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CONTINUING ENGINEERING STUDIES: AN EVALUATION OF THE MODERN ENGINEERING COURSE FOR ENGINEERING MANAGERS

by
Chris Allen Common

A dissertation submitted in partial fulfillment
of the requirements for the degree of
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INTRODUCTION

An important aspect of American higher education has been the emergence of the activity known as continuing education. Rapid changes in all sectors of our society have necessitated revisions in the curricula of most universities, colleges, and community colleges. The vast amount of new knowledge contained in the new curricula has created a problem for the graduate of ten years or even less. How does a professional keep up-to-date with the latest developments in a given field? The answer to the question apparently exists in the area of continuing education. The professional must accept education as a lifetime activity if he is to remain current in his field.

Background

During the late 1950's and throughout the 1960's, the term "obsolescence" crept into literature pertaining to the engineering profession. Concerned persons in education, industry, and government were reacting to the great advances made in science and technology since the end of World War II. The exponential growth in knowledge and the significant changes in engineering education had created a gap between the latest technology and current practices in the engineering profession. One educator commented:

> The gap between the technical frontier and contemporary industrial practice is often dangerously large. Many industrialists complain that our country cannot adopt new techniques as rapidly as it should to maintain its position in the international market place. (Brown, G. S., 1963, p. 456)

In order to bridge the gap and provide an adequate supply of personnel capable of applying the latest technology to current problems, the President's Advisory Panel on Scientific and Technical Manpower recommended that programs be established to increase the number of Ph.D. and M.S. degrees awarded in engineering, mathematics, and physics. The committee urged that the burden for meeting the challenge be shared by the Federal Government, state governments, foundations, individuals, and industry (Furnas, 1963, p. 115). A program designed to funnel more students into the graduate school is one way of meeting future manpower requirements but, in the meantime, what can be done for the practicing engineers?

The obvious answer to the question was to provide educational programs which would enable the practicing engineer to be updated and to be made aware of the latest developments in modern engineering. The need for action was apparent.

> Yet, in this national debate about the crisis in technological education, have we not overlooked something? If the knowledge and skill of selected, key, practicing engineers were updated and reoriented, these men could take care of much of the work. We hear from many quarters that technological obsolescence of our older scientists and engineers is at the base of the chronic shortage of high-quality personnel. As the pace of scientific advance continues, the position of engineers in this age group is likely to become progressively worse. It appears to me, therefore, that the quickest and perhaps best way to fill the gap, in both numbers and capability, in industry and education is to embark on a formal program of updating and reorienting the skills of the most promising men now in these two fields. (Brown, G. S., 1963, p. 456)

Hence, a multitude of continuing engineering study programs were initiated to reduce the gap between the practicing engineer's repertoire and the current "state-of-the-art." Educational institutions, industrial organizations, professional societies, and private educational firms developed programs with varying formats

to update engineers at different stages in their careers. The number of programs available to engineers in the U.S.A. increased greatly during the 1960's. One directory listed over 1000 programs being offered during the 1970 calendar year (Engineers Joint Council, 1969b).

In light of the great deal of activity in the area of Continuing Engineering Studies (CES), the Joint Advisory Committee on Continuing Engineering Studies was formed to study the CES area in relation to industry, academic institutions, engineering societies, and government. The committee proposed the following definition for CES:

> At the outset, the objective of "continuing engineering studies" was recognized as the specific enhancement of the competence of the individual as a practicing engineer, rather than the attainment of an additional academic degree. In turn, this objective required a process of enhancement so planned as to keep the individual abreast of both advances in the underlying basic sciences, and the evolving technical applications and methods of enhancement including courses, seminars, conferences, institutes, and related educational programs uniquely designed to provide the required diversity needed to match the wide range of backgrounds that the participating individuals might possess. (Joint Advisory Committee on Continuing Engineering Studies, 1965, p. 11)

It is evident that a particular course or program may be considered a part of CES if the activity meets the requirements of the individual in terms of the above definition. A college credit course may not be uniquely designed to match the backgrounds of all possible students, however, it would be difficult to exclude from CES. A full-time student taking such a course would simply view the course as credit toward a degree whereas a practicing engineer would see the same course as a definite part of his involvement in CES. Most of the activity in CES has been in the form of noncredit programs uniquely designed to serve engineers with diversified backgrounds. This report will consider CES as an individualized activity which permits the practicing engineer to enhance his competence as an engineer.

The Purpose of the Study

Although the literature is replete with descriptions of the many continuing engineering study programs, little information is revealed about the success of the various programs. Evaluations are performed at the end of a given program in relation to the educational experience (Madlon and Wong, 1967), however, no documentary evidence is available to describe the benefits derived from a program by the participant or the participant's employer. One of the two critical points, pertaining to the literature on CES, noted in a report prepared for the National Science Foundation was:

> . . .there are few systematic studies of any kind based on direct observations of the continuing education process -- neither by employers, who pay most of the bills, nor by the universities or professional societies, which sponsor many of the activities. (Social Research, Inc., 1969, p. 171)

The Joint Advisory Committee on Continuing Engineering Studies noted the need to evaluate programs on the basis of results.

