



Knowledge-Management Systems and Technologies

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Introduction

“Knowledge management is the systematic management of an organization's knowledge assets for the purpose of creating value and meeting tactical & strategic requirements; it consists of the initiatives, processes, strategies. Knowledge management (KM) therefore implies a strong tie to organizational goals and strategy, and it involves the management of knowledge that is useful for some purpose and which creates value for the organization.

Where and in what forms knowledge exists; what the organization needs to know; how to promote a culture conducive to learning, sharing, and knowledge creation; how to make the right knowledge available to the right people at the right time; how to best generate or acquire new relevant knowledge; how to manage all of these factors so as to enhance performance in light of the organization's strategic goals and short term opportunities and threats.

Knowledge management (KM) is the process of creating, sharing, using and managing the knowledge and information of an organization. It refers to a multi-disciplinary approach to achieving organizational objectives by making the best use of knowledge. An established discipline since 1991, KM includes courses taught in the fields of business administration, information systems, management, library, and information sciences. Other fields may contribute to KM research, including information and media, computer science, public health, and public policy.[5] Several universities offer dedicated Master of Science degrees in knowledge management.

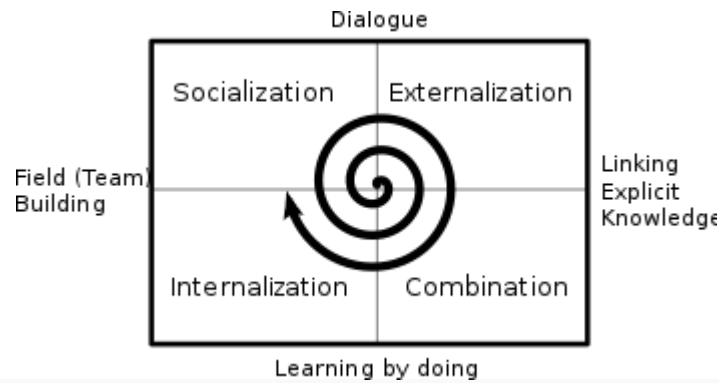
In 1999, the term personal knowledge management was introduced; it refers to the management of knowledge at the individual level. In the enterprise, early collections of case studies recognized the importance of knowledge management dimensions of strategy, process, and measurement.[12][13] Key lessons learned include people and the cultural norms which influence their behaviors are the most critical resources for successful knowledge creation, dissemination, and application; cognitive, social, and organizational learning processes are essential to the success of a knowledge management strategy; and measurement, benchmarking, and incentives are essential to accelerate the learning process and to drive cultural change.[13] In short, knowledge management programs can yield impressive benefits to individuals and organizations if they are purposeful, concrete, and action-orientated.

- [community of practice](#)
- [social network analysis](#)
- intellectual capital^[28]
- [information theory](#)
- [complexity science](#)
- constructivism

The practical relevance of academic research in KM has been questioned with [action research](#) suggested as having more relevance and the need to translate the findings presented in academic journals to a practice.

Dimensions

Different [frameworks](#) for distinguishing between different 'types of' knowledge exist. One proposed framework for categorizing the [dimensions](#) of knowledge distinguishes [tacit knowledge](#) and knowledge. Tacit knowledge represents internalized knowledge that an individual may not be consciously aware of, such as to accomplish particular tasks. At the opposite end of the spectrum, explicit knowledge represents knowledge that the individual holds consciously in mental focus, in a form that can easily be communicated to others.



The Knowledge Spiral as described by Nonaka & Takeuchi.

Subsequent research suggested that a distinction between tacit knowledge and explicit knowledge represented an oversimplification and that the notion of explicit knowledge is self-contradictory.[11] Specifically, for knowledge to be made explicit, it must be translated into information (i.e., symbols outside of our heads).[11][38] More recently, together with Georg von Krogh and Sven Voelpel, Nonaka returned to his earlier work in an attempt to move the debate about knowledge conversion forward.[4][39]

A second proposed framework for categorizing knowledge dimensions distinguishes embedded knowledge of a system outside of a human individual (e.g., an information system may have knowledge embedded into its design) from embodied knowledge representing a learned capability of a human body's nervous and endocrine systems.[40]

