

Instructors' Resource Manual

for

Managing Engineering & Technology

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Chapter 1 Engineering and Management

- 1-1. Q:** The precursors of today's engineers listed in the quotation from Wickenden had no classes and few or no books from which to learn scientific principles. How can you explain their success?
A: Certainly there was a great deal of trial and error, and lessons learned were passed on through long apprenticeship to the masters of such knowledge as existed in the field. Knowledge migrated slowly with the travels of artisans, and centers of unrecorded knowledge could disappear in the wake of conquerors or natural disaster. Nonetheless, the discoveries of some early thinkers (such as that of density measurement by Archimedes) were recorded for posterity, but progress was slow. In the Renaissance the leaders of scientific discovery in Europe maintained a correspondence with each other, and the written documentation of science and scientific progress began to accelerate.
- 1-2. Q:** Compare how well *engineering* and *management* satisfy the several parts of the definition of a profession.
A: Engineering clearly meets all of the criteria of a profession. One might argue that engineering is not as consistent in establishing and self-policing ethical standards nor as unwavering in the pursuit of the public interest as it ought to be, but neither are medicine and law. Management fails to meet the criteria of a profession in a number of ways: while there is a continually increasing body of literature in the art and science of management, many successful managers gain their knowledge of it through reading and experience rather than formal study, and the need for continuing education in management theory is hardly as pressing as it is in engineering. Further, no common professional society of managers acts effectively to certify proficiency in the field, establish standards, and require conformance: policing the actions of management occurs instead through legislation and government regulatory authority. The inexperienced student may evidence an overly idealistic notion that management ought to act as a profession, and the instructor needs to point out that most management is instead still an art.
- 1-3. Q:** Why is it so difficult to answer the simple question "How many engineers are there in the United States?" Is the question "How many physicians are there in the United States" easier?
A: The number of physicians is normally taken as those who are licensed by the several states to practice medicine, a matter of record. Registered professional engineers, on the other hand, represent a minority even of engineers who have graduated from accredited engineering programs, since few engineers in industry seek registration. Bureau of Labor Statistics data lists people currently employed in positions that normally require a graduate engineer, regardless of their original degree. National Science Foundation data include all those with an engineering degree, even though half may now be working in management or other positions.
- 1-4. Q:** Comment on the sensitivity of U.S. engineering employment to a major change in the Department of Defense budget. What types of engineers would be especially affected?
A: DOD weapons R&D is an especially intensive employer of engineers, both internally and indirectly through defense contractors. Aerospace engineers are especially vulnerable to DOD budgets, followed by electronics engineers and then by mechanical engineers. Civil engineers would be more affected by expansions of military bases than by R&D.
- 1-5. Q:** What are the similarities in the definitions of *management* quoted from authors of management textbooks? Do the definitions provided by business executives differ in any way? Synthesize your own definition of management.
A: Management textbook definitions typically emphasize the achievement of organizational objectives through effective use of human and material resources. Definitions from business executives are not inconsistent with these, but tend also to cite more applied aspects such as making profits and satisfying customers with quality products. Two examples of student definitions are:
*"Conversion of tangible and intangible resources of an individual or organization into the goals and desired results set by well defined standards."
*"Utilization of human and material resources in an effort to produce quality products while minimizing costs and maximizing company profits."
- 1-6. Q:** How does the job of supervisor or first-line manager differ from that of a higher manager?
A: The first-line supervisor is unique -- manages only nonmanagers, has the shortest range viewpoint, may have risen recently from the ranks, and has the best understanding of the technology of his or her group. Increasing levels of management deal in longer range concerns and need more conceptual skills.