> Where sponsors desire a measure of creditable participation in CES, this should be related to resultant performance in practice, or to demonstrated leadership of other engineers, and not related simply to the academic credit ladder. Thus the evaluation of the individual's entitlement to support would be more specifically that of the sponsor. (Joint Advisory Committee on Continuing Engineering Studies, 1965, p. 60)

Although many educators are apprehensive about evaluating "educational" programs, it would seem only logical to obtain some type of "results" feedback into the educational system. The evaluation procedure is difficult and the answers to pertinent questions may be elusive but programs can be improved only if the effective "results" output can be measured.

The purpose of the study is three-fold:

1. Review the pertinent literature to place the study in the proper perspective with peripheral factors related to the

engineering profession.

2. Conduct a questionnaire survey of the participants in a type of CES program specifically designed to update and enhance the competence of engineering managers and supervisors. The program included subject material related to the latest developments in modern engineering and hence was generally referred to as the Modern Engineering Course (MEC). The sample for the survey included the participants from five similar programs presented during the years 1965 and 1967. Four of the five programs were conducted by a college or university and one by an industrial organization. The questionnaire attempted to determine the benefits derived from the program by the participant and his employer.
3. Present the findings of the study and make recommendations based on the questionnaire survey and the literature review.

Significance of the Study

Since the literature is devoid of material pertaining to the evaluation of CES programs, this study will provide persons interested in continuing education with documentary evidence related to the success of a particular program. Although the results will be based on one special type of program, the findings should be applicable to other CES programs now in existence.

The review of relevant literature will provide a convenient reference for those persons interested in factors related to CES programs. Questions will be raised which may stimulate further research into the area of continuing education.

Organization of the Report

Chapter I reviews the literature in order to call attention to the many factors related to the problem of continuing education.

Chapter II presents the survey methodology and describes the five different Modern Engineering programs which make up the sample.

Chapter III presents the findings of the survey and compares them with previous work where applicable.

Chapter IV summarizes the study, draws conclusions from the findings, and presents recommendations.

The appendices contain the questionnaire, questionnaire cover letters, a letter mailed by one of the participating companies to their participants, descriptions of the programs included in the questionnaire survey, and write-in responses to the questionnaire.

The bibliography includes all the sources utilized in preparing the report.

CHAPTER I

REVIEW OF THE LITERATURE

In order to place the subject of continuing engineering studies (CES) in the proper perspective, it is advantageous to examine some of the contingent factors which influence this educational process. The questionnaire survey portion of this study presents the opinions of former participants to a selected educational program. The responses to the items on the questionnaire will not only reflect judgment of the program but will also include attitudes shaped by the participant's everyday environment.

This chapter will review many peripheral conditions which directly or indirectly influence the practicing engineer. An overview is necessary since the environment affects the continuing adult student just as it does the regular college student.

Every person passes through various developmental stages in his lifetime. These different phases all bring pressures to bear on the individual which influence his behavioral pattern. The maturing adult is faced with many obstacles necessitating varying degrees of personal adjustment.

Early Adulthood (Ages 18 to 30)

- Selecting a mate
- Learning to live with a marriage partner
- Starting a family
- Rearing children
- Managing a home

- Getting started in an occupation
- Taking on civic responsibility
- Finding a congenial social group

Middle Age (Ages 30 to 55)

- Achieving adult civic and social responsibility
- Establishing and maintaining an economic standard of living
- Assisting teen-age children to become responsible and happy adults
- Developing adult leisure-time activities
- Relating to one's spouse as a person
- Accepting and adjusting to the physiological changes of middle age
- Adjusting to aging parents

Later Maturity (Age 55 and over)

- Adjusting to decreasing physical strength and health
- Adjusting to retirement and reduced income
- Adjusting to the death of a spouse
- Establishing an explicit affiliation with one's age group
- Meeting social and civic obligations
- Establishing satisfactory physical living arrangements

(Havighurst, 1964, p. 2)

Therefore, it is necessary for the person planning or evaluating CES programs to be aware of the complexity of the total situation. The following sections describe many of the factors which influence the area of continuing engineering studies.

Economic Considerations

The importance of the development of human resources is accepted as one of the most critical parameters upon which a nation must concentrate if it is to enjoy continued economic growth. Harbison and Myers (1964, p. 2) discuss many of the elements of human resource development in their view of nation building and suggest that the formal educational system consisting of primary, secondary,

and higher education is the basis for any investment in future growth. Continuing education in the form of on-the-job training, adult education, employer-sponsored programs, or membership in various political, social, religious, and cultural groups is an important function of the developmental process. Reading, correspondence courses, and informal personal contacts must also be considered in the growth of human resources.

The measurement of human resources has been discussed over the years in relation to economic considerations. Adam Smith (1937, pp. 266-267) conceived that the acquisition and maintenance of useful abilities by the members of a society can be considered as fixed capital. The expenses involved in either process are indicative of the value of this fixed capital and the profits garnered through such capital expenditure benefit not only the individual but also the society to which he belongs.

Alfred Marshall (1925, p. 216) considered the expenditure of public and private funds on education to be an investment providing opportunity for the masses. The economic value of one new idea or invention is sufficient to defray the costs involved in the education of many people. The benefits of education are not always immediately apparent and many years may elapse before benefits begin to accrue to society. There are, therefore, short-range and long-range investment considerations to the educational process.

Theodore W. Schultz (1963, pp. x, 38) amplifies the proposals made by Smith, Marshall and others in attempting to relate education to economic indicators over the years. His proposition is that people improve their abilities as producers and consumers by investing in themselves and that schooling is the greatest investment in human capital. Three benefits can be assigned to education: (1) current consumption, (2) future consumption, and (3) future productive capa-

bility. The concept of human capital can be used to help explain the economic growth of a nation when associated with the other barometers such as structures, equipment, and inventories.

