good repair, and the employee's own staff, if any, are trained and capable of being of assistance. The manager should also clarify the performance goals to the employee and clearly explain what is required from him/her.

Implications on Instrumentality. The manager should clarify to the employee what the manager's expectations of him/her are and what the employee's responsibilities are. The manager should also communicate the performance-outcome possibilities specific to each particular situation, and demonstrate that desired rewards are contingent on expected performance. However, this is often difficult in practice because of company policies with regard to pay and benefits, union policies, and the difficulty of measuring certain jobs.

Implications on Valence. The manager should determine if the rewards he/she will give as a result of high performance are the ones that the employee needs. In order to do so, managers have to identify individual needs and adjust the rewards to fit the individual's needs. However, that is not always possible in practice due to time constraints, union policies, and company policies.

Path-Goal Theory of Leadership

The expectancy theory inspired a formal theory of leadership called the Path-Goal Theory of leadership. House and Mitchell (1974) suggest that leaders and managers can effect their subordinates' effectiveness through the impact that they have on the subordinates' beliefs concerning valences, instrumentality, and expectancies.

> The motivational function of the leader consists of increasing the number and kinds of personal payoffs to subordinates for work-goal attainment and making paths to these payoffs easier to travel by clarifying the paths, reducing road blocks and pitfalls, and increasing the opportunities for personal satisfaction en route (House & Mitchell, 1974, quoted from Downey, Hellriegel, & Slocum, 1977, p. 226).

Leaders can influence their employees' satisfaction, beliefs that effort can result in performance, and that performance will result in the desired rewards by using one of the following four leadership styles depending on the situation, the subordinate's characteristics, and the nature of the task.

Directive. The leader structures the work, assigns tasks, clarifies his/her roles with his/her subordinates, creates and maintains standards of performance. This style mostly complements ambiguous and unstructured tasks. For example, when an employee feels unsure on how to do a job, he/she needs directives from the leader.

Supportive. The leader shows concern for the employee's needs and status and attempts to make work more pleasant. The leader treats employees as equals, and is friendly and approachable. This style complements routine and highly structured tasks; employees do not need instructions but they need the work to be made more pleasant.

Participative. The leader involves subordinates in the decision making process by consulting them, and taking their suggestions into account whenever possible. This style complements a working environment where subordinates are highly capable, and hence their expertise can be a valuable input to the leader.

Achievement-Oriented. The leader sets challenging goals, emphasizes excellence and continuous improvement in performance, and shows confidence that the subordinates can reach those goals. This style complements a situation where employees are growth-oriented; the leader needs to merely clarify higher goals and set high performance aspirations.

Equity Theory

According to J. Stacy Adams, felt inequity is a motivating state. The theory rests upon three major assumptions. First, people have beliefs about what constitutes a fair and equitable return for their contribution to their jobs. Second, people tend to compare how they perceive they are treated to how they perceive others are treated. Third, when they believe that their treatment is not equitable, people are motivated to do something about it. When comparing his/her input (the contribution to the work) and outcomes (consequences of doing the work) to those of his/her peer, the employee considers the ratio of inputs to outputs rather than considering the absolute outcomes only. For instance, people can tolerate seeing others receive a higher outcome (a higher pay for example), if they perceive that the others are working harder. However, if they perceive that others are receiving a higher outcome while putting forth the same amount of contribution, tension will result - a tension that will motivate behavior to equalize the ratios -. To equalize the ratio, people can change their work inputs, try to change the rewards received, use different comparison points, rationalize the situation, or simply leave the situation.

Since the equity judgement is based on beliefs, organizations must structure their reward systems so that employees are rewarded in accordance to what they believe they are contributing to the organization. In addition, inequity in rewards is often due to the fact that it is not always trivial for managers to notice high performers and reward them accordingly. Another major problem is favoritism, which tends to generate feelings of inequity among employees. Hence, the best way to deal with the problem of perceived inequity is to carefully communicate to the employees the intended value of the reward being given in relation to the work being performed.

Goal-Setting Theory

The basic tenet of Goal Setting Theory is that goals and intentions are responsible for human behavior. The second tenet of the theory is that if goals determine effort, then higher or harder goals will result in higher performance. The third tenet is that specific goals result in higher levels of effort than vague goals. The fourth tenet is that incentives such as money and competition will have no effect on behavior unless they lead to the setting or acceptance of the specific goals.

Goal Difficulty. The difficulty of the goals determine the level of effort. The more difficult the goals, the higher the level of effort expanded to reach it. However, goals have to be viewed as realistic and attainable.

Goal Specificity. The specificity of the goals determines the level of performance. For instance, a goal such as "improve productivity by 20% over the next three years" lead to a higher performance then "do your best in improving productivity".

<u>Goal Acceptance and Commitment</u>. The acceptance and commitment to the goals result in people feeling that the goals are their own, and hence truly believing in them and working harder to achieve them.

The role of participation in goal setting as a prerequisite to high performance is controversial. Intuitively, there are reasons why participation would lead to high job performance. First, goals set jointly by an employee and his/her supervisor may sometimes be harder to achieve than goals set by the supervisor alone, and hence more effort will be put forth to attain those goals.

Second, an employee who has participated in setting goals for his/her performance is more likely to be ego-involved in the attainment of those goals, and hence augment the level of effort to reach those goals. Third, the employee will gain better understanding of the job to be done while setting the goal. However, even though these arguments seem intuitively appealing, the evidence that addresses them is somewhat mixed. In addition, not everyone wants to participate. There is some evidence though that participation in goal setting contributes to greater understanding of task requirements. There is evidence also that feedback about performance received during participation is necessary to sustaining high levels of performance.

Goal setting seems to be effective in increasing work motivation as goals direct attention and action. In addition, goal setting requires the development of a strategy (especially for difficult goals) which represents a specific means to attaining the goals.

Reinforcement Theory

All of the aforementioned theories of motivation attempt to understand human motivation by explaining "why" people do things in terms of satisfying needs, pursuing positive valences and task goals, and resolving felt inequities. Reinforcement theory, however, views human behavior as determined by its environmental consequences. The basis for reinforcement theory is Thorndike's law of effect: "Behavior that results in a pleasant outcome is likely to be repeated; behavior that results in an unpleasant outcome is not likely to be repeated" (quoted from Schermerhorn, 1989, p. 368).

Operant conditioning, a term popularized by Skinner is the process of changing the frequency of occurrence of a behavior by manipulating its consequences. A behavior occurring in a particular context can be followed by any of the three types of consequences: reinforcement, punishment, or extinction. Reinforcement increases the probability of occurrence of a behavior in the future. Punishment and extinction decrease the probability of occurrence of a behavior.

Reinforcement can be either negative or positive. Negative reinforcement increases the frequency or strengthens desirable behaviors by making the avoidance of an unpleasant consequence contingent on the occurrence of the behavior. Positive reinforcement increases the frequency or strengthens desirable behavior by making a pleasant consequence contingent on the occurrence of the behavior.

To be effective, positive reinforcement has to be contingent on the occurrence of the behavior and administered immediately after the occurrence of the desired behavior. The timing of positive reinforcement can be varied from continuous to intermittent schedules. Continuous reinforcement occurs when every instance of the desired behavior is reinforced. Intermittent reinforcement occurs when desired behavior is reinforced only periodically.

Continuous reinforcement will shape a desired behavior faster than intermittent reinforcement. However, a behavior shaped under intermittent reinforcement will be more permanent than a behavior shaped by continuous reinforcement. Hence, the best is to use continuous reinforcement to shape the desired behavior until it is achieved. At that point, intermittent behavior becomes sufficient to maintain the behavior.

Integrated Theories

In the following section, two integrated motivation theories are introduced. The first theory is Porter and Lawler's revised model. The second theory is Katzell and Thompson's integrated model.

Porter and Lawler's Revised Model

Vroom's expectancy theory did not tackle the origin of expectancy, instrumentality, and valence. Porter and Lawler address these issues in their model (Figure 1).

According to Porter and Lawler, effort is determined by two factors. The first is the value that the employee places on rewards and the second is the degree to which the person believes that the expended effort will lead to the attainment of those rewards.

Effort will lead to performance provided that the person is capable to perform (has the ability) and that he/she clearly understands what the job consists of. Hence, even if the person is highly motivated to perform, but does not have a clear understanding of the task, or does not have the technical knowledge, he/she would not be able to perform.

The link between performance and satisfaction is dependent on rewards. Rewards can be intrinsic or extrinsic.

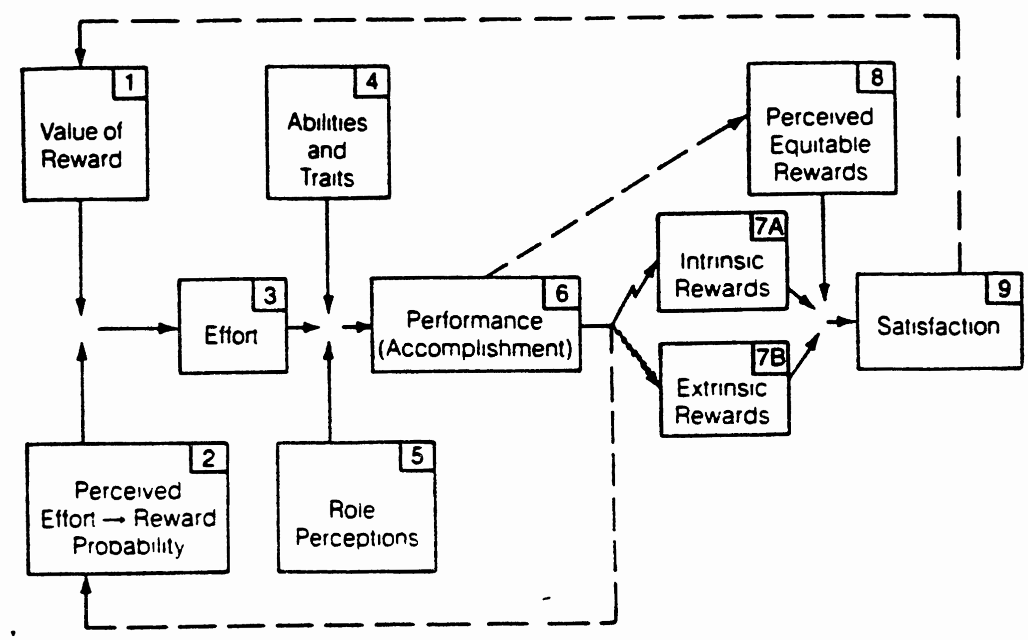

Figure 1. Porter and Lawler's Model Revised by Pinder

Note: Figure from <u>Work Motivation: Theory, Issues, and Applications</u> by G. C. Pinder (1984), Scott, Foresman and Company.

