CHAPTER 1

The Engineer and Design Professional in Management

HIGHLIGHTS

Successful Management depends on four factors:
1. Communication skills
2. People management
3. Ability to focus on the bottom line
4. Legal Knowledge

In addition to the above management success factors, it is necessary to develop what may be called "executive qualities" which are comprised of the following attributes:
- Strong leadership
- Effective delegation
- Accurate decision making
- Discipline

Legal knowledge allows managers to perform their duties efficiently and effectively in the face of a legal dilemma.

Most professionals are problem solvers. Their expertise in stating and solving problems results from specialized training in problem-solving techniques. It is this ability to state and solve problems that employers hope to find when they hire engineers and design professionals, and it is because of the many uses for this knowledge that there is presently a significant demand for graduates in these fields.[1] Most training equips engineers and design professionals to solve problems of a mathematical and technical nature—problems that may readily be reduced to symbolic form. However, not all problems lend themselves to such an approach. The stress resulting from a given force applied to a particular beam design is stated easily in mathematical terms. It is exceedingly difficult, however, to formulate or state laws governing the relationships between people in terms of Xs and Ys with proper coefficients and thereby solve legal and ethical problems. Most such problems involve the interpretation of human laws and the use of discretion and judgment in determining rights and responsibilities.

[1]According to the Bureau of Labor Statistics, overall architect and engineering employment is expected to grow during the 2014–2024 decade. (http://www.bls.gov/ooh/architecture-and-engineering/home.htm, accessed 3/10/16)

Often, the legal solutions are no less important than the solutions to mathematical problems. In most jobs, the engineering or design professional is part of a management team. Before turning to the legal aspects of law with which it is necessary to be familiar, consider certain management skills which should be acquired.

Engineering and Design Management

For the vast majority of graduates, the first job secured is merely a stepping stone to higher positions.

Normally, entry-level engineering and architecture jobs require a large amount of technical skill. As engineers and design professionals move up their career ladders, the percentage of time in utilizing their technical skills usually decreases. Regardless of the ladder chosen to climb—research, manufacturing, consulting, sales, or any other job—progression to higher levels depends on at least four factors in addition to technical ability:

1. Communication skills
2. People-management skills
3. Ability to focus on the bottom line
4. Legal knowledge

Communication Skills

An idea may have very great latent value, but until it is used or communicated in some way, the idea is worthless. In addition, the mental work necessary to develop the idea in a detailed description or a diagram is in itself of value. Nearly everyone has had the experience of gaining new insight, or of discovering added features of an idea, when faced with the task of trying to explain it to someone else. This ability to communicate effectively is of increasing importance because a manager sets the tone in which the team works.

People-Management Skills

A promotion from a strictly technical position to one of greater responsibilities almost always leads to managing people. Being a "boss" isn't easy. The manager who takes time to explain to subordinates "why" and to keep them informed is likely to be more successful than one who does not. Some people-management issues are discussed in Part 3, Chapter 18 (Agency) as well as in Part 6, Chapters 28 and 29, (Labor and Workers' Compensation, respectively). As more and more employees work remotely and virtually, managing people working in several environments creates more management complexity.

Ability to Focus on the Bottom Line

Most operations are undertaken with a profit incentive. Even when certain operations are not expected to make a profit (such as a service department), cost is usually important. If the selling price of a company's product is unchanged, money saved in manufacturing or raw material cost represents added profit; conversely, added cost decreases profit. Many engineers win promotions and many consultants earn their livelihoods on their ability to analyze operations and reduce costs. Part 3 (Project and Contract Management) provides a good overview of how costs and contract specifications are used to select optimal payment methods.

Legal Knowledge

Engineers and design professionals are not expected to become attorneys from an exposure to one survey course in law, any more than attorneys could become engineers or design professionals by taking one survey course in computer-aided design. However, engineers and design professionals should be aware of the effects of carelessness in dealing with others. They should know when they need the advice of an attorney. A legal background is a "preventive" asset; that is, with basic legal knowledge, professionals should be equipped to help prevent costly lawsuits against their company. Meticulous contract review before signing is an important preventive measure. It is surprising how little attention is paid to contracts and supporting documents, particularly in view of the fact that these documents outline the rights and responsibilities of all parties.

Executive Qualities

In recent years there has been a trend toward filling top management or executive positions with engineers. Companies have recognized the value of the engineer's analytical approach to executive problems. Several top CEOs started their careers as engineers or have engineering degrees.[2]

While specialized technical training is beneficial to the executive aspirant, but so is a knowledge of many other fields. An executive who appreciates systems engineering and interdisciplinary teams is an especial asset to organizations that encourage innovation and product development.