Burton A. Weisbrod (1962, p. 106) brings out the concept that society must and has begun to recognize that economic progress involves changes in men as well as in machines. Education can serve to provide the individual with options in terms of job choices or in relation to technological change, a hedging option.

> There is another respect in which education provides a person with options: the increased ability to adjust to changing job opportunities. With a rapid pace of technological change, adaptability (which may be a worthy outcome of additional education) becomes important. Education may be viewed as a type of private (and social) hedge against technological displacement of skills. New technology often requires new skills and knowledge; and those persons having more education are likely to be in a position to adjust more easily than those with less education, and to reap the returns from education which the new technology has made possible. (Weisbrod, 1962, p. 113)

In our capitalistic society, it becomes increasingly difficult to separate the economic aspects of education from the purely humanistic or cultural considerations. Continued national growth depends upon the development of successful business, political, and social organizations along with the attributes of natural resources, geographic location, and external political relationships. Human resource development is a sound starting point for any policy which would seek to cultivate sound nation building for without the physical and intellectual activities of human beings there can be no progress. Every society needs and must cultivate those individuals who are capable of leading the never ending challenge of change.

Joseph A. Schumpeter (1942, pp. 81-86) points out that capitalism is an evolutionary process which is based on economic change and cannot ever be stationary.

> The fundamental impulse that sets and keeps the capitalist engine in motion comes from the new consumers' goods, the new methods of production or transportation, the new markets, the new forms of industrial organization that capitalist enterprise creates. . . . This process of Creative Destruction is the essential fact about capitalism. It is what capitalism consists in and what every capitalist concern has got to live in. (Schumpeter, 1942, p. 83)

Schumpeter goes on to emphasize that any system which fully utilizes its potential at every point in time may in the long run be inferior to a system that never reaches that goal. The long-run higher performance level may be determined by the failure of the system to achieve maximum performance at a lower level since this could lead to complacency and stagnation at that level.

Since the United States of America is a capitalistic nation, it is evident that continued economic growth will depend upon change. It is imperative that two basic issues be resolved: (1) the creation of an adequate pool of high-level personnel capable of meeting the technical and managerial problems related to continued growth, and (2) the up-grading of underutilized manpower (Harbison and Myers, 1964, p. 15). The nation depends upon the maximum use of its available manpower to create the new products, organizations, and transportation necessary to insure continued development. Industry must insure that it is competitive by maintaining technological currency. William W. Seifert cites the possible reasons for the demise of an industry:

> If the percentage of individuals in an organization who are suffering from technical obsolescence becomes too large, the organization itself becomes obsolescent, and one observes that (1) its products continue unchanged over long periods of time, (2) its competition becomes increasingly effective in cutting into its markets, and (3) few new ideas develop. (Seifert, 1964, p. 144)

The best interests of a nation or a business are best served when either is able to rapidly adapt to technological change.

Gruber (1969, pp. 43-48) describes the failure of U. S. Steel firms to incorporate a major technical advance, the basic oxygen furnace (BOF). While U. S. Steel firms continued to use the open-hearth technique for the manufacture of steel, foreign steel producers switched to the more economical BOF process. It was not long before U. S. Steel firms were unable to compete in the world marketplace. The U. S. share of world steel production dropped from 39 percent in 1955 to 25 percent in 1962. In an attempt to catch up with foreign competition, the U. S. Steel industry was forced to spend ten billion dollars for BOF equipment during the period 1963-1967.

This example illustrates the economic pressures which demand industry to incorporate the latest technological breakthroughs. Popper sums up the situation:

> Any company that operates at the forefront of technical knowledge must ensure that its personnel are mentally equipped to take full advantage of that knowledge. The choice . . . is to breed this mentality, or buy it -- or disappear in 25 years. (Popper, 1967, p. 144)

The economic future of a nation or a business is inextricably meshed with the capabilities of their high-level manpower. Hence, manpower planning is a primary consideration in economic growth or survival.

Manpower Planning

Organizational efficiency depends upon effective manpower planning and utilization. John R. Hinrichs stresses this important concept:

> The most important asset of any industry or business organization as it marshals its resources to achieve a profit and to meet competition in the dynamic years ahead is "know-how" -- human talent. This is the key to the continued vitality and success of today's organization through the remainder of the 1960's and the turbulent 1970's and 1980's. (Hinrichs, 1966, p. 9)

The organization must rely on the ability of its personnel to create and innovate in order to be competitive in the everchanging marketplace.

However, an effective manpower planning system cannot be accomplished without a clearly stated set of organizational goals. Kenneth R. Andrews observes:

> It seems to me clearly impossible to develop the climate and process suitable to management development unless it is clear in what direction the company is moving, toward what goals, and with what in mind. Both personal development and corporate development should have discernable objectives, though each often does not in fact. The development of policy skills in general managers is unlikely if policy skills are not being exercised by the company's leadership. By this I mean . . . that the company's opportunity in its industry is constantly being examined in the light of indicators of what the future will bring. The company's distinctive competence, changing as the product of growth, is continually the object of conscious appraisal. The best match between distinctive competence and economic opportunity is being made or sought. In addition, the formulation of basic policy requires the identification of professional and personal aspirations which can or must be satisfied and the nature of the contribution to society which the firm will elect to make. Unless the strategy is conceived which balances these components in a way that seems valid to those whose efforts are essential to achieving it, the object of managerial activity will be hazy. It will be expressed in general terms like profitability and growth, which move no one. (Andrews, K. R., 1966, pp. 244-245)

After the organizational goals have been clearly established, it is then possible to determine the manpower capabilities necessary to fulfill those goals.