> Intrinsic rewards are much more closely connected to good performance than extrinsic rewards, because the former result (almost automatically) from performance itself, whereas the latter depend upon outside sources (both to recognize that performance has been attained and to administer rewards accordingly) (Pinder, 1984, p. 141).

The level of performance the person believes he/she attained influence his/her beliefs about what level of reward is equitable. Finally, satisfaction is defined by Porter and Lawler as "the extent to which rewards actually received meet or exceed the perceived equitable level of rewards" (Quoted from Pinder, 1984, p. 142). Hence, Porter and Lawler state that the level of satisfaction determines the value that the individual will put on those rewards in the future. The strength of the person's belief that performance leads to rewards will also influence effort in the future.

Katzell and Thompson's Integrated Model

In an attempt to understand and predict motivation in the work place, Katzell and Thompson integrated motivational theories in a comprehensive model of work attitudes, motivation, and performance (see Figure 2).

> The model is novel not in its constructs or elements, which have been based on various well known existing theories, but in its combination and ordering of those elements into what we believe is a coherent and logical causal framework (Katzell & Thompson, 1990, p. 76).

In this model, the organizational policies, practices, and working conditions in the work environment serve as

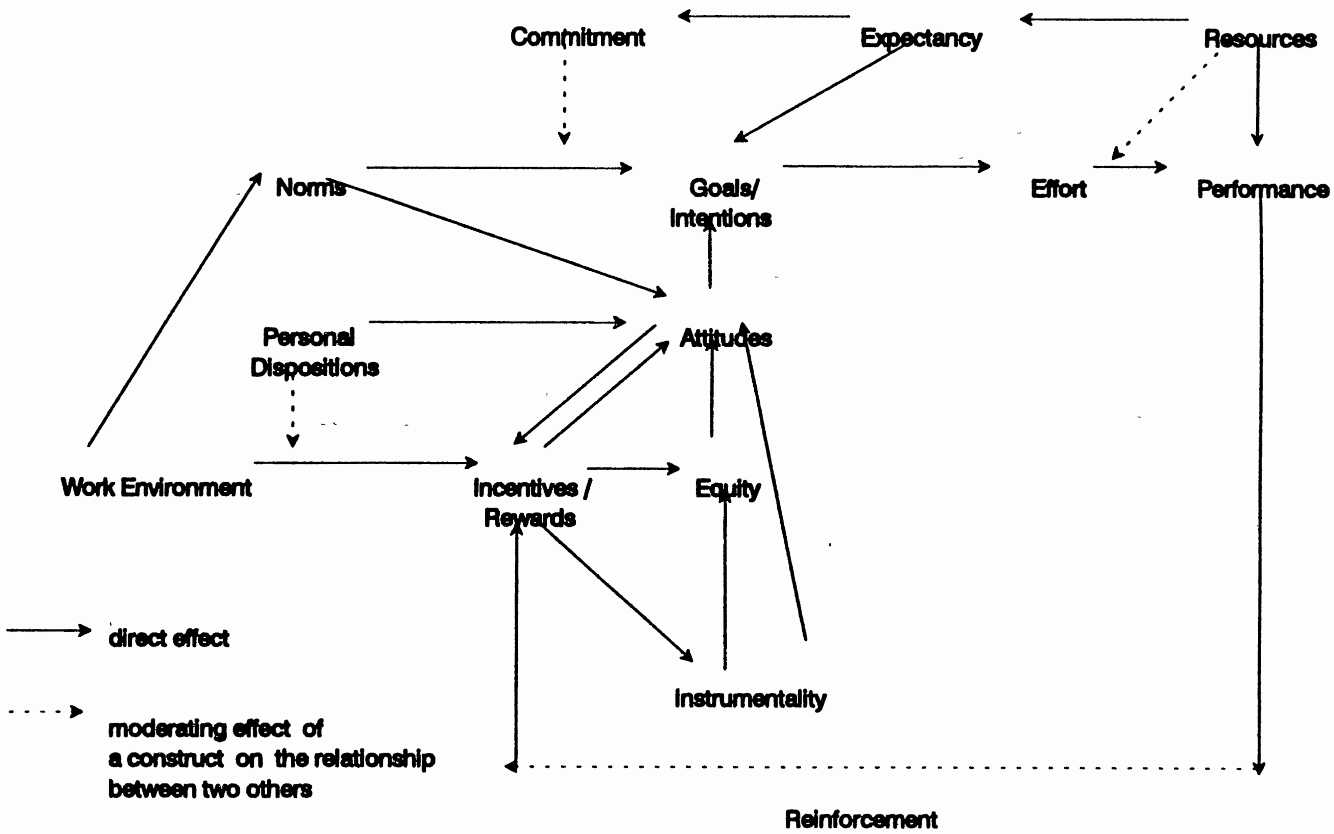

Figure 2. Katzell and Thompon's Model of Work Attitudes, Motivation, and Performance

stimuli that may act as incentives to potential rewards (such as specific policies that tie performance to rewards). The value of those stimuli depends on the individual's personal dispositions (motives and values). The latter shape attitudes (rewarding properties induce favorable attitudes, and vice versa). Attitudes also influence the personal dispositions in the future. For example, Katzell and Thompson state that "work involvement has been found to be higher among people with stronger achievement need and intrinsic motivation" (Katzell & Thompson, 1990, p. 72).

Attitudes in turn affect effort through goals because "people with more favorable attitudes are prone to adopt higher goals" (Katzell & Thompson, 1990, p. 72). Goals are also determined by other factors such as achievement motivation, Type A personality and situational experience (Katzell & Thompson, 1990). The person's expectancy that the goal can be attained also determines the choice of a goal. The norms of management, peers and other role models also influence goal setting. The influence of norms is also moderated by the individual's commitment or compliance. Commitment is also influenced by expectancy.

Expectancy also depends on the person's material and personal resources. Resources also affect performance and moderate the relationship between effort and performance.

The bottom part of the model shows that the equity of rewards also shape attitudes. The person's perception of equity is directly influenced by his/her instrumentality (belief that performance leads to rewards). Finally, through the reinforcement principle, rewards result from performance.

Motivation and Engineers

Engineering professionals that have written on the subject of motivating engineers have not been able to reach a consensus on how engineers are motivated. Hence, each researcher presents his/her views on what motivates engineers. The following summaries of this research is classified according to the theory (content or process) the researchers have used in explaining engineering motivation.

Content Theories

The articles in the following section have primarily used content theories to explain the motivation of engineers. The researchers have mainly focused on identifying the factors or needs that arouse the motivated behavior.

Matrix Structures, Quality of Working Life, and Engineering Productivity (Denis)

In a study of matrix structures, quality of working life, and engineering productivity, Denis (1986) asked engineers to define motivation and satisfaction in an open ended questionnaire. She found that "the most frequently appearing elements defining both variables are related to work content" (p. 152). The elements appearing in the definition of motivation are the factors or needs that arouse the motivated behavior. Denis found that motivation was linked with work content 63% of the time and with interpersonal relations 37% of the time. In addition, she found that satisfaction was linked with work content 67% of the time and with interpersonal relations 33% of the time.

This indicates that engineers are more concerned with their work than with interpersonal relations with their peers (see Tables 1 and 2).

From Table 1, it is clear that engineers are mostly motivated by challenge and teamwork. Engineers derive a feeling of satisfaction from meeting their objectives and being challenged.

Motivating and Managing Engineers (Aronberg)

According to Aronberg, engineers have needs that have to be satisfied. He explains that meeting the engineer's needs and providing a "healthy" environment in which they can work is the key to optimizing the engineer's production. Aronberg argues that the first step in motivating engineers is to insure that they are not demotivated. He explains that engineers are demotivated by close supervision, organizational politics, work organization, bureaucratic controls and authority systems, and excessive focus on

TABLE 1

ELEMENTS MENTIONED IN THE OPEN
DEFINITION OF MOTIVATION

Element	Percent Mentioned	Type
Challenge	28	Work Content
Teamwork	21	Interpersonal Relation
Freedom	10	Work Content
Well Defined Objectives	9	Work Content
Meeting of Objectives	7	Work Content
Esteem, Recognition	7	Interpersonal Relation
Remuneration	5	Work Content
Adequate Resources	4	Work Content
Client Satisfaction	4	Interpersonal Relation
Relations with Client	4	Interpersonal Relation

Note: The data are from "Matrix Structures, Quality of Working Life, and Engineering Productivity" by H. Denis, 1986, IEEE Transactions on Engineering Management, EM-33 (3), p. 152.

TABLE 2

ELEMENTS MENTIONED IN THE OPEN
DEFINITION OF SATISFACTION

Element	Percent Mentioned	Type
Meeting of Objectives	33	Work Content
Challenge	22	Work Content
Teamwork	9	Interpersonal Relation
Esteem, Recognition	9	Interpersonal Relation
Client Satisfaction	9	Interpersonal Relation
Relation with Clients	6	Interpersonal Relation
Well Defined Objectives	6	Work Content
Freedom	4	Work Content
Adequate Resources	2	Work Content

Note: The data are from "Matrix Structures, Quality of Working Life, and Engineering Productivity" by H. Denis, 1986, IEEE Transactions on Engineering Management, EM-33 (3), p. 152.

organizational efficiency. He emphasizes that engineers are "sensitive to what they consider unfairness", and that engineers are more demotivated by organizational politics than the average employee.