A third proposed framework distinguishes between the exploratory creation of "new knowledge" (i.e., innovation) vs. the transfer or exploitation of "established knowledge" within a group, organisation, or community.[36][41] Collaborative environments such as communities of practice or the use of social computing tools can be used for both knowledge creation and transfer.[41]

Strategies

Knowledge may be accessed at three stages: before, during, or after KM-related activities.[28] Organisations have tried knowledge capture incentives, including making content submission mandatory and incorporating rewards into performance measurement plans.[42] Considerable controversy exists over whether such incentives work and no consensus has emerged.[7]

One strategy to KM involves actively managing knowledge (push strategy).[7][43] In such an instance, individuals strive to explicitly encode their knowledge into a shared knowledge repository, such as a database, as well as retrieving knowledge they need that other individuals have provided (codification).[43]

Another strategy involves individuals making knowledge requests of experts associated with a particular subject on an ad hoc basis (pull strategy).[7][43] In such an instance, expert individual(s) provide insights to requestor (personalization).[29]

Hansen et al. defined the two strategies.[44] Codification focuses on collecting and storing codified knowledge in electronic databases to make it accessible.[45] Codification can therefore refer to both tacit and explicit knowledge.[46] In contrast, personalization encourages individuals to share their knowledge directly.[45] Information technology plays a less important role, as it is only facilitates communication and knowledge sharing.

Other knowledge management strategies and instruments for companies include:[7][23][29]

- Knowledge Sharing (fostering a culture that encourages the sharing of information, based on the concept that knowledge is not irrevocable and should be shared and updated to remain relevant)
- Storytelling (as a means of transferring tacit knowledge)
- Cross-project learning
- After action reviews
- Knowledge mapping (a map of knowledge repositories within a company accessible by all)
- Communities of practice
- Expert directories (to enable knowledge seeker to reach to the experts)
- Expert Systems (knowledge seeker responds to one or more specific questions to reach knowledge in a repository)
- Best practice transfer
- Knowledge fairs
- Competence management (systematic evaluation and planning of competences of individual organisation members)
- Proximity & architecture (the physical situation of employees can be either conducive or obstructive to knowledge sharing)
- Master-apprentice relationship
- Collaborative software technologies (wikis, shared bookmarking, blogs, social software, etc.)
- Knowledge repositories (databases, bookmarking engines, etc.)
- Measuring and reporting intellectual capital (a way of making explicit knowledge for companies)

- Knowledge brokers (some organisational members take on responsibility for a specific "field" and act as first reference on whom to talk about a specific subject)
- Inter-project knowledge transfer

Motivations

Multiple motivations lead organisations to undertake KM. Typical considerations include:

- Making available increased knowledge content in the development and provision of products and services
- Achieving shorter new product development cycles
- Facilitating and managing innovation and organisational learning
- Leveraging the expertise of people across the organisation
- Increasing network connectivity between internal and external individuals
- Managing business environments and allowing employees to obtain relevant insights and ideas appropriate to their work
- Solving intractable or wicked problems
- Managing intellectual capital and intellectual assets in the workforce (such as the expertise and know-how possessed by key individuals or stored in repositories)

KM technologies

Knowledge management (KM) technology can be categorized:

- Groupware—Technologies that facilitate collaboration and sharing of organizational information. One of the earliest successful products in this category was Lotus Notes. Notes provided tools for threaded discussions, sharing of documents, organization wide uniform email, etc.
- Workflow—Workflow tools allow the representation of processes associated with the creation, use, and maintenance of organizational knowledge. For example, the process to create and utilize forms and documents.
- Content/Document Management—Systems that automate the process of creating web content and/or documents. Roles such as editors, graphic designers, writers, and producers can be explicitly modeled along with the tasks in the process and validation criteria. Commercial vendors started either to support documents (e.g., Documentum) or to support web content (e.g., Interwoven) but as the Internet grew these functions merged and vendors now perform both functions.
- Enterprise Portals—Web sites that aggregate information across the entire organization or for groups such as project teams.
- eLearning—Enables organizations to create customized training and education software. This can include lesson plans, monitoring progress and online classes.
- Scheduling and planning—Automate schedule creation and maintenance, e.g., Microsoft Outlook. The planning aspect can integrate with project management tools such as Microsoft Project.[21]
- Telepresence—Enables individuals to have virtual "face-to-face" meetings without assembling at one location. Videoconferencing is the most obvious example.