Although manpower planning is required in all sectors of the organization, this study is concerned with engineering personnel. Since rapid technological change is an accepted part of our present society, it is the engineers and scientists that will be called upon to solve the problems of the present and future (Shapero, 1969, pp. 24-28). Creative and innovative engineers will provide the business competition of the future, a competition of ideas (Schneider, 1960, p. 212). Forecasting the demand for engineers can be a difficult task but most studies show a potential shortage to exist in the long run (Hinrichs, 1966, pp. 31-35). This prediction applies in spite of engineering displacement and unemployment

situations created by periodic government cutbacks in the space and defense industries (Loomba, 1965 and Ingersoll, A. C., 1971). Since the supply of high-ability manpower is limited in any society by the laws of nature, it is a matter of self-preservation to create an arrangement by which every individual may contribute to the best of his ability (Weber, 1965, p. 206). A greater concern must be exhibited in the area of engineering personnel and managers must start thinking in terms of long-range organizational manpower budgeting. Improper manpower planning can result in inefficient operations and a reduction in the performance of individuals:

> Obsolescence of professional people is often a secondary effect evolving from the internal affairs of a company. Without an attempt to be all-inclusive, obsolescence could stem from the lack of overall manpower planning, failure to include educational planning into long-range corporate goals, inadequate utilization of engineering capabilities, insistence upon narrow specialization of technical responsibilities, etc. Evidence of some of these ills has appeared in the replacement difficulties of very capable engineering specialists who have been affected by shifts of government-supported defense work. (Joint Advisory Committee on Continuing Engineering Studies, 1965, p. 38)

Obsolescence of engineering personnel can lead to the decline of an organization in a competitive environment.

The progressive organization must continuously examine its engineering goals and compare them with the capabilities of the engineering personnel. Boulgarides and San Filippo (1967, pp. 4-5) consider the problem by establishing a capability profile for an engineering department and comparing this with the necessary profile based on the organization's requirements. Any gap that exists between the two profiles must then be filled. The deficiencies in the manpower profile can be remedied by hiring new personnel to replace inadequate individuals

or by retraining and up-grading present employes. D. B. Miller (1966, p. 33) notes that a company invests over $10,000 in each new engineer before he assumes productive capabilities. If one is to consider releasing such an engineer it would be well to evaluate what might be done with the $10,000 to improve his performance as opposed to cost of a replacement. The $10,000 figure does not include other financial items such as vested interests in retirement plans, severance pay, etc. Educational programs to help improve the employe capabilities are beginning to be accepted by management as a need such as a library or operating machinery. Julian C. Smith (1967b, p. 143) adds that continuing education has become another fringe benefit which must be offered to prospective employes if a company is to be able to compete effectively for new engineers. The organization can also choose to accept the inherent deficiencies in personnel and default on the organizational goals. This type of default reduces the ability of the organization to adequately compete on the open market. Increasing technical competence by updating qualified personnel can fill the technological gap and create a healthy employe-employer relationship. Older employes are experienced and know their way around the company (Bushnell, 1964, p. 1). A business cannot afford to lose an experienced employe since this loss is a blow to the person's self-esteem and eventually the nation as a whole can suffer through reduced technological capabilities (Raines and Missar, 1965, pp. 37-38; Singer, 1969). Thus, the manpower planning function eventually boils down to developing individuals within the organization:

> Thus, the needs of the organization for technical manpower are balanced against present and potential competence as determined through individual appraisals. This integration is often a difficult task, but, without this step, a plan to improve individual knowledge and skills may not be beneficial to the individual and to the organization. (Torpey, 1962, p. 49)

Every organization must establish a program which best suits its particular manpower problems.

The manpower planning function is the business organization's means for survival. In order to insure an up-to-date technical staff, it is necessary to develop educational programs capable of maintaining a competent, competitive work force. The manpower planning function precedes the educational function but both must be an integral part of the total system.

Educational Programs

There are three general steps in the development of an educational program: (1) planning, (2) execution, (3) evaluation. The effectiveness of a program is in a large part determined by the degree of planning which precedes the execution phase. A large number of CES programs have been established over the years which to a great extent have been born under pressure situations. In many cases the needs or objectives for a program have not been carefully defined (O'Neill, 1967, p. 15). The necessity for adequate planning is apparent to some:

> It is tragic that so little investment is put into educational planning because in order to do a proper job, it is necessary to launch a massive attack on real problems. Setting aside a meager sum will imply that researchers will be consigned to leafing through statistics of education in the vain hope of discovering some nuggets of information. In other words, when only a small amount of money is appropriated, it will necessarily be spent on fruitless tasks. So little is known about the process called education that it requires some very deep fundamental research necessitating large expenditures; to spend a fraction of that amount and to expect a corresponding fraction of the benefit is optimistic folly. (Alper, 1968, p. 96)

The industrial corporation depends upon engineering personnel that are up-to-date and capable of generating the creative ideas which insure economic success. The educational programs selected by management must meet the objectives determined by the organization's operations (Day, 1966, p. 8).