What makes an executive? Why does one person achieve this goal while many others strive and fail? At first glance, the behavior of one successful executive appears to have little in common with that of another who is equally successful. However, closer examination reveals certain similar behavior patterns. Each usually possesses the four qualities just mentioned for successful managers, often to a high degree. Other qualities, too, are seemingly common to most top executives, and deserve consideration.

Leadership

The quality known as leadership is difficult to define. It is clearly evident in one person and strangely lacking in another. Psychologically, leadership connects a group with the one who leads. It is necessary that the leader have one or more qualities esteemed by the group.

Indeed, it is doubtful that anyone is truly a "born leader." It is more probable that leadership qualities result from training acquired through study and observation. Leadership qualities are enhanced by practice. Opportunities to practice the poise and purposefulness of leadership occur in limitless ways.

Two outstanding leadership characteristics are the ability to keep the ultimate goal uppermost in mind, and the ability to pursue it enthusiastically. Enthusiasm is infectious. A speech delivered in a monotone makes for dull listening; however, the same speech using the same words but delivered with enthusiasm can move people to action.

Leadership stems partly from the ability to stand firm on principles. However, standing firm on principles doesn't mean being inflexible in all circumstances. The ability to listen and make modifications when circumstances dictate that change is necessary goes a long way toward being an impressive leader.

There is a popular misconception that a leader should not admit mistakes, although few people make perfect decisions all the time. Not only must leaders admit

[2]Drake Baer, "Here's Why a Quarter Of the World's Best-Performing CEOs Studied Engineering," Business Insider, October 22, 2014; http://www.businessinsider.com/top-ceos-study-engineering-2014-10 last viewed September 19, 2016.

their own mistakes; they must take responsibility for the mistakes of their subordinates, because those actions result from the leaders' direction or lack thereof. Placing blame on others is not respected by those in top management.

Delegation

A characteristic most top executives share is the ability to delegate authority and responsibility to others. It is difficult for anyone to rise to the top of any organization without the ability to delegate. There is not enough time for one person to effectively and thoroughly perform the requirements of a top management job. Executives who delegate few tasks rob themselves of time needed for adequate thought before making decisions. Also, the failure to delegate routine tasks to others can be a barrier to executives' promotions; if no one can be found who has performed a portion of the executives' tasks with the authority necessary for that performance, it is natural to leave the executives where they are.

Specialization is an inherent advantage of effective delegation. No one is a specialist in everything. By assigning some of their tasks to others, executives can obtain the advantage of specialized treatment. If the executive is the specialist, mentorship or coaching is a way to be engaged in succession planning and developing new talent within an organization and delegate accordingly.

Delegation, as the term is used here (and in most businesses), means more than merely assigning tasks to be performed. Delegation includes clothing the delegee with the necessary authority to carry out the assigned function. It is this parting with a portion of authority that causes shortsighted executives—consciously or unconsciously—to oppose delegation to others. It is this very aspect of delegation, however, that contributes to the growth of assistants. The able executive realizes this and takes full advantage of it in helping others develop. Please see Chapter 18, Agency, for a further discussion regarding delegation. Chapter 18 is an important chapter to review in order to understand the concept of agency as an engineer moves from completing tasks herself to delegating those tasks to others.

Decision Making

All of us make decisions involving choices from among alternatives. Our choices are not always correct. One attribute that seems characteristic of those people who reach top management is their ability to be right a higher percentage of the time than the average person. Of course, top management decisions are decisions about particularly difficult problems. Decisions run all the way from a single-variable problem to multivariable problems where little, if anything, is fixed or known. Generally, routine decisions are delegated to others; the top manager is the one who makes the decision when major uncertainties exist. The decision to expand a plant or install new production facilities based on an apparently expanding market is such a decision. Many of the assumptions can be reduced to probabilities. If enough of this can be done, the problem can be programmed for a computer, which will then give the executive some answers. However, the answers are based on assumptions and probabilities, and the executive must decide whether to go ahead. The risk is still the executive's, not the computer's.

Top management decisions generally consist of six elements, dealt with in sequence:
1. Gather facts
2. Recognize limiting conditions
3. Assume some facts and conditions as they are expected to be, and recognize them as assumptions
4. Analyze the facts, limits, and assumptions
5. Calculate risk
6. Decide

A few top executives possess such vast knowledge and the ability to analyze and synthesize that they can make rapid-fire policy decisions that are nearly always right. However, such people are rare. Generally, people in top management do not make hurried policy decisions. There is often grumbling from below because of apparently undue procrastination. Despite the grumbling, such delay is usually the course of wisdom, because the risks are frequently sizable. A decision based on inadequate facts

or erroneous assumptions is hazardous, and delay in waiting for more facts is often inescapable. Even the rare management genius who makes correct decisions rapidly usually has had many years of experience in more methodical decision-making that has equipped him for this present role.