- 1-7. Q:** How does the job of a top manager differ from those of the several levels of middle management?
A: Top managers are responsible for the future of an enterprise, and normally have no full time manager above them (although they customarily report to a Board of Directors or some other elected structure). Their decisions have the longest time span and the greatest financial impact.
- 1-8. Q:** Identify the three types of skills needed by an effective manager as conceived by Robert L. Katz, and describe how the relative need for them might vary with the level of management.
A: This question is answered in Figure 1-2 and the discussion under “Managerial Skills.”
- 1-9. Q:** From the 10 managerial roles provided by Mintzberg, choose three or four that you consider most important for the first-line manager and explain your selection. Repeat for middle level and top managers.
A: The responses to this question are, of course, matters of opinion, and will differ with the level of experience of the respondents. Following is the response of a class of 17 seniors and graduate students, most without significant industrial experience above the worker level.

Type of Role	1st Line	Middle Manager	Top Manager
Interpersonal	16	19	26
Figurehead	0	0	15
Leader	13	8	8
Liaison	3	11	3
Informational	16	23	21
Monitor	3	10	4
Disseminator	11	12	1
Spokesman	2	1	16
Decisional	20	19	16
Entrepreneurial	0	3	8
Disturbance handler	13	1	1
Resource allocation	6	6	4
Negotiator	1	9	3

- 1-10. Q:** How would you distinguish between engineering management and management in general?
A: One answer to this question is quoted in the chapter from an earlier article (Note 28). Others will have their own definitions.

Chapter 2

Historical Development of Engineering Management

- 2-1. Q:** What was the lasting significance of the Sumerian priests' need to maintain a permanent record of temple property (which they did on clay tablets)?
A: The lasting significance was that the need to account for property fostered the development of written language. However, students will come up with a variety of other answers unless this point has been emphasized in class.
- 2-2. Q:** Stones for the pyramids were quarried far to the south (upstream on the Nile River) and were brought downstream on rafts only during the spring flood of the Nile. Discuss some of the planning and organizational implications of this immense logistic effort.
A: The depth of planning for the pyramids was certainly impressive. The stones had to be cut up to a year ahead to fit in a specific location. The manpower to quarry stone, make rafts, transport stone to and from the rafts at each end (and to bring raft material from forest to river), much less build the structure, is impressive. George (History of Management Thought, 2nd ed., p. 5) lists 8,386 people in one expedition to quarry stone: "110 [army] officers of each rank, 50 civil officials and ecclesiastics, 130 stone masons, 2 painters, 4 engravers, ... 5,000 common soldiers, 200 members of the king's court, 800 barbarians, and 2,000 bondservants of the temple."
- 2-3. Q:** Why was the Venetian development of double-entry bookkeeping so important to the development of management?
A: Obviously the entry of both a debit and a credit for each transaction permits a check on accuracy, facilitates audits, and increases security.
- 2-4. Q:** The development of cotton and woolen mills in the mill cities of England, and later New England, caused tremendous sociological change as potential workers (especially women) swarmed from rural areas to the growing industrial cities. Cite examples of similar occurrences in more recent times in developing countries.
A: A senior/graduate class of 17 students, about half international, suggested the following:
* The rush of Burmese women to textile and jute mills depleted rice field workers, threatening starvation.
* 1000 Navaho farmers in New Mexico now work instead for General Dynamics.
* Mexico City and Sao Paulo, Brazil are now #1 and #3 among populated cities because of the influx from rural areas.
* Philippine creation of an Export Processing Zone a decade ago established an economic boom (along with overcrowding, crime, and pollution) in the area as rural people flocked in.
* The percentage of Taiwan's population working in agriculture has decreased "to recent low 20's from original high 80's in less than four decades," creating the same urban problems cited for the Philippines.
* Indian villagers have swelled Bombay and Calcutta to populations above 15 million. "A few are successful in finding low paying jobs but a large number turn to other forms of income such as begging and crime."
* Jobs in American border plants in Juarez, Mexico in electronic assembly or sorting 'cents-off' coupons from American supermarkets have swelled the city population to a million.
* Even in the remote country of Bhutan (North of India) rural people are now flocking into the towns, powered looms in the "weaving centers" are replacing obsolete hand/foot driven machines, and workers from India have migrated in to provide needed trained manpower and technicians to work with unskilled Bhutanese in the factories.
* With the discovery of oil in Arab countries of the Near East, "desert nomads turned into oil field workers and goat farmers into businessmen." [Extensive, free education of the relatively small populations there and tremendous construction programs to house the new urban population made possible by oil wealth makes this part of the industrial revolution unique.]
- 2-5. Q:** Summarize the contribution of the American Society of Mechanical Engineers to the dissemination of better methods of (production) shop management. What does this say about your need to be active in at least one professional society?
A: Frederick Taylor provides a good example -- first he was inspired by Henry Towne's paper in 1886, later he shared his own ideas through papers before the ASME, and still later as ASME president he funded Morris Cooke to study the administrative effectiveness of the ASME (which no doubt influenced Cooke's career in governmental