New concepts are necessary to meet the demands of continuing education. CES requirements fall into many areas, including:

1. Stretching the competence of professionals who remain abreast of developments, but who require greater insight.
2. Starting recent graduates on a lifetime program and bridging the gap between their preparation and their practice of engineering.
3. Updating professionals.
4. Upgrading individuals with marginal preparation.
5. Training, updating, upgrading, and advancing technicians and engineering support personnel.
6. Reinforcing the backgrounds of nontechnical industrial people who must be familiar with technology. (Katz, I., 1967, p. 561)

Planning for CES programs is extremely critical for the requirements depend upon each unique situation. No single program will meet the expectations of persons from different environments. Every organization must reevaluate its educational needs periodically by a careful study of the capabilities of each research man. A comparison of capabilities and expected capabilities will define the necessary educational objectives (Kriegel, 1963, p. 138; Boulgarides and San Filippo, 1967, p. 6).

Educational program planning can best be accomplished with the aid of a model which is adaptive in nature. A model which can accommodate the varying forms of continuing education. The effective program model cannot remain fixed:

> As we have seen, the model has to undergo a continuous change in time. It must be adjusted and modified with experience and equipped with additional properties to serve its users for specific purposes. (Ziebolz, 1969, p. 30)

The adaptive model must include a feedback mechanism which will permit the evaluation of a given program on a short-term and long-term basis. The model must include inputs from (1) the employer, (2) the employe, (3) the educational consultant.

The continuing educational needs of the engineer can best be accomplished when there is coordination between study and work assignment. Engineers are employed in various capacities and it has been noted that many CES programs are planned for engineers involved in research and advanced development areas. In many organizations less than one-quarter of the technical graduates work in these areas. The other three-quarters are engaged in the areas of manufacturing, marketing, application engineering, patents, finance, and project management (Church, 1968, p. 34). It is doubtful if any one program can satisfy the variety of needs required by such a diverse population of engineers.

Although organizations do much of their educational planning internally, there have been many examples of cooperation between industry and educational institutions (Mantle, 1968). Unfortunately problems do exist at the college-industry interface (Joint Advisory Committee on CES, 1965, p. 16). Many faculty members are prone to discount the value of the CES activity, even when seemingly equivalent courses are presented in the evenings (Knowles, A., 1967, p. 555). To counter this thinking, it has been proposed that academic and degree programs be designed so as to include the CES concept (Foecke, 1966, p. 883). The Goals Committee of the American Society for Engineering Education placed a great deal of emphasis on the CES philosophy:

> It is recommended that engineering schools recognize more fully the place of continuing studies as a distinct category in the spectrum of engineering education, and that wherever possible they provide increased leadership in the planning and offering of continuing studies as part of normal institutional activity. It is also recommended that engineering schools cooperate to a much greater extent with industry, government, and the engineering societies in such programs, in order to achieve maximum benefit for the student and optimum utilization of teaching resources.

> To impress upon the student that education must be a continuing process throughout his professional career. (Walker, 1968, pp. 377, 388)

The importance of the planning phase was emphasized when the Joint Advisory Committee on CES (1965, p. 26) recommended that a national agency should immediately assume leadership in coordinating the national problem of CES.

The execution of the formal CES program may be accomplished in a variety of ways depending on the needs of the student and his organization. Wheeler (1965) indicates the diversity of educational programs supported by industry which include: tuition refund plans, college credit courses, non-credit courses, short courses, company courses, correspondence courses, etc. His study reveals that non-credit technical courses, work-study programs and sabbatical leaves will be emphasized in the future.

No matter how carefully a CES program is planned, the execution of the program must be done skillfully or the results will not be satisfactory. The instructors for CES programs must be selected with great care. Since the students in a continuing education program have a wide background of experience and a variety of personal objectives, it is an entirely different situation than a regular college classroom. Schlimm (1967, pp. 24-25) observes that, in too many cases, the personnel assigned to teach CES programs are not selected on the basis of ability to do the job. Instead, the CES function is viewed as an area to use a graduate student, a new member of the faculty, or an older professor who is not considered suitable for classes in the regular program. He proposes the following requirements for a CES instructor:

> . . . the teacher must have up-to-the-minute knowledge of his field. Ideally, this should be supplemented by experience. He should possess not only skill in classical

> presentation methods, but also a willingness to experiment with new means of conveying knowledge to members of this heterogeneous group. (Schlimm, 1967, p. 25)

There is a definite need to motivate the qualified teachers to participate in CES activities. Watkins (1969, p. 80) notes that in many cases the deterrent factors which prevent faculty participation are related to recognition:

1. Recognition by the administration -- the president, the deans, and the department heads -- of the value of faculty member participation in CES.
2. Recognition by peer groups of the value of participation.
3. Recognition by professional societies of the value of participation as part of their professional development.
4. Monetary recognition and implications of extra pay for extra effort.

Competent CES teachers will only be available if the proper incentives are provided, especially adequate compensation (Carroll, 1970, p. 34).

The need for experimentation in CES programs has been stimulated to some degree by the distance separating the students and the necessary teacher. Commuting, by either the student or the teacher, is normally frowned upon by both.