This research work has been undertaken to explore the QWL status in organizations functioning in the state of West Bengal. The respondents of the questionnaire survey expressed their opinions on each variable affecting their work life. The data collected has been analyzed by SPSS-software and various hypotheses have been tested for drawing conclusions. The analyzing the data , non-parametric tests such as Chi-square test and KS –test have been applied. Extensive literature review has been conducted by the author to explore facts and figures in various literature on the subject-matter.

List of variables:

Sharing Knowledge through interpersonal communications(1-2-3-4-5):
Document Libraries(1-2-3-4-5):
Knowledge Portal(1-2-3-4-5):
Collaborative Physical Workspaces(1-2-3-4-5):
Web-based training inputs(1-2-3-4-5):
How satisfied are you with the Organizational Training facilities and quality of training in your organization ?
Rate your organization as a Learning Organization(LO) to withstand business competition

H07: In the context of Organizational Learning Environment or Knowledge Management Environment(KME) industries in and around Kolkata(West Bengal) , Present level of usage of e-learning tools for enhanced learning among Engineering professionals working in is quite poor

H08: : In the context of Organizational Learning Environment or Knowledge Management Environment(KME) industries in and around Kolkata(West Bengal), Sharing Knowledge through interpersonal communications is quite poor

H09: In the context of Organizational Learning Environment or Knowledge Management Environment(KME) industries in and around Kolkata(West Bengal), usage of Document Libraries is quite poor

H10: In the context of Organizational Learning Environment or Knowledge Management Environment(KME) industries in and around Kolkata(West Bengal), usage of Knowledge Portal is quite poor

H11: In the context of Organizational Learning Environment or Knowledge Management Environment(KME) industries in and around Kolkata(West Bengal), Collaborative Physical Workspaces are almost absent

H012: In the context of Organizational Learning Environment or Knowledge Management Environment(KME) industries in and around Kolkata(West Bengal), Web-based training inputs are rarely used

H013: In the context of Organizational Learning Environment or Knowledge Management Environment(KME) industries in and around Kolkata(West Bengal), Organizational Training facilities and quality of training in your organization is not satisfactory

H014: In the context of Organizational Learning Environment or Knowledge Management Environment(KME) industries in and around Kolkata(West Bengal), organization can not be called Learning Organization(LO) that could withstand business competition

Management is a term that is used to describe a particular kind of behavior *within* an organization. Specifically, the term describes the behavior of those responsible for the decisions that determine the allocation of the physical and human resources within an organization. It is increasingly recognized that the management function is built upon the social sciences and provides them with interesting problems. Management bears the same relationship to the social sciences that medicine does to such fields as chemistry, physiology, and anatomy.

The central core of the management function, which has made this area of great interest to social scientists, is decision-making behavior. Since this behavior governs the allocation of the resources of a firm, economists in particular have been attracted to the study of management. There is an obvious relationship between the theory of the firm and the field of management. In the theory of the firm under perfect competition, the economist has abstracted significantly from the problems of management and has substituted a simple decision rule for determining price and output. In markets that deviate from the perfectly competitive, the internal structure of the firm and the role of the manager as a decision maker become important. Market forces may no longer dominate the decision but may become only one set of variables in a process that must involve a number of other variables (Cyert & March 1963).

Recognition of the importance of management to the theory of the firm has led to an increase in field studies concentrating on decision making. Concurrently, there has been an increase in interest on the part of social scientists in particular decisions within certain areas of management (Simon 1960). Economists, for example, have become interested in the financial decisions of the firm, and psychologists have become interested in certain marketing decisions. This interaction has been extremely fruitful for the field of management. **General management.** Traditionally, social scientists have viewed the managerial function in simplified terms. Economics has generally posited a single owner whose function it is to make decisions on price and output by using highly rigid decision rules. If one examines the general management function, however, one discovers a much wider and richer range of behavior. To understand this behavior it is necessary to examine briefly the nature of the business firm.