Discipline

Discipline is a necessary component of any well-run organization. People must be taught; old patterns must be changed. However, in order for discipline to be recognized as something other than punishment, those things which are considered appropriate an inappropriate professional behavior should be known throughout the organization and enforced consistently. Most top executives are masters of the use of reward and reprimand in changing the behavior of subordinates. What is often lacking is a mastery of using what motivates people to do their best. In addition to people's drive for food, water, and the means of satisfying other basic needs, they have a whole host of derived needs, not the least of which is the need for recognition.

Every person needs recognition or respect from others—lack of it causes loss of self-respect and, eventually, diminished effort. Recognition can be either tangible or intangible, and both forms are required. Verbal praise sounds hollow after awhile if it is not accompanied by some material reward. Similarly, material rewards without praise for accomplishments are incomplete. It has often been stated that rewards should be public, with criticism private. The truth in the statement is inescapable. Most top managers observe this principle in the interest of preserving their organizations.

Many qualities can make a person successful in top management. Only a few have been mentioned here. Nevertheless, these basic qualities must be mastered by executive aspirants.

Engineering Projects

A large proportion of the capital wealth of the United States has resulted from engineering projects, as well as the intellectual property inherent in them (See Chapter 20, Introduction to Intellectual Property.) Civil engineering projects—roads, bridges, buildings, and the like—are most familiar to the public. As a result, whenever the term "engineering project" is used, visions of a dam or expressway cloverleaf are likely to come to mind. The value of civil projects cannot be denied, but contributions by other fields are also significant, even though the public is not as aware of these activities or results. Since the development and adoption of mass-production methods in the United States, an interdisciplinary approach has developed. People are needed who can apply knowledge of civil, mechanical, electrical, chemical, industrial engineering along with design skill for the built environment.

The following discussion covers the various stages of an engineering project in a construction context. However, the same basic concepts also apply to other types of engineering and design projects.

Project Phases

Engineering and project phases can be reduced three:

1. Conception of the idea
2. Reduction of the idea to practice
3. Refinement of the idea and ensuring that the project works

The stages are fairly distinct, and a particular project team may have responsibilities in one or more of the stages.

Conception of the Idea. Just about every product and convenience we enjoy started as someone's idea. Neither products nor the processes by which they are manufactured can be developed without someone's original idea. Not all ideas are practical, however. A large number of those that are adopted require substantial alterations and financial investment before they are acceptable. Many ideas appear attractive in the beginning, only to be demonstrated as impractical by objective examination. This objective examination of a possible project is known as a **feasibility study**. A feasibility study is a preliminary examination of a proposed idea. At this point, there may be a preliminary design. It is meant to answer such questions as: What will it cost? Can we make a reasonable return on the required investment? Can it be sold at a given price? What processes will be better in the long run? The answers given determine whether it is desirable to proceed to the next stage—actually setting up to produce.

Reduction to Practice. Turning someone's idea into a reality can be quite complex in a manufacturing situation. Planning is necessary, requires vision, and continues until all the pieces are firmly in place. Even then, maintenance should be anticipated. For construction projects, changes are made easily in the planning stage—it costs little to erase a machine location on a layout and place the machine in another location. Even rearrangements of the entire process are inexpensive at this point. It is here that questions pertaining to equipment, locations, and added features must be answered, and the answers justified, if the process is to be successful. Layout changes may be very expensive. For this reason, questions that should have been raised in the planning stage but were never brought up reflect on the process engineer's ability. For example, a process engineer designs a layout of the process, complete with machines and equipment, and writes specifications for the machines to function as desired. The specifications are then sent out, proposals received, and contracts awarded to the successful bidders. Engineers or architects often act as the owner's agents. Engineers often supervise the building of machines or structures to fit the layout, and then supervise the installation. Engineers also must control the times of completion of the elements of layout. Rarely is a process completed and functioning properly within the original time-frame. There is nearly always at least one contractor who is late. A wise engineer will allow some time for this delay in the schedule.

Refinement and Oversight. It is probably safe to state that in every engineering project ever created there were special problems to be solved before full-scale production could begin. The presence of "bugs" in a newly installed process is normal but they must be removed before the process can be considered complete. The engineer who set up the process is the logical person to remove these bugs before the operation is turned over to someone else or put out for bid. These stages will be elaborated upon in Chapter 16 (Project Design and Contracting Procedures).

Law and Engineers

There are two fundamental reasons why engineers should have some knowledge of the law. Specifically, to protect and ensure:
1. The rights of others
2. His or her own rights

In any project, engineers and architects act as professionals; they are frequently the representatives, or agents, of the owner. Their function is to act in the best interests of the owner—to get the best possible results with a minimum of delay and problems. Professionals must deal with the rights of others.