Closed circuit television has been used to reach many students that could not readily commute due to the large distances involved. Florida's GENESYS (Graduate ENgineering Education SYStem) was initiated in 1963 to serve a concentration of engineers in the east-central section of that state (Nattress, 1965). Similar closed circuit television systems have resulted from the GENESYS project which indicate an even greater use in the future (Pettit and Grace, 1970; Lindenlaub and Ogborn, 1967; The Engineer and His Profession, 1969). Video tapes have also been utilized to reach distant students (Biedenbach, 1970; Bridgman, 1971; Neidt and Baldwin, 1970). The video tapes have the additional advantage of being used at the student's convenience. Research on video tapes, closed circuit television, and films indicate there is little relationship between

attitudes toward or preference for different methods of instruction and the learning from these methods (Reid and MacLennan, 1967, pp. 12-13). Hence, an increased utilization of these media is expected for the future.

Other means for reaching the distant student include (1) the ARTS System which utilizes a two-channel audio tape recorder and a synchronized automatic scroll mechanism on an overhead projector (Schultz and Schooley, 1970; Slivinsky, 1970), (2) the telewriter system (electronic blackboard) which utilizes available phone lines for information transmission (Smith, J. C., 1968), (3) programmed instruction (Schramm, 1964), (4) audio tape cassettes plus printed notes (Ho, 1970), and (5) computer aided instruction (Pressman, 1970). The CES instructor must be able to utilize the various media to maximize his effectiveness.

The evaluation of the educational process has been a prime subject for researchers over the years (Gage, 1963; Dressel, 1961). Although much effort has been expended in educational research, many questions remain unanswered. The evaluation of CES programs has received attention (Greenfield, 1969; Katz, I., 1969; Dubois, 1970) but little has been written on the value of such programs to industry because such an assessment must be made in terms of financial savings (Sunderland, 1969, p. 84). The difficulty in accumulating conclusive evidence to support various theories or expectations has led some to discount the worth of any evaluations:

> Because of the great many variables which affect the individual's performance besides the course work, I have very little faith in the results of such studies. For that matter, I have no more faith in the results of a study which has attempted to measure the value of a particular university course on a man's performance in his chosen profession. I believe that my skepticism is valid certainly for all courses which attempt to educate rather than to train the participants. (Personal letter from an assistant dean of engineering, 1970)

One study pertaining to university management training programs led the researcher to comment:

> Our data make evident, to be sure, that using companies should expect no dramatic change in subsequent behavior of the men they send. They should certainly not expect reform in personality or character. The courses we have been looking at are general in content; mastery of new techniques can hardly be expected to follow attendance. Realism requires that miracles not be expected of a few weeks of campus experience. The impact will be personal and perhaps important, but only at most an introduction to new ideas, points of view, and attitudes. It will need support and reinforcement if it is to endure. (Andrews, 1966, p. 215)

One educator feels that CES programs evaluate themselves:

> The value of a particular course can be measured by a very practical criterion: if the course is well attended year after year, it satisfies a need; if it isn't, it doesn't. (Smith, J. C., 1967a, p. 10)

The need for evaluation in the CES area is similar to that noted by Meigniez (1964, p. 23). He observed that during those years when management and supervisory training programs were flourishing and growing, there was an almost total absence of program evaluations. Trainers now show more interest in the evaluation procedure as a feedback mechanism for program improvement and as a means of validating the expenditure of organizational funds for educational programs. The National Science Foundation report found that with respect to non-credit employer sponsored courses:

> However, it would be desirable to know more about the quality of student performance in in-lab, non-credit employer sponsored courses. Consequently, we recommend that management undertake the same type of evaluation which is exemplified in the literature evaluating management and other types of personnel training. To our knowledge, such personnel research techniques have not been applied anywhere in the field of continuing education for scientists and engineers. (Social Research, Inc., 1969, pp. 85-86)

The need for CES programs must be substantiated in terms of the organization and its growth:

> Programs for continuing studies should not be based on emotional or subjective desires, but should be measured by the same yardsticks used to arrive at other managerial decisions. (Joint Advisory Committee on Continuing Engineering Studies, 1965, p. 45)

Programs must be designed to correct deficiencies which are found to exist in the organization.

Evaluation is the final link in the educational chain. Without an adequate evaluation procedure, the necessary corrective feedback cannot be applied to the CES program.

Since continuing engineering studies are rapidly becoming a major area in engineering education and may become the main preparation for professional practice (Katz, I., 1967, p. 561), it is imperative that the three steps in the development of an educational program, planning, execution, and evaluation all be given equal consideration. If continuing education is to become the fastest growing dimension in higher education (Knowles, A., 1967, p. 557), then the development phase must also be integrated with the environmental factors which dominate a given situation. Satisfactory results from an educational program can best be obtained when the program is designed to educate engineers for their desired mission (Shepherd, 1968, p. 100).

Technological Change and Engineering Obsolescence

Many of the problems associated with manpower and educational planning in the engineering area stem from the increased rate of technological change. The initial impetus for the current technological revolution can be attributed to

the feverish military research and development activities necessitated by World War II. Detonation of the first atomic bomb on July 16, 1945, the first Russian atomic bomb (1949), the Korean War (1950-1954), and the launching of the first earth satellite (1957) kept up a series of world pressures which forced the United States to place a continued emphasis on scientific research (Furnas, 1963, p. 113). Americans became especially concerned after the Russian launching of Sputnik and an apprehension developed which sensed the United States was losing its leadership in science. Hence, an increased emphasis was placed on the development of scientific personnel and many began to consider the older engineer obsolete and no longer necessary (Asch, 1967, p. 576).