Aronberg cites money as the leading incentive for engineers. However, he explains that salary "has come to mean a great deal more than just money to the engineer" (p. 34). Money has become a key symbol of status and recognition.

> (W)hile money is important to engineers, it is only motivational to a certain degree ... the engineer must be satisfied that his salary is fair and equitable. However, increasing salary beyond this level will not motivate the engineer further" (Aronberg, 1985, p. 34).

Aronberg also recommends using Herzberg's principles of job enrichment and Gibson's proposed activities to "create an environment of professional self renewal" (p. 36). Some of the activities proposed by Gibson are:

1- Paying the tuition of advanced degree work of engineers, and providing them with time off for this activity.

2- Sharing the cost of professional journals with the engineers.

3- Encouraging engineers to attend, participate, or teach short courses offered by professional societies.

4- Encouraging engineers to take a broad view of the organization.

Aronberg emphasizes that these activities should not take more than 10% of the engineer's time. He also says that all the paid time and additional costs incurred should be considered as normal maintenance costs on the plant capital investment.

One More Time: How to Motivate Your Engineers (Badawy)

Badawy uses Maslow's need model to explain the process of motivating engineers. However, he explains that the following points have to be kept in mind when applying the model:

1- The view that people inherit their performance capabilities as well as the view that people are solely motivated by reward and punishment are wrong.

2- Though the basic needs given by Maslow are shared by everyone, every person has multiple individualized needs.

3- The emergence of needs follows a specific rigid pattern.

4- Satisfied needs are not motivators of behavior. When one need is satisfied, another higher need emerges.

5- It is not necessary to satisfy a "lower" need fully before a "higher" need may emerge and operate as a motivator.

6- The significance of each need varies from one individual to another and varies for the same individual from time to time.

7- People act differently in satisfying the same need.

8- Motivation is internal to the individual, so the individual is not motivated by what people think he/she ought to have, but by what he/she thinks that he/she ought to have.

9- There are factors other than needs that influence motivation, such as the individual's evaluation of him/herself and his/her interpretation of his/her environment.

> Needs are the keys to motivation. They initiate and guide the individual's actions until the goals that generate them are reached, at which time the tensions created by those needs are dissipated." (Badawy, 1978, p. 38).

Badawy also reports that studies have shown that the top three motivating factors among knowledge workers are salary or wages, recognition, and opportunity for growth. He also states that "the importance of money as a motivational incentive for engineers is controversial in the literature" (p. 38). He also states that salary means more than just money to the engineer, it represents a key symbol of status and recognition. Hence, "one cannot deny that salary increases embrace a non financial measure of achievement, and as such can be useful motivators for engineers in that light" (p. 38).

Badawy also affirms that management is facing difficulties in motivating engineers because of the use of bureaucratic controls and authority systems, and an excessive focus on efficiency. Furthermore, the management systems and policies do not take into account the engineer's expectations, for instance, engineers resent superior authority from nonengineers. In addition, the criteria for promotion and professional advancement are not clear. Moreover, the potential of motivating engineers through the task itself is not fully exploited. Badawy states that engineers are strongly motivated by professional achievement, ingenuity, imagination, and flexibility. However, engineers are handling tasks that require fewer skills and qualifications than they are capable. Likewise, there is a lack of proper performance related reward systems. The high engineering performers are promoted to management positions and hence abandon the profession.

Managing Engineers Effectively (Thamhain)

Thamhain constructed his own hierarchy of needs for engineers by asking them about their "most important professional need" to perform effectively in the work environment. He ranked the needs identified from most important to least important according to the number of people who described the particular need as the "most important" need (see Table 3).

1- Interesting and Challenging Work: These characteristics of the work seem to satisfy the professional esteem needs. Thamhain states that this need seems to be oriented toward the intrinsic

TABLE 3

VERY IMPORTANT PROFESSIONAL NEEDS FOR ENGINEERS

Need Category	Percentage
Interesting and Challenging Work	70
Professionally Stimulating Environment	65
Professional Growth	62
Overall Leadership	58
Tangible Rewards	55
Technical Expertise	50
Assistance in Problem Solving	48
Clearly Defined Objectives	45
Management Control	44
Job Security	42
Senior Management Support	40
Good Interpersonal Relations	35
Proper Planning	32
Clear Role Definition	30
Open Communication	25
Minimum Changes	15

Note: The data are from "Managing Engineers Effectively" by H. J. Thamhain, 1983, IEEE Transactions on Engineering Management, EM-30(4), p. 233.

motivation of engineers.

2- Professionally Stimulating Environment: This need is very similar to the need for interesting and challenging work. Engineers said that a professionally stimulating environment is crucial for professional involvement, creativity, and interdisciplinary support. This type of environment was found to foster team work.

3- Professional Growth: It is measured by promotional opportunities, salary advances, acquiring new skills and techniques, and professional recognition.

4- Overall Leadership: This implies the need for effective communication, participation in decision making, and effective leadership of the engineering effort toward the accomplishment of organizational goals. In fact, many engineers relate their success in a particular effort to the quality of leadership obtained from their management.

5- Tangible Rewards: Tangible rewards include financial rewards such as salary increases, bonuses, and incentives, and nonfinancial rewards such as promotions, recognition, better offices, and educational opportunities.

6- Technical Expertise: This need includes having the interdisciplinary skills and expertise within the engineering team. These skills range from an understanding of the technology, theories, principles, and design methods to an understanding of the applications, markets, and business environment.

7- Assistance in Problem Solving: This need overlaps with the previous need for technical expertise. It means obtaining assistance from management in facilitating solutions to technical, administrative, and personal problems. The lack of assistance in problem solving leads to frustration and conflict, hence demotivating engineers because they interpret this deficit as a disinterest and indifference from management toward their effort.

8- Clearly Defined Objectives: The clear communication of objectives, goals, and outcomes of the engineering effort lessens role conflicts and ambiguities, and hence leads to high motivation.

9- Management Control: Even though this seems in contradiction with the need for a stimulating work environment with freedom for decision making, it is consistent with modern leadership theories. Engineering managers should understand the interaction of organizational and behavioral variables and exert the direction, leadership, and control necessary to steer the engineering effort toward goal accomplishment.

10- Job Security: Thamhain emphasizes that "Job security is one of the very fundamental needs which must be satisfied before people consider higher order growth needs". Thamhain hypothesized that this low number (42%) probably indicates that most engineer feel relatively secure in their position, and hence do not perceive job security as one of the most important needs. Job security is reflected by the need for stability of employment as measured by voluntary terminations, layoffs, and firing. Job security also includes choosing the type of work or the location.

11- Senior Management Support: This support is viewed necessary in obtaining financial resources, providing an effective operating charter, facilitating cooperation from support departments, and obtaining the necessary facilities and equipment.

12- Good Interpersonal Relations: Interpersonal relations are necessary to achieve the high teamwork performance required to achieve goals. Good interpersonal relations foster a stimulating work environment, low conflict, and high productivity from all the members of the team.

13- Proper Planning: Effective planning requires more than writing documents and preparing schedules. Communication of those plans, of actual resources required, and administrative support are also necessary.

14- Clear Role Definition: It is required to avoid role conflicts and ambiguities over who does what in the engineering team. Clear charters, plans, and good management direction are some tools to clarify role definitions.

15- Open Communications: The free flow of information horizontally and vertically allows personnel to be informed of technical and organizational developments.

16- Minimum Changes: Engineering professionals see change as an unnecessary condition that impedes their creativity and productivity. However, since change is unavoidable, and to help engineers accommodate it, communication of the changes and their impact on the engineers is crucial to minimize negative impacts.

Organizational Designs for Scientists and Engineers: Some Research Findings and Their Implications for Managers (Badawy)

Badawy investigated the work goal orientations, need systems and attitudes of engineers and scientists. He found that the goals of engineers are more in accord with the aims of business than the aim of publications or knowledge for itself (see Tables 4 and 5). The value systems of engineers were also found to be directed toward growth and prosperity of the firm, and satisfaction from exercised authority and initiative, and from teamwork. The needs of engineers were found to be primarily "pay", "moving ahead and advancement within the company", and "gaining influence in their organizations" (see Table 6).

Engineering Motivators and Demotivators (Stevens and Krochmal)

The research from Stevens and Krochmal seems to be implicitly based on McClelland's needs theory. They state that "engineers exhibit a high degree of task or

TABLE 4

GOAL ORIENTATION OF ENGINEERS

Work Goals	Percentage Indicating item is "Most Important"
Achieving Goals and Welfare of the Company	92
Technical Achievement and Success in the Market Place	90
Advancing Within Company and Reaching a Particular level in Organization Hierarchy	87
Getting into Management	85

Note: The data is from "Organizational Designs for Scientists and Engineers: Some Research Findings and their Implications for Managers" by M. K. Badawy, 1975, _IEEE Transactions on Engineering Management, EM-22_(4), p. 136.

TABLE 5

JOB ATTITUDES OF ENGINEERS

Job Attitudes	Percentage Indicating Item is "Most Important"
Problem Solving	91
Interested in Breadth Rather than Depth	87
Application of Technology to the Business Aims of the Company	82
Work is a Mean to Achieve Company Goals	77

Note: The data is from "Organizational Designs for Scientists and Engineers: Some Research Findings and their Implications for Managers" by M. K. Badawy, 1975, _IEEE Transactions on Engineering Management, EM-22_(4), p. 136.