Engineers and architects are guardians of the owner's rights and, in a manner of speaking, of the rights of others with whom the owner deals. Because court proceedings are costly in both time and money, engineers and architects generally should avoid entanglements that would lead to litigation. And, because violation of the rights of others is likely to lead to court proceedings, engineers must know the characteristics of these rights, if their preventive job is to be well done.

For construction projects, the relationships between the owner and contractor are set forth in a series of documents drawn up by the engineer. Documents such as instructions for bidders, requests for proposals, proposals, general terms and conditions, specifications, drawings, and sometimes purchase orders, order acknowledgments, invoices, and the like, compose parts of the contract. See Chapters 16 (Project Design and Contracting Procedures) and 17 (Contract Management and Specifications). Careless errors in the preparation of these documents can cause legal controversies, or place the owner and others in indefensible positions when controversies arise. Documents must be prepared in such a way that the owner's position is protected. Imposing an undue hardship on the contractor may lead to unnecessary litigation. Similarly, ambiguities in the terminology or leaving too much to future agreement can lead to unnecessary litigation. Hence, specificity and realistic goals are what the contract usually requires.

In some respects the engineer's or architect's position is between the owner and the contractor. When disputes arise, they are likely to be called on to mediate or participate in the controversies. To do a reasonable job in this position, engineers and architects must be acquainted with the legal rights and responsibilities of both parties. They don't have to be attorneys, but some knowledge of the law is essential, and they should be able to recognize situations in which it is necessary to consult an attorney. Remember, people can't very easily recognize legal troubles unless they have some knowledge of the rights involved.

As with other human endeavors, obtaining expert advice as early as possible can avoid problems or serve to provide damage control. There is another reason to acquire a knowledge of the law. Besides their professional activities, professionals are citizens as well. The law controls many of our private day-to-day dealings with others. Whether we buy insurance or apply for a credit card, our rights and responsibilities should be clear.

Engineers and architects are members of society as well as professionals who possess technical skills. As educated members of society and professional people, their knowledge and abilities should extend well beyond their technical skills. Information available to us online or via radio, television, newspapers, and magazines has legal significance. An awareness of current events and especially their legal ramifications is essential.

Legal Analysis

Engineers and design professionals often have backgrounds in analysis of scientific or technical things. In the design of a bridge or automotive component, for example, an engineer analyzes forces and reactions to them, statically and dynamically. Using the results of analyses, architects and engineers adjust the designs to serve both their employers and the public appropriately. Increasing reliance on computer simulation may ease the architect's or engineer's duties from a drafting stand-point, but does not relieve her from the responsibility for the reliability of the final product.

In the legal setting, engineers and design professionals are often called upon to provide analysis in tort, and particularly product liability cases, which are discussed more thoroughly in Chapter 26, Products Liability. They may conduct investigations known as **failure analyses** to find why some malfunction occurred. Scientific analysis may be required in a variety of criminal-case settings. Engineers and architects are accustomed to the kind of analysis where most things are reasonably precise and even the provision for error is usually predictable. Legal analysis is less precise.

Although legal analysis is similar to technical analysis in that both methods require the analyst to consider all potential outcomes when presented with a problem, the difference lies in the unpredictable nature of human decision-making. A software engineer can predict the effect of bad code in a program and debug it. A civil engineer

or architect can consider the wind effects on a bridge and design to accommodate it. Human behavior is harder to predict with certainty, rendering an often confusing and unintelligible legal construct.

Yet there are guidelines. If there is a case before a civil or criminal court, lawyers look to legal precedents or prior cases that were resolved under similar circumstances and facts, which may help predict the result of a case in which he is involved. Statutes, passed by elected officials, serve as legal guides to federal and state governments. The Federal Trade Commission and Department of Justice use formulas to predict the effect of mergers.

The thing to remember about law is that as a member of society you deal with it every day. If you look hard enough at the tax code, you will see a series of "if/or," "if/but," and "only if" statements (not that you would want to do such a thing, however). When you fill out your 1040 form, you are progressing through parts of the United States tax code that have been summarized on a few sheets of paper. From this perspective, the transition from technical analysis to legal analysis is not that far of a leap. Your problem-solving skills will aid you significantly.

Review Questions

1. Why should an engineer or design professional have some knowledge of the law?
2. Identify three additional qualifications an engineer or design professional should possess for success in management which are not included in the material.
3. How does delegating authority and responsibility help an executive?
4. What are the phases of an engineering project? What would each phase be composed of in the proposed manufacture of, say, table lamps?
5. What is the purpose of a feasibility study?
6. How is legal analysis similar to technical analysis?

Suggested Readings

Gillian Tett, *The Silo Effect: The peril of Expertise and the Promise of Breaking Down Barriers*, Simon & Schuster, 2015.