While world pressures continued to foster additional scientific research, business and industry began to utilize many of the new technological developments. Feedback control systems, analog and digital computers, atomic energy, solid-state devices, and many other advances were applied to commercial activities. It was soon evident that the successful organization must keep abreast of the latest technology (Chamberlain, C. J., 1961, p. 88) and the "knowledge explosion" generated a growing concern as to whether or not engineers could keep abreast of the technology. The accelerated rate of technological advance also had an effect on engineering education. The American Society for Engineering Education initiated a study in May of 1952:

> The charge to the Committee was to recommend the pattern or patterns that engineering education should take in order to keep pace with rapid developments in science and technology, and to educate men who will be competent to serve the needs of and provide the leadership for the engineering profession over the next quarter-century. (Grinter, 1955, p. 3)

The final report of the committee was presented to the Society on June 15, 1955, by the chairman, L. E. Grinter. The report consisted of ten major recommendations, one of which called for an increased emphasis on the basic sciences including mathematics, chemistry, and physics. The new engineering curriculum should permit the graduate engineer to deal with new situations in terms of fundamental principles. Engineering graduates after the mid-1950's began to receive an education based on the recommendations of the Grinter report. However, Balabanian (1969, p. 2) notes that engineering schools, prior to the implementation of the Grinter report, provided the engineer with a repertoire of skills and techniques that could be called upon immediately and supposedly would enable him to perform the engineering function throughout his career. Gordon S. Brown (1963, pp. 456-57) adds that between the years 1940 and 1962, the colleges graduated about 600,000 engineers with a bachelor's degree. Approximately half of those degrees were issued prior to 1953 when the engineering curricula began to assume a more scientific base. It is logical to assume that a very large percentage of the total engineering population received little or no training in nuclear engineering, feedback control, information theory, computers, solid-state physics, plasma physics, probability theory, relativity theory, or modern mathematics.

The literature has been plentiful with respect to the older engineer's problem of keeping up with the new technology. The term most often used to describe this phenomenon has been "obsolescence." The negative connotations derived from "obsolescence" are obviously not constructive although the term has called many people's attention to the problem area. James Killian proposed that the half-life of an engineer's usefulness be set at about seven and one-half years. This generalization created quite a stir since it implied that an engineer was only half as

valuable to his concern after being out of school for only seven and one-half years. It has been stated:

> Unless a graduate of ten years ago has systematically spent about ten percent of his time extending his knowledge beyond the level of development achieved in his collegiate training, he will not have value in excess of a new graduate. This assumes, too, that he retains all of his previous training, which is probably far from realistic. If decay from neglect or disuse is also ten percent per year, an engineer is then faced with the task of growing in new knowledge at the rate of about 20 percent per year to remain of equal value to his employer and society. To increase in value at a significant rate, he should probably devote about one-third of his productive hours to self-education and improvement. (Chilton, 1963, p. 14)

Harold A. Foecke (1966, p. 880) believes that such half-life statements alongwith other "myth-information" are only assumptions which have not been proved.

Another term that crept into the literature was "retreading" the engineer. Everitt (1963, p. 346) uses the term in a discussion related to the development of new skills when the old skills are nolonger of any value. The use of such terms would seem to add little to the status of the engineering profession.

The use of the term engineering obsolescence has led many to propose definitions. William W. Seifert mentions one definition of obsolescence which has received wide acceptance.

> [Obsolescence] as applied to the individual is illustrated by measuring at the same point in time the difference between the knowledge and skills possessed by a new graduate of a modern engineering curriculum and the knowledge and skills possessed by the practicing engineer who may have completed his formal education a number of years ago. (Seifert, 1964, p. 144)

Alfred C. Ingersoll presents the obsolescence problem in four parts:

a. Information once taught, no longer correct.
b. Information once taught, still correct but no longer useful.

c. Information once taught, still useful, but hopelessly inadequate in the light of expanding technology (true, for example, of many electrical engineering courses taught five to ten years ago).
d. Information once taught and learned, still useful but largely forgotten. (Ingersoll, 1963, p. 21)

He notes that the last item is the responsibility of the individual.

Boulgarides and San Filippo present their definition of obsolescence in the hope of relating the phenomenon more closely to the individual:

> Technical obsolescence of specific knowledge and/or skills occurs at that point in time when the specific knowledge and/or skills are no longer required. An individual is technically obsolete when his total body of technical knowledge and technical skills are no longer required. (Boulgarides and San Filippo, 1967, p. 1)

J. Morley English considers the notion of obsolescence to probably be an oversimplification but a method of dramatizing the problem:

A man may be obsolete because:

a. His specialized knowledge is out of focus from lack of practice.
b. Some of what he learned is no longer useful.
c. New knowledge is available but the pressures of his position preclude him from keeping up with anything other than what is related to his immediate problems. (English, 1963, p. 3)

Julian C. Smith approaches the obsolescence problem from the view of the educational needs of three groups of engineers:

> The problems of the first group, in fact, are almost insurmountable: retreading the really obsolete engineer is hopeless, analogous to rebuilding a machine after its main frame is broken and its internal parts rusted together. The second group . . . are the engineers who are aware of the threat of obsolescence and who wish to do something before it is too late . . . The needs of the third group at the threshold of their professional career, have only just begun to be recognized . . . a program of preventive maintenance is essential . . . (Smith, J. C., 1967b, p. 141)

Smith's comment on the "really obsolete" engineer gains some backing from Ernst Weber:

> We can quickly dispose of the ten to fifteen percent of individuals with the lowest technical performance. Investment in advancement is hardly justified and the principle problem is a social one:

> how to derive satisfaction from the assigned job if the ambition outruns the ability. (Weber, 1965, p. 202)

Weber's remarks, which were made in the year 1965, certainly do not seem to fit the emphasis on societal problems being espoused by the engineering profession today, 1971. Clinton J. Chamberlain discussing the management of engineering personnel also handles the obsolescence problem rather coldly.