TABLE 6

NEED ORIENTATION OF ENGINEERS

Incentives Considered "Most Important"	Percentage of Engineers Agreeing
Pay	92
Moving Ahead and Advancement Within Company	87
Participation in Decision Making and Gaining Influence in the organization	84
Status	76
Recognition	68

Note: The data is from "Organizational Designs for Scientists and Engineers: Some Research Findings and their Implications for Managers" by M. K. Badawy, 1975, IEEE Transactions on Engineering Management, EM-22(4), p. 137.

"achievement" motivation, little relationship, and almost no influence or "power motivation" (p. 473). According to Stevens and Krochmal, engineers who have a high degree of task motivation demand a high degree of control over their activities. They also need feedback on how they are doing, and how the work is progressing; they are "turned-off" when they do not know how they are doing or how their work is progressing. These engineers like "moderate (not extreme) risks and challenging goals".

Engineers do not like boring activities; they set challenging goals, sometimes to excess. Engineers sometimes set their sights on a goal with such vigor that they become oblivious to anything else. For this reason, they are sometimes perceived as independent and insensitive. Engineers are "turned-off" by politics, paperwork, and what they cannot control. Engineers are also demotivated by policy statements, personnel forms, and regulations.

Engineers often do not remember feelings, birthdays, and social events; hence they need to be given an assistant who does all the social activities for them. Stevens and Krochmal also say that engineers are "turned-off" by group concerns and organizational goals. In addition, engineers like praise, even if they hate to admit it.

Organizational Systems Barriers to Effectiveness (Liker and Hancock)

In their article, Liker and Hancock define systems barriers as "systems characteristics (that) impede or discourage work that is consistent with the organization's goals or encourage work that is not consistent with those goals" (p. 82). Hence, systems barriers are quite similar to Herzberg's hygiene factors. From a survey administered to the engineers of a U.S. auto manufacturer, they found five major system barriers to engineering effectiveness.

Lack of Time for Organizational Design. In this study, design engineers were found to spend 81% of their time in activities other than engineering design (e.g., uncreative paperwork), and 29% of their activities in tasks that can be delegated to support staff (i.e., secretaries and technicians) (see Table 7).

Lack of Information. The lack of information about a

TABLE 7

PERCENT OF TYPICAL "WORK WEEK" SPENT
ON VARIOUS ACTIVITIES:
ACTUAL VERSUS REAL
(shown are Mean Responses)

Activities	Actual[b]	Ideal[c]	Differences	Delegate To[d]
Uncreative Paperwork[a]	23.4%	10.5%	12.9%	Secretary
Gathering/Searching for files	3.7%	1.5%	2.2%	Technician
Telephoning	15.5%	11.5%	4.0%	Technician
Searching for People	7.9%	2.7%	5.2%	Technician
Scheduling	4.5%	5.2%	-0.7%	e
Attending Scheduled meetings	12.7%	11.3%	1.4%	e
Attending Unscheduled meetings	8.5%	5.4%	3.1%	e
Writing Letters	7.0%	7.7%	-0.7%	e
Other Engineering Activities	19.2%	44.0%	-24.8%	e

Note: Columns should add to 100%, but they do not because of rounding errors, different response rates for specific questions, etc.

a Mail handling, copying, blueprinting, filing out forms, and proof-reading.

b Actual percent of time spent on these activities in a "typical" work week over the last three months.

c Percent of time should spend on activity so that time spent on it "aided in work" and "could not be done by support staff".

d Person most often mentioned as person to whom some of the activity could be delegated.

e No particular support personnel mentioned by a large proportion of respondents.

Note: From "Organizational Systems Barriers to Engineering Effectiveness" by J. K. Liker and W. M. Hancock, 1986, IEEE Transactions on Engineering Management, EM-33(2), p. 86.

project prior to starting the assignment was found to be a serious barrier to engineering effectiveness. Because engineers are concerned with finishing their own assignments, they do not have the time to provide information on what they are doing to their peers working on related projects.

Career Patterns, Training, and Motivation. Eighty three percent of the engineers surveyed felt that they "often" or "always" have enough training and experience to accomplish their assignments. However, 72% said that "the specific responsibilities and requirements of their positions were not made clear to them", when they first started the job, and 78.5% of these engineers reported that as a result their work suffered at least to "some extent". Results of attitudinal surveys of engineers (Ritti, 1971) show that engineers want to be involved in their work and make a contribution to the firm. However, because of the systems barriers, 84% of the engineers at a U.S. auto manufacturer (which name was kept anonymous in the article) said that getting the work done is "an uphill battle". However, because people tend to adapt their expectations to fit the current situation (Lawler, 1973), the negative feelings of those engineers did not carry over into a feeling of dissatisfaction with the work place.

Therefore, according to Liker and Hancock because engineers spend their time "fire fighting", they do not have much time left to do their job. Hence, they become dissatisfied with the situation.

Liker and Hancock also state that attitude surveys indicate that engineers are highly motivated to work on projects that are important to their organization. Surveys also show that engineers feel very frustrated when they perceive that their organization is underutilizing their talent. Hence, according to Liker and Hancock "... removing systems barriers to getting the work done is tantamount to improving general job satisfaction" (p. 83).

Occupational Stressors for Engineers (Saleh and Desai)

The American Heritage Dictionary defines stress as "a mentally or emotionally disruptive or disquieting influence". Hence, stressors prevent engineers from putting forth the effort necessary to attain high job performance.

Saleh and Desai state that engineers face two types of occupational stressors: microstressors and macrostressors. Microstressors are related to the engineer's job, while macrostressors are related to the general work environment. The following are examples of job microstressors:

1- Unclearly defined objectives, expectations, and responsibilities.

2- Role conflict due to receiving incompatible requests.

3- Quantitative work overload due to having too many tasks to do.

4- Qualitative work overload caused by having tasks that are too complex to do.

5- Lacking opportunities for career progress and advancement.

6- Being accountable for the work of others.

7- Having a multitude of deadlines.

8- Lacking task variety.

The following are examples of macrostressors:

1- Organizational politics and power plays

2- Lack of opportunities for human resource training and development.

3- Unfair rewards which are not related to performance.

4- Lack of participation in the decision making process.

5- Underutilization of the engineer's skills and abilities.

6- Lack of concern of supervisors with the subordinates' needs.

7- Unclear chains of command and restrictive rules and policies.

Saleh and Desai established that macrostressors contribute more to the stress of engineers than microstressors (see Table 8). Hence, the engineer's general work environment is full of influences that disrupt his/her normal behavior and demotivate him/her from performing. For example, rewards were ranked first in the engineering stressors, which indicates that engineers perceive that rewards are not based on performance.

TABLE 8

RANK ORDER OF STRESS CATEGORIES

Stress Factor	Rank
Rewards	1
Time Pressure	2
Human Resources Development	3
Participation	4
Under Utilization	5
Politics	6
Supervisory Style	7
Overload/Quantitative	8
Organization Structure	9
Career Progression	10
Job Scope	11
Role Conflict	12
Role Ambiguity	13
Responsibility for People	14
Overload/Qualitative	15

Note: The data is from "Occupational Stressors for Engineers" by S. D. Saleh and K. Desai, 1986, IEEE Transactions on Engineering Management, EM-33(1), p. 8.

Process Theories

In the following articles, the researchers have tried to use the most recent process theories to explain the behavior of engineers. Process theories address the "thought process through which individuals give meaning to rewards and allow them to influence their behavior" (Schermerhorn, 1989, p. 358). However, despite having tried to rationalize the motivation of engineers using thought processes, the engineering researchers rarely explicitly mention that they are using process theories.

Individual Needs, Organizational Rewards, and Job Satisfaction Among Professional Engineers (Orpen)

Orpen emphasizes the importance of the thought process through which engineers rationalize the rewards they obtain. He compared the career and professional attitudes of engineers whose individual needs matched organizational rewards to those of engineers whose needs failed to match such rewards. He found that contrary to the allegations of need theories, there was no strong correlation between the match between needs and rewards and overall job satisfaction. However, Orpen found that "the way engineers view their careers and profession can help to explain individual differences in job satisfaction over and above the match between needs and rewards" (p. 179). Orpen's study concludes that to be satisfied, engineers need not only to feel adequately rewarded at work, but also to approve of their career and be well inclined to their profession.

The Value of Engineers and Managing Engineers (Munson and Posner)

In their study, Munson and Posner implicitly used the concept of valence. They investigated the impact of engineers' personal values on their satisfaction and performance. They found that "above-average success engineers exhibited significant differences in values from below-average success engineers" (p. 99). The researchers suggest that these findings could be useful in the selection and placement process, promotion and job counseling decisions as well as the design of motivation and incentive programs. For instance, before being hired, the engineer's values could be screened for their compatibility with the values of the group he/she is expected to work in. Further, knowing the engineer's values would be useful in determining effective motivational strategies. The study also uncovered that engineers who perceive themselves as above average as compared to their peers in terms of success attach significantly more importance to "accomplishment" and "responsibility" and place less emphasis on values related to good interpersonal or social relationships.

Job Characteristics, Job Satisfaction, Motivation and Satisfaction with Growth: A Study of Industrial Engineers (Helphingstine, Head, and Sorensen)

The purpose of this study was to determine whether or not there is a direct link between motivation and job satisfaction. The application of the Hackman-Oldham model of job satisfaction was investigated with industrial engineers as the subject population. The Hackman-Oldham model is concerned with the relationship between some job characteristics (skill variety, task identity, task significance, and autonomy) and outcome variables such as general satisfaction, internal work motivation and satisfaction with opportunities for self-growth. The model also utilizes moderating variables such as job security, relations with co-workers, nature of supervision, and individual growth needs. The study has concluded that there is a positive relationship between job characteristics and the variables of internal motivation and satisfaction with growth opportunities. Skill variety, autonomy, and feedback were found to be most associated with satisfaction with growth opportunities. However, the study did not find any support for a relationship between the motivating potential score and general satisfaction.