The business firm in the American economy does not have the autocratic organizational structure attributed to it in popular writing. The management cannot exercise disciplinary power over the members of the organization in the manner of a military organization. Rather, the general management of the business firm should be viewed as a coalition of members, each of whom brings to the coalition a set of preferences that represent his model for the firm's behavior. In the process of making decisions for the firm as a whole, coalition members will have their preferences modified, ignored, or incorporated as goals (constraints) for the decisions the coalition makes.

Membership in the coalition is an operational definition of general management. In most large organizations this membership would include the president of the firm and the vice-presidents. However, in very large organizations this membership might include only a subset of vice-presidents, and in smaller organizations others, such as plant managers, might be included.

The general functions of the coalition, or general management, fall into the two broad categories of decision making and decision implementation.

Decision making. The decision making of the coalition will be concentrated in areas involving the allocation of the resources of the firm to broad categories of activities. These decisions may involve changing or modifying an old activity; for example, investing in new equipment for an established plant. The decision may involve the elimination of an old activity; for example, the elimination of a particular product line because it does not meet the profitability constraints determined by the coalition. Finally, the decision may involve allocating resources to a new activity; for example, acquiring another firm through purchase or merger.

In all these classes of decisions it is clear that the firm's goals must be defined by the coalition. A business firm does not have a stated list of goals that governs all decisions; rather, the process of decision making includes the process of determining goals. A continuous bargaining-learning process takes place among the members of the coalition. The goals of the organization are not a weighted function of the individual members' preferences. In general, the coalition continues to exist by utilizing some preferences of members as goals (constraints) and by making policy side-payments to others. The preferences that are used as goals define the criteria which a proposed solution or alternative must meet. The determination of the goals of the organization for a particular decision is also a function of the alternatives discovered by the search activity of the organization.

The preferences of coalition members may be in direct conflict and, therefore, some preferences of some members will have to be ignored. In such cases, the firm may make side-payments to keep those members within the coalition. Side-payments may take many forms. For example, at the next budget period the individual whose preferences have been ignored may get a relatively large increase in his department's budget. The side-payment might take the form of an expansion in the size of his department to give him more power, or he might be put on additional committees and given more voice in the management. In short, he will usually be given inducements to remain within the coalition in compensation for having his preferences excluded in the decision.

Decision implementation. Implementation is the procedure by which general management accomplishes its goals. The procedure can be viewed as a process of programming the firm (in the sense of computer programming). These programs are known as standard operating procedures and can be classified into four major types.

(a) *Task performance rules.* To keep a firm operating smoothly, over time and with changing personnel, it is necessary to specify the methods for accomplishing the tasks assigned to individuals and subgroups within the organization. When the task is a recurring one, the task performance rules represent the results of past learning. The rules represent the firm's attempt to educate new employees in the firm's methods.

(b) *Records and reports.* A firm's records and reports are its written history. Current records and reports contain most of the quantitative data that are the basis for making decisions and for controlling the behavior of individuals and subgroups within the organization.

(c) *Information-handling rules.* These rules define the formal communication system within the firm. They cover three kinds of information: (1) Information about the environment relevant to the firm. (2) Information about the firm for internal use. (3) Information about the firm for external use. The information-handling rules specify the distribution pattern of the information as well as the security measures on information leaving the firm.

(d) *Plans and planning rules.* We do not include within this category strategic, long-run planning for the firm. We include activities, such as budgeting, which involve repetitive planning that lends stability to the organization's activities. Such planning results in schedules for behavior over a period of time and puts constraints on acceptable alternative behaviors. General management tends to continue existing decisions on resource allocation from year to year, except in cases where achievement is unsatisfactory.

We have defined management in broad terms, but it is necessary to look more closely at some of the substantive areas of management to gain a better understanding of the field. A convenient way of analyzing management is by functional fields. Although there is no hard and fast classification system, we shall examine finance, marketing, and production. These three describe important segments of the management function and will serve to illustrate the interrelations of the management field with the social sciences.

Finance. In general, the field of finance is concerned with the problems and decision-making processes involved in the allocation among competing uses of the scarce financial resources of the firm. This concept of the field is in contrast to the approach which dominated the finance field until the last ten to fifteen years (Solomon 1963) and which emphasized description of the institutional aspects of financial markets and the various financial instruments available to a corporation. The problem focus was almost entirely one of determining the kinds of securities that might be used in particular financing situations.