service organizations). The reasons for activity in professional organizations should be evident to any real professional, but this question can be used as a springboard for emphasizing this need to students.

2-6. Q: Matsushita emphasized the residual disadvantages to the United States of the teachings of Frederick Taylor. Discuss the positive contributions Taylor and his contemporaries in the scientific management movement made.

A: Taylor and his followers developed methods of work measurement and work design that provided tremendous savings in labor intensive work and led to development of much of traditional industrial engineering. These methods are still valid, but they can be strengthened if the ideas and enthusiasm of the (now much better educated) work force can complement the work of the industrial engineer using techniques such as quality circles and their derivatives.

2-7. Q: What was the positive value of Max Weber's model of "bureaucracy?"

A: Weber's bureaucracy provides a formal, consistent structure, staffed on the basis of training and achievement, with formal authority of position and consistent procedures. All large organizations doing routine work need much of this structure. The challenge to management is to provide a more flexible structure for those areas where innovation and creativity are more important.

2-8. Q: The essence of the Relay Assembly Test Room Experiments at the Hawthorne Works was that expected correlations between productivity and physical factors such as illumination and rest periods were not demonstrated. What other factors could explain the regular productivity increases observed in these experiments?

A: Some of the conventional explanations have included (a) the feeling their work was important, (b) development of a friendly social group and a team spirit, and (c) being able to assume more responsibility for their work in the absence of a supervisor. Other factors may have been (d) the six women may have been a picked group (one of the original six 'didn't work out' and was replaced), (e) their piecework pay was based on productivity of just those six women, so they felt they could influence their pay, and (f) during the long experimental period their productivity might be expected to increase compared with a standard group with higher turnover.

2-9. Q: Read at least part of *In Search of Excellence* and elaborate on one significant finding of Peters and Waterman.

A: Each answer will need to be evaluated separately. Peters and Waterman (Note 61) summarize for us: "The eight attributes that emerged to characterize most nearly the distinction of the excellent, innovative companies go as follows: 1. A bias for action ... 2. [staying] Close to the customer ... 3. [fostering] Autonomy and entrepreneurship ... 4. Productivity through people ... 5. Hands-on, value driven [philosophy] ... 6. Stick to the knitting [don't acquire a business you don't know how to run] ... 7. Simple form, lean staff ... 8. Simultaneous loose-tight properties [being both centralized and decentralized]. One would hope a student's reply would comment on at least one of these themes.

2-10. Q: As made clear in this chapter, engineers and engineer managers have made strong contributions to management theory and practice. List the engineers and engineer managers identified in this chapter, together with their contributions, and add any others you may know of.