Joint Moderation of the Relation Between Task Complexity and Job Performance for Engineers (Kozlowski and Hults)

According to goal-setting theory, there should be a positive relationship between task complexity and job performance for engineers. In this study, Kozlowski and Hults found that task complexity perceptions were more relevant to engineers in R&D contexts. The task complexity-performance relation was also found to be sensitive to position tenure for the R&D engineers. The researchers also found that the relation between task complexity and job performance was relatively stable for staff engineers because task complexity is not a meaningful component in their work context. The researchers hence concluded that position tenure as well as position nature should be taken into account when trying to predict job satisfaction for engineers.

In conclusion, the works of all the engineering professionals presented above shed some light on the process of motivating engineers, each from a different perspective. Some findings seem to agree with others, while others are partially contradictory.

In the following chapter, a criticism and evaluation of the engineering literature presented will be performed. The factors presented will also be classified. This classification and evaluation will lead to the integration of these findings in a comprehensive model of engineering motivation.

CHAPTER III

CRITIQUE AND EVALUATION OF THE ENGINEERING LITERATURE

In an attempt to understand how engineers are motivated, researchers have undertaken numerous surveys and published many papers. However, they have always presented their findings and analyzed them according to one or two basic theories. The following discussion will analyze the findings on motivating engineers by tying them to the general motivational theories presented in Chapter II.

Content Theories

The content theories "focus on human needs as a way to understand and predict the attitudes and behaviors of people at work" (Schermerhorn, 1989, p. 362). Despite the difference in terminologies used by Maslow, Alderfer, and McClelland, the theories are all quite similar in the insight they offer.

Maslow's Theory

The major characteristics of Maslow's theory are the prepotency of needs and the fact that only unsatisfied needs can motivate behavior. The prepotency of the needs proposed by Maslow has not been validated by the engineering literature.

The two lower level needs (physiological and safety) are supposed to be already satisfied for engineers merely by having a job. Maslow's social needs, however, are questionable for engineers. For instance, in Denis' study, teamwork (which automatically supposes the existence of interpersonal relations) was ranked second as a motivation element by respondents. However, in Thamhain's study, "good interpersonal relations" were ranked twelfth in the "very important professional needs". In addition, Stevens and Krochmal say that engineers have "little relationship needs". Therefore, these three research give conflicting messages concerning the engineers' social needs. Badawy states that even though Maslow's theory tries to explain human needs, the significance of each need varies from one individual to another, and varies for the same individual from time to time. Thus, it is not possible to draw any conclusions concerning the social needs of engineers from the existing research.

According to Katzell and Thompson, factors such as personality types and background can also influence how the engineer is motivated. Hence, further research taking into account personality types and background may help in reaching a conclusive answer concerning the social needs of engineers (since social needs are affected by personality types and background).

Nevertheless, there is consensus in the engineering literature about Maslow's two higher needs (e.g., esteem and self-actualization) for engineers. In Denis' study, challenge was ranked first in the motivation elements of work. Badawy mentioned recognition, opportunity for growth, and professional achievement as the top motivating factors among knowledge workers. Interesting and challenging work, professionally stimulating environment, and professional growth were the three top "very important professional needs" for Thamhain's engineers. Moving ahead, status, and recognition were also mentioned by the engineers in Badawy's study. Stevens and Krochmal also state that "engineers exhibit a high degree of task or achievement motivation".

Pay as a need for engineers is controversial. It is not clear whether pay represents just the fulfillment of the physiological and safety needs or also of higher needs due to the status given by money. Denis' engineers ranked remuneration seventh and only 5% of them cited it as an element of motivation. Tangible rewards ranked fifth in Thamhain's needs, and was mentioned by 55% of the engineers. However, Aronberg and Badawy cite money as the leading incentive for engineers; pay ranked first in Badawy's survey and was cited by 92% of the engineers as the "most important incentive". However, Aronberg says that money is motivational only "to a certain degree ... However, increasing salary beyond this level will not motivate the engineer further" (p. 34). Badawy says that "one cannot deny that salary increases embrace a non financial measure of achievement, and as such can be useful motivators for engineers in that light" (p. 38). Therefore, it appears that money is, up to a degree, one of the factors that motivate engineers. Its acquisition stands for more than the material things it can fetch; it represents the satisfaction of one of the dimensions of the achievement need.

It seems that the needs of engineers do not agree with Maslow's two principles. Opponents provided enough evidence to cast doubt on Maslow's prepotency principle because of the lack of consensus concerning the engineers' social needs. Second, Maslow's statement that satisfied needs are not motivators of behavior has not been established either; if satisfied needs are not motivators of behavior, why would engineers still continue to perform at a high level once they obtain the respect, growth, and advancement that they are seeking? Are respect, growth, and advancement a final state or are they just a transitional state, since there is no limit to growth? If that is so, then the self-actualization need can never be fully satisfied, and hence remains a motivator for engineers. However, that is not so for all engineers. It appears that some people are "satisfiers", and hence do the minimum just to get by while others are perfectionists and always try to grow and do better. For the satisfier, once they obtain the respect and prestige, they most probably would not be motivated to self-actualize. However, for the perfectionists, even though their esteem needs are satisfied, they are still motivated to do better.

Therefore, due to its prepotency hierarchy, Maslow's theory is rejected as a comprehensive explanation to the engineering motivation.

Alderfer's Theory

Alderfer's theory does not have the notion of hierarchy and hence does not assume that lower-level needs have to be satisfied before higher-level needs become activated. Therefore, it explains the motivation of engineers better than Maslow's hierarchy because it does not get entangled in the confusion that shrouds the engineer's social needs. However, Alderfer's theory is characterized by the "frustration-regression" principle. As mentioned in Chapter II, this principle states that an already satisfied lower-level need becomes reactivated when a higher level need cannot be satisfied. This issue is not addressed in the engineering literature. However, it is my belief that the principle might be true. For instance, when an engineer's esteem needs are not met in his/her work, he/she might try to satisfy his/her social needs instead by socializing and interacting with his/her peers. This probably happens to compensate for the feeling of loss and betrayal felt after performing high, but not being rewarded. The proof or counter proof to the "frustration-regression" principle needs to be further investigated.

McClelland's Acquired Needs Theory

The major difference between McClelland's theory and Maslow's and Alderfer's theories is that in the former, needs are learned. The engineering literature does not address the issue of the origin of the engineer's needs. However, there is a consensus in the literature on the engineer's high needs for achievement: the strongest characteristics of engineers is their desire to master complex tasks. The engineering literature also supports McClelland's claim that high achievers demand feedback and prefer tasks with moderate levels of difficulty in which success depends on their effort. Stevens and Krochmal say that engineers like "moderate (not extreme) risks and challenging goals" (p. 476) and demand feedback about their performance.

McClelland's second need is the need for power. The engineers' need for power and influence is controversial in the literature; Saleh and Desai stated that being responsible for the work of others stresses engineers, Stevens and Krochmal said that "engineers have almost no influence or power relationships" (p. 476), while Badawy stated that engineers need "gaining influence in their organization" (p. 136). Since power is exercised in social contexts, the need for power and the need for social interactions are inseparable. Hence, the controversy around social needs leads to the controversy around the need for power. As said earlier, for the independent engineers who have high achievement needs, they do not need power over others; they mainly need to have control over their own work. However, the satisfiers -who have lower achievement needs and higher social needs- seem to need power. As for the need for affiliation, as mentioned earlier, it is controversial for engineers.

Therefore, the engineers' needs for power seem to depend on the individual's traits (perfectionist or satisfier). Hence, Alderfer's theory seems to best explain how engineers are motivated.

Herzberg's Two Factor Theory

Herzberg's theory is considered to be part of the content theories because it uses the concept of work content and context to explain motivation. The theory addresses the issue of the influence of the institutional factors on the motivation of the individual.

Liker and Hancock, and Saleh and Desai mentioned the lack of time to do engineering work as one of the barriers to higher engineering performance. The lack of information due to the absence of communication was also mentioned by Liker and Hancock as a barrier to performance and job satisfaction. Unfair rewards and bureaucratic controls were also mentioned by Badawy, Saleh and Desai, and Aronberg as other barriers to higher engineering performance. Other factors mentioned as barriers to higher performance are the lack of participation in decision making (Saleh & Desai, 1986), unclear chains of commands (Saleh & Desai, 1986), and restrictive rules and policies (Aronberg, 1985; Saleh & Desai, 1986).

In fact, the engineering literature contradicts Herzberg's findings about hygiene factors. For Herzberg, improving those factors leads to less job dissatisfaction without causing job motivation and satisfaction. For Aronberg, close supervision, organizational politics, and bureaucratic controls are demotivators for engineers, which, if removed, would lead to increased motivation. It seems that even though the engineering researchers recognize that supervision, company policies, and organizational controls are barriers to engineering effectiveness, they do not make the distinction between no job dissatisfaction (which leads to a minimum performance level) and job motivation and satisfaction (which lead to a much higher than minimum level of performance). Therefore, Herzberg's theory that improving hygiene factors will not cause job satisfaction is not supported by the engineering literature. Liker and Hancock indicate that "removing systems barriers to getting the work done is tantamount to improving general job satisfaction" (p. 83). In addition, Herzberg's allegations about satisfiers/motivators is not valid for engineers. Helphingstine et al. and Orpen found that there was no direct correlation between motivation and job satisfaction for engineers. Thus, Herzberg's theory of hygiene versus motivation factors is not supported for engineers as the only point of agreement between it and the engineering findings is that the work content itself should be used more in motivating engineers (Badawy, 1978).

Process Theories

Process theories address the "thought process through which individuals give meaning to rewards and allow them to influence their behavior" (Schermerhorn, 1989, p. 358).