The modern approach, on the other hand, investigates such questions as the following: (1) What are the financial constraints that determine the rate of growth and the ultimate size of the firm? (2) What is the optimum portfolio of assets and liabilities for the firm? (3) What considerations are involved in obtaining external funds and what is the optimum method of obtaining them? Such problems are characterized by a concern for choosing among alternative uses and sources of funds.

The distinguishing feature of the finance problem is the emphasis on maximizing the return to invested funds. From the finance point of view, the importance for production or marketing of an investment is not taken into account. It is up to other members of the firm to show that an investment should be made when the return does not meet the financial standards.

Cash management. While the problems described above are, in one sense, the crux of financial decision making, the short-run problems of cash management are also significant. Cash management involves forecasting the amount of cash that will be available for expenditures at particular points in time. This kind of forecasting is closely related to accounting and is one of the ties between finance and accounting. The first step in planning cash receipts is to forecast cash sales and the expected collections from credit sales. In addition, one has to look at other sources of cash, such as interest and dividends, sales of assets, and tax refunds. In a similar fashion it is necessary to set out anticipated expenditures for such things as raw materials, labor, travel, and miscellaneous supplies. Expected receipts and disbursements are then matched, usually on a monthly basis for six months or a year in advance, so that the firm knows its planned cash balance for each month.

Working-capital management. A similar planning problem exists in the management of working capital. The expected amount of working capital at various points in time must be projected. Working capital is defined as the difference between current assets, which include cash, marketable securities, accounts receivable, and inventories, and current liabilities, which include accounts payable, notes payable, and other debts that must be paid in a short period of time.

Managing shortterm credit is another important aspect of working-capital management, as is the planning of inventories. In recent years, much work has been done on the problem of determining an optimal inventory level (Holt et al. 1960). This involves an analysis of the costs of holding inventory, which include insurance, taxes, interest, and warehousing costs. Against these must be weighed the cost of lost sales which come about when a customer wants an item that is not in stock.

Cost of capital. Another major concern of finance is the evaluation of investment alternatives. The general approach used in choosing among alternatives is to determine the present worth of each alternative (Solomon 1963). To find the present value of the investment in question, its net earnings for each year are computed and discounted to the present according to the following formula:

Here K is the discount rate, E_i the net earning in year i , and PW is the present worth. The discounted value for any year, $E_i/(1+K)^i$ is the amount that has to be invested now at rate K in order to equal E_i in year i . For example, where i 's equal to 1, let K equal .25 and E_i equal one dollar. Then $PW = \$1.00/1.25 = \$.80$.

There are obvious problems in this analysis, when uncertainty is taken into account, because both E and K must be estimated. The more difficult concept is K ; it is currently the source of controversy. The prevailing view is that the proper K to be used in a calculation such as the one above is the rate which measures the cost to the firm of obtaining new capital.

But the cost of capital is difficult to measure because capital is raised in a wide variety of ways, ranging from bank borrowing to issuing stock. It is, therefore, difficult to determine a precise cost. This difficulty is compounded because one is interested in the cost of raising additional capital; in an uncertain world it is difficult to forecast this cost for some unknown time in the future when a firm may want to raise capital. Much work in finance is concerned with determining the cost of particular kinds of capital, such as equity capital, debt, and retained earnings.

One of the cost-of-capital controversies concerns the use of borrowed capital, which is said to give "leverage" to the owners of the firm. Modigliani and

Miller (1958) have contended that under the assumptions of certainty, perfect markets, and maximizing behavior on the part of investors, the amount of leverage bears no significant relationship to the market value of a company. This would mean that the financial structure does not need to be examined in order to determine the cost of capital. The argument about this position has not been settled, and it has reached something of an impasse because of the difficulties of doing empirical work to test the hypothesis precisely.

The total plan. Finally, there is the problem of integrating financial planning with the over-all objectives of the firm. This involves the integration of plans from all parts of the firm and bears specifically on decisions involving the outflow of cash, the desired level of liquidity, and additional financing. It requires a more elaborate analysis than is used to deal with the cash account alone. Sophisticated mathematical techniques are being applied to this problem, and new developments in capital budgeting give promise of producing a relevant analytical framework (Weingartner 1963; Beranek 1963).