A: Craftsmen inventors such as Hargreaves, Arkwright, Crompton, Cartwright, and Maudslay made the English industrial revolution possible, although these inventions are not contributions to management theory and practice directly. Smeaton and Watt in their steam engine works, Robert Owen in his mills, Henri Fayol in the French mining complex, Andrew Carnegie in the American steel industry, and Col. John Stevens in railroad construction made substantial 19th century innovations in industrial management. Frederick Taylor, Henry Gantt, Frank Gilbreth, and Morris Cooke were turn-of-the-century U.S. engineers who made great contributions to management of the shop and other enterprises; Lillian Gilbreth was educated as a psychologist but continued Frank's work and was a member of several engineering societies. Henry Towne, Chester Bamard, Alfred Sloan, and Thomas Watson Jr. were executives in enterprises that were high technology in their time. Russell Robb and Vannevar Bush were electrical engineers who contributed to industrial management theory in the mid 20th century. The list can be extended indefinitely. However, social scientists such as Weber, Elton Mayo, and others who were neither engineers nor managers should not be considered responsive to the question.

Chapter 3 Planning and Forecasting

- 3-1. Q:** Why is planning said to have “primacy” among the managerial functions?
A: Planning, and especially the initial objective-setting step of planning, must occur first to establish a basis for organization, goals to provide leadership in achieving, and standards against which controls can be applied.
- 3-2. Q:** Develop your own model of the steps in the planning process.
A: No single answer can be provided, but the key steps in Figure 3-1 should be apparent in a student’s response.
- 3-3. Q:** Select a company (other than Sears) whose apparent mission or purpose has changed over its history and describe the change.
A: This question will produce a variety of answers, depending on the experience and prior education of students. Sample student answers: *Georgia Pacific moved from a primary emphasis on lumber for the very cyclical new housing industry to an emphasis beginning in the late 1970’s on higher-profit paneling and millwork and premium papers such as branded tissues and towels and printing papers. *San Miguel, the biggest corporation in the Philippines, expanded from its original concentration on beer starting in 1890 to a variety of industries (paper, prawn culture, food production, packing) emphasizing development of Philippine natural resources. *Apple’s Macintosh was changed from a self-contained system to one compatible with external drives, modems, and other peripherals to meet customer demand for system growth.
- 3-4. Q:** Select a company or industry for which the strategic management of technology is important. Describe some of the base, key, and pacing technologies that are important for their strategic management of technology.
A: Answers will vary with the company or industry selected, but should be consistent with the discussion on “Strategic Management of Technology.”
- 3-5. Q:** Pick a company with which you are familiar and estimate from their actions what their objectives appear to be in each of Drucker’s “key result areas.”
A: This is too complex a question for a specific comment here, but it does provide considerable insight into student understanding of the meaning of manager development, worker attitudes, innovation, productivity, and the other four (most of which will be discussed in some detail later in the book).
- 3-6. Q:** Briefly outline the concept of management by objectives (MBO) and the steps involved in implementing this technique in organizations.
A: The student response should capture the highlights of the MBO discussion in the chapter, especially regarding the mutual involvement of superior and subordinate in goal setting and later review of progress.
- 3-7. Q:** For what types of employees or positions do you think management by objectives (MBO) should prove particularly effective? Ineffective?
A: MBO can be effective when applied to a manager at any level or a professional having sufficient discretion regarding the work done and resources needed to achieve objectives. Nonmanagers whose assignments are routine and allow of little discretion, autonomy, or chance for creativity are unlikely to benefit.
- 3-8. Q:** For a given product and company (such as automobiles from Ford) list a set of premises (assumptions) regarding such matters as the economy, competition, materials, labor, customer demand, and other factors that should govern planning over the next five years.
A: Each answer must be judged on its own merits.
- 3-9. Q:** What length of planning horizon would you recommend for planning (a) the forest resources of a large paper company; (b) construction of a new automobile plant; (c) creation of a new housing development of 15 homes?
A: (a) Fast-growing pines for paper products still take 20 to 25 years to mature, which defines the planning horizon for forest investment.
(b) Allowing a year or more for site selection and plant design and several for construction gives perhaps four years to get an auto plant into operation, but one might want some confidence of profitable operation for a decade beyond that to justify the plant. (c) In the suburbs of a fast growing city a small development might be