Expectancy Theory

Research on engineering motivation has concentrated on the content theories to explain how engineers are motivated. Thus, expectancy theory was not explicitly tested. However, the idea of expectancy, instrumentality, and valence were used implicitly. When Stevens and Krochmal found that engineers like "moderate (not extreme) risks and challenging goals" (p. 476), they are implicitly using the idea of expectancy (the strength of the belief about achieving a particular outcome).

According to the expectancy theory, the engineer's expectancy about reaching a particular goal is influenced by his/her beliefs about the difficulty of the task as well as his/her beliefs about his/her capabilities. The engineer's expectancy is also influenced by his/her training and the help that his/her superior provides in the problem solving process. In the survey done by Liker and Hancock, 83% of the engineers felt that they "often" or "always" have enough training and experience to accomplish their task. However, 72% said that they did not feel that they had enough understanding of the specific responsibilities of their task when they first started, and 78.5% of those engineers reported that as a result their work suffered to some extent.

Role ambiguity and unclearly defined objectives and expectations were also mentioned by Saleh and Desai as stressors for engineers. Therefore, it appears that engineers often suffer from unclear expectancies, especially when they are first starting a job.

There is a consensus in the engineering literature that the link between performance and rewards is often not clear to engineers (Badawy, 1978; Saleh & Desai, 1986). In addition, engineers are often not offered rewards that they value because of the lack of knowledge by their managers about what they value (Northrup & Malin, 1985; Saleh & Desai, 1986).

Consequently, it seems that the managers of engineers are not influencing their subordinates' expectancy, instrumentality, or valence. The former is probably due to their lack of understanding of the expectancy theory. In a study of engineering managers familiarity and use of motivational theories, Babcock found that from the 408 engineering managers surveyed, 10 were familiar with the expectancy theory, while only one used it.

Path-Goal Theory of Leadership

Leaders and managers can affect their subordinates beliefs about expectancy, valence, and instrumentality by using one of the four leadership styles mentioned in Chapter II. The engineering literature does not specifically address the leadership style issue. However, Thamhain found that engineers need leadership, and many engineers in his study related their success in a particular effort to the quality of leadership obtained from their managers. However, because of the practice of promoting high engineering performers to management positions, the managers of engineers are poor managers. The engineering managers are often technically competent but they rarely have the necessary managerial and interpersonal skills needed to manage (Badawy, 1978). Therefore, engineers often suffer from being led by poor managers. Furthermore, the practice of promoting high engineering performers to management positions often leads the engineers to be dissatisfied because their promotion means more power (which engineers do not value according to Stevens and Krochmal), and being accountable for the work of others (which stresses engineers) (Saleh & Desai, 1986).

Equity Theory

There is a consensus in the engineering literature that engineers are very demotivated by organizational politics

(Badawy, 1978; Saleh & Desai, 1986; Stevens and Krochmal, 1977). Badawy stresses that engineers are more demotivated by organizational politics than other employees. Perceived inequity would be especially demotivating for the perfectionist engineers who are very achievement oriented and who have low social and power needs. When the perfectionist engineers see a discrepancy between their ratio of outputs to inputs and the ratio of others, they become very demotivated to perform in the future. This demotivation is due to the fact that their need for achievement is frustrated. In addition, since they do not have any power, they cannot change the allocation of resources and rewards.

Goal-Setting Theory

Stevens and Krochmal say that engineers set challenging goals. Thamhain found that engineers have a strong need for clearly defined objectives. Thus, the engineering literature supports the idea that goal setting improves the effort to perform. According to the goal setting theory, the difficulty of the goals determine the level of effort; the findings about engineers support the theory.

Kozlowsky and Hults' findings about the lack of correlation between task complexity and job performance for engineers also supports the goal setting theory that says that the goal difficulty, -not the task difficulty- determines the level of effort. It is important here to distinguish between goal difficulty and task difficulty, as they are not the same, and they are often confused for engineers. It was stated in Chapter II that the role of participation as a prerequisite to high performance is controversial. However, it seems that when the engineer participates in setting a goal, his/her ego is involved. Therefore, reaching the goal, in itself, fulfills the engineer's need for achievement. In addition, by participating in setting the goal, the engineer understands the task better, and hence is able to achieve the goal. Hence, engineers need to participate with their managers in setting goals and deadlines.

Reinforcement Theory

According to this theory, human behavior is determined by its environmental consequences. Supporting this theory, engineers were found to need rewards to be motivated. However, performance contingent rewards are often not existent in the engineering environment "(the) failure of management to recognize individuals for their accomplishments is the most cited source of dissatisfaction among professionals" (Northrup & Malin, 1985, p. 159).

Rewards can be either tangible or intangible. Examples of tangible rewards are stock options and cash. Intangible rewards can also be a powerful motivator. Northrup and Malin give an extensive list of intangible rewards for engineers from which praise, recognition of personal achievement by superiors, and promotion are only a few. The scheduling of rewards (for example, how frequently cash bonuses should be given) is not addressed in the engineering literature; it thus needs to be investigated.

Researchers have attempted to explain how engineers are motivated mostly by using Maslow's theory. None of their research tried to use an integrative approach. Therefore, their findings need to be integrated in a comprehensive model of motivation that would give the entire picture of the process. In the following chapter, an integrative model is developed to explain the motivation of engineers using the analysis and findings presented in this chapter.

CHAPTER IV

THE INTEGRATED MODEL OF ENGINEERING MOTIVATION

The critique and evaluation of the engineering literature as well as insights from Porter and Lawler's and Katzell and Thompson's integrative models led to the development of the following integrative model of motivation for engineers.

Background

Porter and Lawler's revised model is based on the expectancy theory, but with the addition of insights concerning the origins of expectancy, instrumentality, and valence beliefs, as well as the nature of those relationships. However, it is believed that Porter and Lawler's model is lacking two major components. The first missing component is the influence of the environment on the individual's behavior. Therefore, there is a need to add a variable titled "environment". The second missing component is the influence of the needs of the engineer on his/her behavior. In addition, some of the relationships in the model need to be modified so that they can be adapted to engineers.

Katzell and Thompon's model was not selected to explain the motivation of engineers for two major reasons. The first reason is that this model assumes that the work environment is independent of the effect of performance. However, there is a feedback process; when individuals perform at a high level because they have high needs for achievement, there is less need to supervise them on a continuous basis. Hence, the management practices and the supervisory styles are not the same as for individuals who need to be continuously "pushed" to perform. In addition, when those achievers perform at a high level, the engineering organization as a whole becomes more competitive and innovative.

The second reason is that the model suffers from some redundancy. Katzell and Thompson use circular arguments; for example, they explained attitudes by using personal dispositions (which are really almost the same as attitudes). In addition, Katzell and Thompson attributed norms solely to the work environment, which is not very accurate. People acquire norms almost from the day they are born, and those norms are brought to the work place.

There were elements in these two models that seemed to explain the empirical findings in the literature. In addition, there are elements in those models (such as equity) that seem to be even more important for the motivation of engineers. Hence, an integrated model for the motivation of engineers has been developed (see Figure 3).

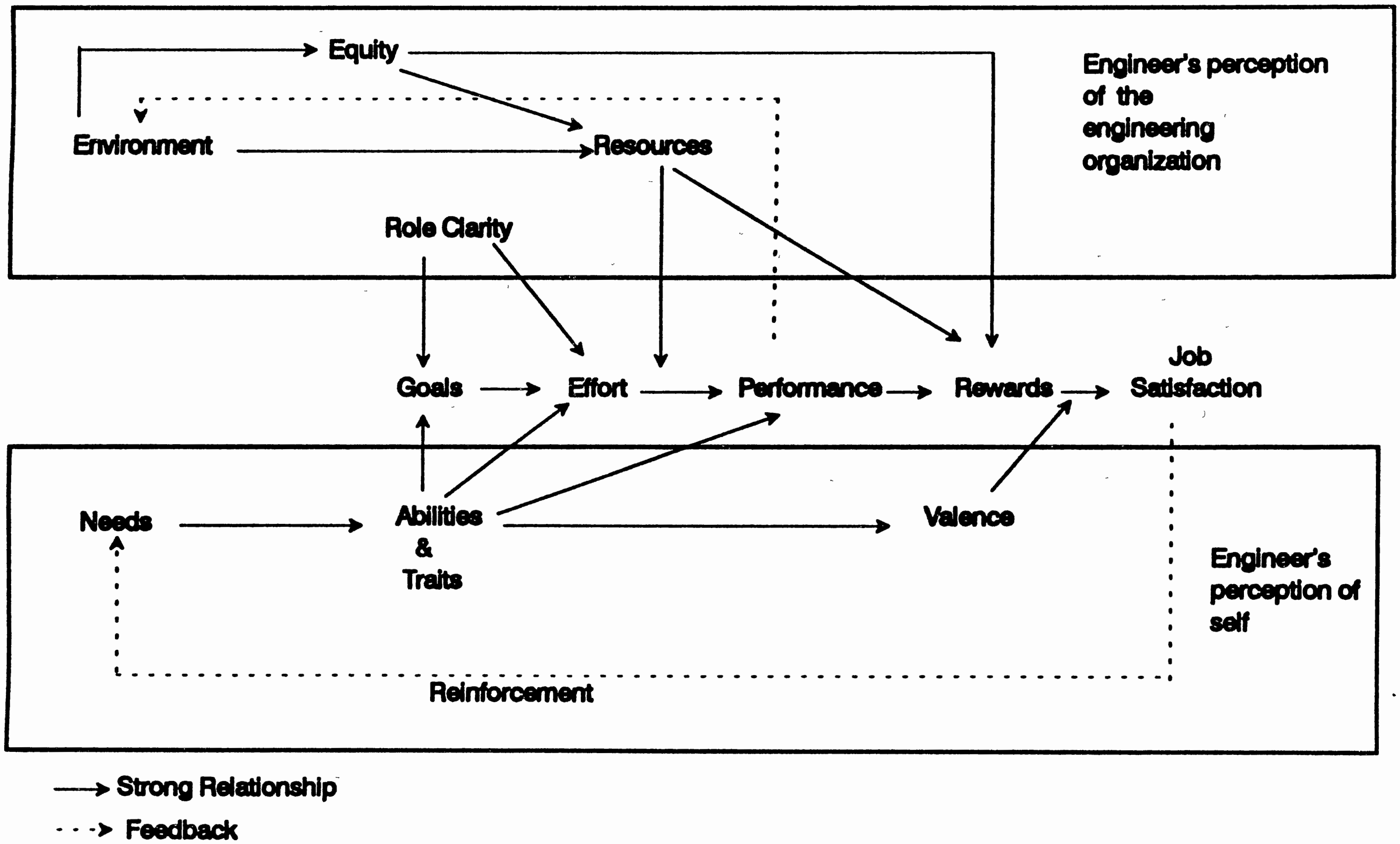

Figure 3. The Integrated Model of Engineering Motivation

The Model

The following section is a description of the model in Figure 3. A complete discussion of the model will follow after the list of attributes.