Marketing . Marketing is concerned with all of the variables affecting the sale of the product to the customer, whether the customer is a household or a firm. This range of concerns is broken up into the following broad categories:

- (1) Understanding consumer behavior.
- (2) Responsibility for variations in product quality and design.
- (3) Price determination.
- (4) Selection of distribution channels.
- (5) Choice of advertising media and the level of advertising.

Consumer behavior. In economics, one way of summarizing consumer behavior is through the use of a demand curve, which relates the amount of a product a consumer will buy to its price [*see Demand and supply*]. The curve is based on the assumption that income, the prices of related products, and consumer tastes are all fixed. To make sound marketing decisions, however, it is necessary to investigate the process by which consumers decide what to buy.

Work on this problem has taken essentially two paths. The first attempts to observe and survey consumers and to discover their goals. It relies heavily on sociological and psychological theory. The type and source of the buyer's information have been investigated in the context of the whole communication problem. For example, Katona and Mueller found that 50 per cent of the consumers in their sample received information about durable products from friends (Mueller 1954, p. 45). This line of research is attractive and shows promise. The major difficulty to date lies in the integration of the results into broader decision models; that is, in transforming explanatory propositions into normative operational propositions on which a firm can act.

Another approach in the analysis of consumer brand choice utilizes the concept of consumer learning (Kuehn 1962, pp. 390–392).

Product decision. Decisions must be made about the addition of a new product or the elimination of an old one. Also existing products may be modified. Increasing expenditures for research and development have made decisions about products more important. One line of attack attempts to determine the characteristics that buyers are seeking in new products and the way in which buyer decisions about new products are made. Unfortunately, there are few studies in this area, and they are not directly applicable to marketing problems. Most of them are diffusion studies on the use of innovations, done by sociologists and anthropologists. Marketing students are seeking help from these studies in the development of the proper strategy for introducing new products.

There are a number of other interesting problems in this area, of which we will mention two. The first involves testing the marketability of new products before they are added to the company's product line. Here two basic approaches have been used. One attempts through questionnaire and interview data to determine consumer reaction to the new product through comparisons with other products on the market. The difficulties with this approach stem from the problem of eliciting accurate answers from the consumer. The consumer is asked in an artificial setting to describe his potential behavior in a real situation. The measurement of the reliability of response in such situations is a fruitful area of research for psychologists. The other approach primarily utilizes statistical analysis. The product is test marketed and predictions of the success of the product are made from the analysis of such phenomena as repeat purchases. The market areas are usually picked with the aid of sampling theory.

The second problem is that of deciding the amount of funds that should be invested in research for new product development. This problem is clearly not the sole concern of the marketing group; however, marketing considerations must play an important role in the solution. Currently, this decision is made by some rule of thumb, such as allocating a fixed percentage of sales to research and development. To improve such decisions, more knowledge is needed about the desired frequency of new product introduction. Answers to this will probably be obtained through an application of behavioral science and mathematical techniques.

Pricing. One of the most important problems for the marketing manager is to determine the price to charge for a product or the items in a product line (a set of related products, each differing from the other primarily in quality—for example, men's suits in a department store). There are no firm rules that will guarantee proper pricing. The best that can be done, given the current state of knowledge, is to indicate some variables that should be examined and to review some current practices.

Some of these variables are considered in economic analysis. It is clear, for example, that the prices of competitive products must be taken into account and that potential competitors exert a downward pressure on price. The latter force is more important in markets where there are only a few sellers and where new competitors may enter freely. The characteristics of the demand must be investigated, particularly its price elasticity (the percentage change in quantity demanded divided by the percentage change in price). If price is lowered by a given percentage, will quantity demanded increase relatively more or less than price? [*See Elasticity.*] If quantity increases relatively more, it may be profitable to lower the price. In this case, of course, cost

considerations become important.

Since the marketing manager must come to a decision, he uses some practical techniques that give him specific, but imperfect, information. Experimental methods have been used in which different prices are set in a number of similar markets to determine the influence of prices on sales. Interviewing has been used for the same purpose as has the analysis of sales data in situations where prices have been changed. All of these techniques give useful but not decisive information.