Description of the Model

The proposed model presents the major variables that influence the engineer's motivation. The engineer's needs influence his/her abilities and traits. These abilities and traits in turn influence the goals set as well as the effort expended. The engineer's role clarity also moderates the engineer's goals and directly impacts the effort expended. The engineer's role clarity is not directly influenced by any variable as it represents the engineer's inherent understanding of his/her task, before the intervention of any exterior influence. In addition to the engineer's role clarity and his/her abilities and traits, the effort expended is also influenced by the difficulty of the goals. Effort directly influences the performance. The relationship between those two constructs is moderated by the resources available.

The performance is also moderated by the abilities and traits of the engineer. Performance should be followed by rewards, if the environment is equitable and if the rewards are available in the work environment. If the engineer values the reward he/she obtains, job satisfaction results. This job satisfaction reinforces the engineer's need for high achievement, which then leads to even higher needs for accomplishments.

The engineer's high performance also has a positive impact on the engineering environment, as higher performance from all the engineers in the organization results in a more competitive, higher performance engineering organization.

Key Attributes

The following is a definition of the key attributes of the integrated model of motivation for engineers.

Needs. The engineer's physiological, safety, social, esteem and self-actualization needs.

Abilities and Traits. Abilities are the skills or talents needed to perform a task. Traits are the distinguishing features of the engineer such as being a high achiever.

Valence. The value that the engineer assigns to a work related outcome.

Goals. They end states or results toward which behavior is directed.

Effort. The energy and time expended in pursuing a goal.

Performance. The act of carrying out a task to completion in accordance with preset requirements.

Rewards. They are the work outcomes given to the engineer as a return for his/her performance.

Satisfaction. A feeling of gratitude and fulfillment.

Role Clarity. The engineer's understanding of the task.

Resources. The factors in the environment, such as equipment and assistance from others, that affect the engineer's ability to perform a job.

Equity. The balance perceived in one's benefit-to-cost ratio, and the comparison of one's ratio to those of others.

Environment. The organization where the engineer works.

Discussion of the Model

The engineer's motivation to work starts by the desire to fulfill his/her needs. From the analysis of the literature on engineering motivation and the content theories, engineers were found to have rather strong physiological, safety, esteem, and self-actualization needs. Their social needs were however controversial.

The physiological and safety needs are satisfied just by having and keeping a job. The need for achievement and self-esteem are the characteristics of most engineers. Those needs shape the engineer's abilities and traits. It is assumed that the high achiever is also a perfectionist, while the engineer with less need for achievement and more social needs is a satisfier. The engineer with high needs for self-esteem and achievement (perfectionist) accumulates comparatively more knowledge and technical skills in the course of acquiring educational and vocational experience than someone else with a lower need for achievement, or someone who lost that propensity along the way.

Because they are perfectionists, those engineers have a high drive for fulfilling goals. As stated earlier, when engineers participate in setting goals, their ego is on the line, and hence the meeting of the goals is in itself a fulfillment of the self-actualization and achievement need. For the engineer with high needs for achievement, the goals set will automatically be difficult, as higher goals will lead to higher self-actualization. As Kozlowsky and Hults found, the goal difficulty contributes in determining the level of effort. Therefore, the effort expended by the high engineering achiever will be higher than the effort expended by the satisfier, who has lower achievement needs, and hence has set lower goals and does not even strive as much to meet those goals.

The setting of goals and the effort expended is also influenced by the engineer's role clarity. If the engineer does not understand the task at hand, he/she is less likely to set high goals. Liker and Hancock found that 72.5% of the engineers that they surveyed felt that they did not have enough understanding of the specific responsibility of their task when they first started a new job assignment. In addition, role clarity directly affects effort because the lack of clarity of the job hinders the effort to perform. In the same study by Liker and Hancock, 78.5% of the engineers who felt that they did not have enough understanding of the task reported that as a result, their work suffered to "some degree". Role ambiguity and unclearly defined objectives were also mentioned by Saleh and Desai as stressors for engineers. Therefore, the first question that needs to be tested is whether clarifying the role of engineers and allowing them to participate in setting goals does in fact lead to a higher effort to performance relationship.

When the engineer has the knowledge to perform and exerts high effort, he/she performs at a higher level of proficiency, provided that he/she has the necessary resources. The presence or lack of the resources that are provided by the organization can either help or hinder the engineering effort. For example, when an engineer is very enthusiastic about a project but he/she does not have the secretarial support to do his/her work efficiently, a part of the effort is wasted on doing "non-engineering" work, which results in lower than possible performance.

In a survey by Liker and Hancock, engineers wasted approximately 13% of their time on uncreative paperwork that could have been delegated to a secretary. In the same study, engineers wasted approximately 11% of their time on work that could have been delegated to technicians. Those same engineers reported that while they should be spending about 45% of their time on engineering activities, they only actually spend around 19% of their time, which represents a loss of approximately 25% of the time for projected engineering activities.

The effort of the high achiever will lead to a higher performance level than the same level of effort exerted by the satisfier. Because of being a high achiever and having accumulated a wealth of skills thereof, the perfectionists perform at a higher level than the satisfiers. A perfectionist considers a job done only when he/she is satisfied that the output is of very high quality.

When high performance is attained, rewards should follow, depending on the resources available and the equity with which those rewards are allocated. Since high achievers perform at a high level, they expect to be rewarded accordingly. However, performance contingent rewards are often rare, if not nonexistent in the engineering environment (Badawy, 1978; Northrup & Malin, 1985).

High engineering performers are often not properly rewarded because of organizational policies, limited resources, and inequity in the engineering environment. Organizational policies often restrict the distribution of financial rewards to the personnel department. However, engineering managers have to understand that they have a large inventory of intangible rewards to choose from. Northrup and Malin give an extensive list from which praise, challenge of the projects, and the freedom to manage one's own work are only a few (see Table 9). The question of whether particularly need-tailored rewards lead to the reinforcement of high achievement in engineers hence needs to be addressed.

TABLE 9

EXAMPLES OF INTANGIBLE REWARDS
FOR ENGINEERS

1. Recognition of professional achievement
   a) praise
   b) personal mention in oral and written reports
   c) basing status and salary on technical contribution
2. Work being brought to the attention of top management
3. Recognition of personal achievement by superiors
4. Challenge of projects
5. Variety or work-increases breadth of one's experience and competence as a professional
6. Treatment as a professional
   a) advice sought on technical problems
   b) opportunities to publish
   c) opportunities to participate in professional societies
7. Management's actions towards engineers and scientists-support, genuine interest, etc.
8. Freedom to manage one's own work
9. Acceptance of ideas by management
10. Implementation of ideas by management
11. Opportunity to learn in the field
12. Prospects for promotion
13. Status symbols-title, company name, etc.
14. Regard by associates

Note: From <u>Personnel Policies for Engineers and Scientists</u> (p. 163) by H. R. Northrup and M. E. Malin, 1985, Philadelphia, University of Pennsylvania.

The inequity of distribution of those rewards is also very important to the engineer's motivation. When the high engineering achiever feels that he/she did in fact receive the reward that he/she deserves, their need for self-actualization is satisfied, and hence they feel encouraged to maintain their high performance. However, if they feel that the rewards were inequitably awarded because of favoritism and organizational politics, the engineers might withdraw from the situation by performing at a lower level or quitting the job. The impact of inequity on engineering motivation has been emphasized by the engineering researchers but none gave any empirical evidence. Hence, another question that needs to be investigated in testing the model is whether there is a significant difference between the performance of engineers in an equitable environment and in a non equitable environment.

When the rewards are valued by the engineer, job satisfaction results. Tailoring the rewards to the specific needs of the engineer is crucial to the engineer's satisfaction. Giving the engineer a reward that he/she does not value leads to job dissatisfaction. The dissatisfaction leads to a regression in the engineer's needs. For example, when a high achiever is rewarded by a raise while he/she really values acquiring freedom over their work more, the engineer may become dissatisfied. This dissatisfaction leads to the regression in the needs from self-actualization and esteem to the lower needs (Alderfer's Frustration-regression principle). Hence, the engineer may adjust to his work environment, negatively or positively. The perfectionist may become a satisfier, who does not strive to self-actualize, but just does the minimum required because he/she has no hope of obtaining the desired freedom over work that they wanted.

Hence, the other question that needs to be investigated is whether giving engineers rewards that they do not value trigger the regression from achiever to satisfier. Another question that also comes to mind as a result of this logic is whether satisfiers (who were originally achievers) would turn back into achievers in a different environment. Finally, another question is also whether the ratio of achievers to satisfiers in an organization affects the performance and behavior of the achievers.