Distribution channels. Producers must determine the route by which their product reaches the consumer. A variety of ways are possible, of which the simplest is that in which the consumer buys directly from the manufacturer at his plant. The most complicated distribution channel might include four different middlemen—sales agent, wholesaler, jobber, and retailer. The marketing manager generally decides upon the best channel for the product on the basis of a qualitative analysis that examines the characteristics of the product and of the various possible channels. He considers such factors as the need for demonstration of the product, the amount of repair and maintenance, and the number and variety of the items that must be shown to the customer. In other words, he must decide how to make the product easily accessible to the customer under conditions in which the selling effort can be effective.]

Promotion. Promotion generally covers the entire selling effort, and promotion expenses include all expenditures specifically aimed at increasing sales. Promotion problems can be summarized by the following set of questions:

- (1) What is the optimum level of funds to allocate to promotion?
- (2) How much should be allocated to advertising and how much to other forms of promotion?
- (3) How should advertising expenditures be allocated among various media?

In addition, there are problems in measuring the effectiveness of advertising and other promotional devices. As yet, no completely satisfactory techniques have been developed for solving these problems.

In this whole area, however, the use of mathematical and statistical techniques is increasing rapidly. Until about 1950 there was no indication that advertising problems were amenable to quantitative analysis. Currently, many attempts at such analysis are being made, and the outlook for improving management decisions is hopeful.

Production. Production is concerned with the operations by which inputs of men and materials are converted into goods and services through the use of machines and other fixed equipment. Recent definitions of production include all of the physical operations of the firm. In addition, a systems concept is developing which relates previously disparate parts of the firm. Thus, a production or operations system would include the following range of problems (Buffa 1963, pp. 26–28):

- (1) Forecasting sales.
- (2) Converting these forecasts into plans for a relatively stable production rate, inventory level, and work force.
- (3) Specific plans for the mix of items in the inventory and development of a control system to insure against “running out” of items.
- (4) Detailed scheduling of transportation facilities, machines, and men.
- (5) Development of control systems to insure the quality of the product and the viability of the whole production process.

Within this framework a number of decisions have to be made:

- (1) The product must be designed and production costs must be estimated as they may in turn affect the design.
- (2) The processes to be used must be determined and equipment selected. Decisions to replace equipment must also be made.
- (3) The layout of the production facility must be designed. Capacities must be determined and the flows of materials and men within the system organized.
- (4) Provision must be made for maintenance of the system.

These problems and decisions constitute only a brief overview of the production problem. In economic theory it is assumed that surviving firms in the long run use the optimum production function and operate at the lowest average cost curve possible for the given plant. It is the broad goal of production management to achieve this state; it studies the techniques and develops the methods for attaining the position that is assumed in economic theory.

Production, like other functional areas of management, relies heavily on still other disciplines. Production management since about 1946 has in particular utilized psychology, mathematics, statistics, and computer technology.

Psychology is used in problems of machine design, job design, and general work environment. Much work has been done by psychologists in designing and positioning the dials and meters used by workers. The object is to design the information and control panels so as to minimize errors and the time required to do the job. Work schedules have been examined and redesigned to minimize fatigue. The effect on productivity of noise, temperature, and lighting in the work environment has also been investigated.

Use of linear programming. Perhaps the most important impact on the production area has come as a result of the application of a particular mathematical technique, linear programming. By means of linear programming a linear function subject to certain inequality restrictions can be minimized or maximized. A number of problems can thus be solved mathematically that in the past were handled on a judgmental basis:

(1) *Mix problems.* Frequently, in making a product such as gasoline, alternative inputs can be used to meet specific product requirements. With linear programming the minimum cost combination can be found.

(2) *Production scheduling.* Production can be scheduled over time to minimize storage costs and to obtain a relatively stable work force.

(3) *Shipping problems.* Frequently products must be shipped from several locations (warehouses) to other points (customers). Linear programming can help to achieve minimum transportation costs.

In the inventory problem, classical mathematical and statistical methods have been used. The general approach is to start with a probability distribution for sales in a given period. Taking into account such variables as sales, losses incurred if the producer is out of inventory, losses on items left in inventory, interest, and warehousing costs, a solution for the desired inventory level can be determined. Significant work has been done in this area, especially the development of the linear decision rule.

Use of computers. Computers are becoming increasingly important in production in two primary uses. The first is in simulating a process in order to determine a policy. For example, job-shop simulators are used to determine the results of various scheduling rules. In a job shop, where each job has different characteristics and goes through different operations, there is no "best" rule for scheduling the various jobs when there is competition for the facilities. One approach is to program the computer to simulate the shop and then, using different scheduling rules, schedule a series of jobs that is similar to an actual series. The simulation can help to evaluate the results of following any of the rules or some set of them. An analogous procedure has been followed for determining the optimal maintenance force.

Computers have also been used as decisionmaking devices. Programs have been written for assembly-line balancing (designing successive operations so as to minimize waiting time) as well as warehouse location problems (Tonge 1961; Kuehn & Hamburger 1963). These applications fall in the category of heuristic programming and have been used for problems in which a mathematical optimum cannot be found. The programs utilize decision rules suggested by an analysis of previous human attempts to solve the problem. By a systematic use of the rules and greater processing ability the computer is able to improve on the unaided human solution.

Education for management. We have described briefly three areas in which much of the work of management is done. Other areas such as personnel and accounting (particularly controllership) could have been mentioned. The trend in education for management, however, has been to reduce the emphasis on specialized training and to stress training for general management.

Courses valuable for business management fall into two categories: the disciplines on which management is based and management courses as such. In the first category we include psychology, economics, mathematics, and statistics.

Psychology is important in human relations and in organization theory. The student of human relations is given an adequate background in psychology, especially individual psychology. He is then taught to use this background in understanding human behavior. The aim is to establish the attitude that problems of human relations should be approached scientifically.

Organization theory also builds on psychology. It seeks to give the student an understanding of human behavior in the context of organizations as well as a better understanding of the administrative process. In particular, the student learns the importance of organizational structure in the implementation of decisions and in the changing and designing of organizations.

Economics courses are oriented toward giving the future manager an understanding of the economic environment in which he will operate. He needs to become familiar with the operation of the economy as a whole—with the determinants of the level of gross national product, employment, and the price level and with the relation of these aggregates to actions of the government and the banking system. He must also study economics to understand the role of the firm in the functioning of the economy.

In mathematics the student should, at a minimum, know elementary calculus and matrix algebra. More importantly, he must be able to relate the mathematics to management problems. He need not be able to develop new theorems or invent new mathematics. An analogous statement can be made for statistics. It is important that future managers have a working knowledge of both disciplines, as well as the ability to know when to call in an expert and how to use him.

The student of management must understand the role of the computer in management decision making and in the development of information systems within the firm. This knowledge should be developed through course work in which some programming language is taught and where the computer is used by the student.

The three functional areas of business management described above must also be covered. In addition to required work in each, there should be an opportunity for the student to go somewhat deeper into at least one of the areas. It is important, however, that this depth be limited, since the student is training for general management and not a specialty. Accounting must be covered, with an emphasis on the managerial uses of accounting—the use of accounting data for decision making and control.

There is also need for a course in the techniques of management science, the most important of which is linear programming. This course should build directly on the mathematics course, and the techniques learned should be used in the functional courses.

We have tried to sketch briefly the basic ingredients of an education oriented toward general management. We have not tried to describe a curriculum in detail but rather to mention some of the principal courses that any curriculum should cover. In general, there are three guiding principles for the construction of a curriculum in management. The first is that the disciplines underlying the practice of management must be present. Courses in the social sciences and mathematics and statistics give the student the basic knowledge and techniques he will need. The second principle is that the emphasis should be on breadth rather than on specialization. The specialization can generally be learned as necessary on the job, but breadth is acquired more efficiently in the classroom. The third principle is that the management curriculum must anticipate changes in management practices and not reflect only past management practices (Cyert & Dill 1964, p. 223). The faculty should know current management practices as well as have the objectivity to stand off and speculate on new techniques. The student, after all, will not ordinarily reach a top management position until fifteen or twenty years after his graduation (Bach 1958, p. 351).

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