Because valence is influenced by the abilities and traits of the engineer, the high performer who values the freedom to manage his/her own work for example, is very satisfied when he/she is awarded that freedom. The moderating effect of valence on the relationship between rewards and satisfaction is supported by Orpen who emphasizes the importance of the values of the engineers on their satisfaction. According to Orpen, the way engineers view their career and whether they feel adequately rewarded at work determines the engineer's satisfaction more than the match between needs and rewards. Valence is a consequence of the traits of the engineers. The high engineering achievers (perfectionists) have a high opinion of their career. They chose the engineering career not because of the money, but because of the challenge of the profession, their desire to solve problems, and to master the environment and make the world a better place to live.

The satisfaction derived from the rewards that the high achiever values, is in itself a fulfillment of the need for achievement. This need is hence reinforced, and the engineer wants to self-actualize even more by striving to perform at a higher level in the future. The engineers in Denis' survey ranked the meeting of objectives first as an element of satisfaction.

When we have engineers who perceive themselves as partners in the organization (because they participated in setting goals), who are also high achievers, who have adequate resources, that live in an environment that is relatively equitable, the result is the highest possible level of performance, given the available technology. This will reinforce the engineering organization, and increase its resources and competitiveness in a mutually reinforcing process, that is also self reproducing. The opposite is also true. This relationship, which was not described in any other model, is essential. The sum of the performance of each and every individual engineer in the organization and the interaction of their outputs lead to the synergy that makes an organization a leader among its competitors. Therefore, the higher the performance of each engineer, the higher the synergy, and the better off the organization is.

There is also feedback between the engineer's satisfaction and his/her needs. The engineers who work in the organization characterized above, who are adequately rewarded, and satisfied with their rewards (because those rewards were tailored to their specific needs) will have their high achievement needs reinforced. Since high achievement is never fully satisfied because higher achievement is always sought, this process is also self-reinforcing, and self reproducing.

The interaction between the organization and the individual engineer, i.e., the upper and the lower halves of the model in Figure 3 should generate the sustenance and continuous growth of the entire system. High achievers, in an appropriate environment will bear the fruits of high performance. This will enrich that environment, making the satisfaction of the individual engineers and their particular needs more feasible.

The integrated model proposed in this chapter was based on the needs, process, and reinforcement theories. From the needs theories, the engineer's high need for achievement was used in the model to show how that leads to high performance. The case of the relatively few engineers who have lower need for achievement (the satisfiers) and its consequences was also explained by the model. Process theories, such as expectancy, equity, and goal setting theories were also used to construct the variables that mediate between needs and performance. Finally, reinforcement theory was also used in the relationship between performance and rewards.

The proposed model of engineering motivation is different from the Porter and Lawler's Revised model since it goes beyond just using the expectancy theory. The proposed integrated model is also different from Katzell and Thompson's model in three aspects. First, the proposed model ties the needs of the engineer to his/her behavior. Second, it takes into consideration the impact of the performance of engineers on their work environment. Third, it is more compact than Katzell and Thompson's model in its attributes.

CHAPTER V

SUMMARY AND RECOMMENDATIONS

The concluding chapter of this thesis presents the questions derived from the model presented, a summary of the entire thesis, and some recommendations on how to test the model. As said in the beginning of the thesis, the model developed was not tested in this research, and hence further research is necessary to test its validity.

Questions

The following are some of the questions that need to be investigated to test the integrated model of motivating engineers presented in Chapter IV as well as some questions pertaining to the engineering environment in general. The first question is a question to test the direct relationship between role clarity and goals. The second and third questions are more intricate because they represent the link between more than two variables; their testing will thus be a more complex task. The fourth, fifth, and sixth questions tackle what happens in the engineering environment; testing them would hence be an even more complex task.

Question 1

This question addresses the direct relationship between role clarity and goals. The lack of role clarity was reported by engineers as a major cause of poor performance and demotivation. Hence, the first question that needs to be investigated is: would clarifying the role of engineers and allowing them to participate in setting goals lead to a higher effort to performance relationship?

Question 2

This question addresses the rewards -> satisfaction -> needs -> abilities and traits -> effort -> performance relationships. Engineers often reported the lack of performance contingent rewards or obtaining rewards that they do not value as a major source of dissatisfaction. Hence, the second question that needs to be investigated is: would particularly need-tailored rewards lead to the reinforcement of high achievement in engineers (through their impact on satisfaction), and hence impact future effort and performance?

Question 3

This question addresses the equity -> rewards -> satisfaction -> needs -> abilities and traits -> effort -> performance relationships. It seems that engineers are very affected by inequity. Hence, it is necessary to investigate whether there is a significant difference between the performance of engineers in an equitable environment and a non equitable environment. Therefore, the third question

is: would high achiever engineers yield significantly different performance outcomes in a non equitable environment than in an equitable environment, given adequate resources (holding all other factors equal)?

Question 4

One feature of the integrated model of motivation for engineers is the significance of the high achievement needs for engineers, and whether they engineers become satisfiers if not properly rewarded. Hence, the following question needs to be investigated: does giving engineers rewards that they do not value trigger the "frustration-regression" phenomenon (from achievers to satisfiers)?

Question 5

A corollary of the fourth question is the question of the significance of the impact of the environment on the engineer. Hence, the fifth question is: would satisfiers (who were originally high achievers) turn back into high achievers in a different environment?

Question 6

The impact of the environment is also addressed from another perspective in the model. The impact of the ratio of achievers to satisfiers on the performance of the achievers is also questioned. Hence, does an environment with a high ratio of satisfiers to achievers significantly

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REFERENCES

Aronberg, R. (1985). Motivating and managing engineers. Journal of Professional Issues in Engineering, 111(1), 33-38.

Babcock, D. L. (1991). Managing engineers and technology. Prentice Hall International Series in Industrial and Systems Engineering.

Badawy, M. K. (1971). Industrial scientists and engineers: motivational style differences. California Management Review, 14(1), 11-16.

Badawy, M. K. (1975). Organizational designs for scientists and engineers: Some research findings and their implications for managers. IEEE Transations on Engineering Management, EM-22(4), 134-138.

Badawy, M. K. (1978). One more time: how to motivate your engineers. IEEE Transactions on Engineering Management, EM-25(2), 37-42.

Brown, D. M. (1985). Cognitive perceptual differences of the world situation among motivated and demotivated engineers and their mangers. Doctoral Dissertation, United States International University, San Diego.

Denis, H. (1986). Matrix structures, quality of working life, and engineering productivity. IEEE Transactions on Engineering Management, EM-33(3),

Dewhirst, H. D. & Holland, W. E. (1975). Effect of organizational change on career goals of scientists and engineers. IEEE Transations on Engineering Management, EM-22(3), 114-115.

Gellerman, S. W. (1968). Management by motivation. American Management Association.

Giegold, W. C. (1982). Training engineers to be leaders: A classical management Approach. IEEE Transations on Engineering Management, EM-29(3), 94-103.

Helphingstine, S. T., Head, T. C., & Sorensen, P. F. (1981). Job characteristics, job satisfaction, motivation and satisfaction with growth: A study of industrial engineers. Psychological Reports, 49, 381-382.

Herzberg, F., Mausner, B., & Snyderman, B. B. (1959). The Motivation to work. John Wiley & Sons, Inc.

Herzberg, F. (1966). Work and the nature of man. The World Publishing Company.

Howard, B. & Lebell D. (1989). Tapping technical talent. Personnel, (11), 53-56.

Katzell, R. A. & Thompson D. E. (1990). An Integrative model of work attitudes, motivation, and performance. Human Performance, 3(2), 63-85.

Kopelman, R. E. (1977). Psychological stages of careers in engineering: An expectancy theory taxonomy. Journal of Vocational Behavior, 10, 270-286.

Liker, J. K., & Hancock W. M. (1986). Organizational systems barriers to engineering effectiveness. IEEE Transations on Engineering Management, EM-33(2), 82-91.

Munson, J. M., & Posner, B. Z. (1979). The values of engineers and managing engineers. IEEE Transations on Engineering Management, EM-26(4), 94-100.

Myers, M. S. (1964). Who are your motivated workers. Harvard Business Review, 42(1), 73-88.

Nelson, A. (1987). Just praise won't do it. Supervision, 49(5), 8-9.

Orpen, C. (1985). Individual needs, organizational rewards, and job satisfaction among professional engineers. IEEE Transations on Engineering Management, EM-32(4), 177-180.

Orth, C. D. (1987). More productivity from engineers. Harvard Business Review, 54-62.

Pinder, G. C. (1984). Work motivation: Theory, issues, and applications. Scott, Foresman and Company.

Richardson, L. D. (1985). Motivation- the key to productivity. Chemical Engineering, (11), 209-210.

Rosenbaum, B. L. (1982). How to motivate today's workers. McGraw-Hill Book Company.

Ruskin, A. M. (1986). Personal factors in technical management, Part 1. Chemical Engineering, (7), 67-71.

Ruskin, A. M. (1986). Personnal factors in technical management, Part 2. Chemical Engineering, (7), 68-80.

Saleh, S. D., & Desai, K. (1986). Occupational stressors for engineers. IEEE Transations on Engineering Management, EM-33(1), 6-11.

Schermerhorn, J. R. (1989). Management for productivity. John Wiley& sons, Inc., Third edition.

Shapero, A. (1985). Managing professional people. The Free Press.

Shell, R., Souder, H. R, & Damachi N.. (1983). Using behavioral and influence factors to motivate the technical worker. Industrial Engineering, (8),58-62.

Smith, E. A. (1990). The Productivity manual, Gulf Publishing Co., Houston.

Steffen, R. J. (1984). Coping with the role of boss. Chemtech, (2), 78-83.

Stevens, H. P. & Krochmal. J. J. (1977). Engineering motivators and demotivators. IEEE 1977 National Aerospace and Electronics Conference. 473-479.

Thamhain, H. J. (1983). Managing engineers effectively. IEEE Transactions on Engineering Management, EM-30(4), 231-237.

Thamhain, H. J., & Wilemon, D. L. (1987). Building high performing engineering project teams. IEEE Transations on Engineering Management, EM-34(3), 130-137.

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