> Its general engineering competence level must be upgraded and the residue disposed of. (Chamberlain, C. J., 1961, p. 90)

The general loss of engineering ability has been likened to that of the depreciation of machinery. Chemical Engineering reports that a half-serious suggestion was made that tax credit be allowed for each engineer in proportion to the number of years since he received his primary engineering education ("Ten Years Out?" 1961, p. 104).

Theodore N. Ferdinand (1966) developed the following framework of definitions which permit the delineation of the obsolescence problem.

1. Professional obsolescence (whole discipline).
2. Areal obsolescence (technical specialty).
3. Ex officio obsolescence (current needs).

Professional obsolescence is a function of how knowledgeable a person is with respect to the total body of knowledge currently available in his discipline. If professional obsolescence can take on values of from 0 to 1, then the following formula would apply:

$$O_p = 1 - \frac{\Sigma K_d I}{\Sigma K_d P}$$

O_p = degree of professional obsolescence

0 = minimum or zero obsolescence

1 = maximum obsolescence

LK_dI = Level of Knowledge (in the discipline) known by Individual

LK_dP = Level of Knowledge (in the discipline) Possible to be known by the individual.

It is obvious that as the individual approaches the utopian condition of knowing all the knowledge in the discipline, his obsolescence goes to zero. Conversely as his knowledge approaches zero, his obsolescence factor becomes unity.

Areal obsolescence refers to the individual's deficiencies in his technical specialty. Generally the trend is for a person to specialize in a given area in order to gain recognition. By so doing he increases the possibility of becoming obsolete professionally while at the same time reducing his areal obsolescence. Areal obsolescence can assume values of from 0 to 1.

$$O_a = 1 - \frac{L K_a I}{L K_a P}$$

O_a = degree of areal obsolescence

0 = minimum or zero obsolescence

1 = maximum obsolescence

LK_aI = Level of Knowledge (in area) known by Individual

LK_aP = Level of Knowledge (in area) Possible to be known by individual.

As the individual's knowledge approaches the total body of knowledge in his area, the obsolescence factor approaches zero.

Ex officio obsolescence pertains to the knowledge needed in the performance of a currently held position. This type of obsolescence is primarily what determines if a person is obsolete. Is he able to do the job assigned?

$$O_x = 1 - \frac{L K_x P}{L K_x N}$$

O_x = degree of ex officio obsolescence

0 = minimum or zero obsolescence

1 = maximum obsolescence

LK_xP = Level of Knowledge necessary to perform current job assignment Possessed by individual

LK_xN = Level of Knowledge necessary to perform current job assignment Needed by the individual.

The person's obsolescence approaches zero as the level of knowledge possessed by the individual becomes equal to that necessary to perform the current work assignment.

Every individual can be evaluated in terms of his professional, areal, or ex officio obsolescence. Using this type of an evaluation plan it becomes evident that everyone is obsolete in one way or another and in varying degrees. Separating obsolescence into the various categories permits each person to be evaluated as an individual with provision being made for strengths and weaknesses.

Ferdinand (1966, pp. 51-55) points out that areal obsolescence tends to develop among personnel that have been working in an area of specialization that is changing rapidly after a long period of inactivity. Organizations that are constantly being asked to develop new concepts and systems must require their engineers and scientists to do likewise. It is therefore found that areal obsolescence is uncommon in this kind of an environment. Ex officio obsolescence most probably occurs when a specialist is assigned responsibility for a project in his chosen area and the details of his position interfere with his keeping abreast of the new developments related to his specialty. Professional obsolescence is an inherent part of the present system since this is an age of specialization. The

specialist is more concerned with keeping abreast of the latest developments in his specialty than being aware of all the knowledge in his discipline. Popper (1967, p. 145) notes that many young engineers immediately seek to concentrate their energies in one area in order to obtain recognition in as short a time as possible. Industry could help the young engineer to strike a balance in his activities so as to preclude the problems associated with later moving out of a specialty area.

Raines and Missar (1965, pp. 35-37) and Hunter (1966, p. 135) feel that obsolescence does not refer to the individual but only that he has failed to keep abreast of the evolving knowledge in his field. The individual's development has failed to advance at the same rate as the new knowledge being generated in his field. Over-specialized and nonengineering assignments over long periods of time may restrict the engineer's broader outlook and consequently he may develop a myopic view of his field.

While the subject of engineering obsolescence engenders a great deal of negative discussion in relation to the older engineers, there are some favorable words. Israel Katz (1967, p. 561) notes that if some people find themselves becoming obsolete in some manner then it must be true that some other people are making technological advances. Madlon and Wong (1967, p. 146) operate on the premise that knowledge is the only thing that becomes obsolete and that people can be updated through the use of appropriate training programs. Howard M. Miller puts the problem into perspective:

> Technological change is a fact, and the obsolescence of some engineers and scientists is a fact, but equally evident is the high current technical competence of many practitioners. (Miller, H. M., 1969, p. 1114)

Church, (1968, p. 35) cannot see the basis for the claims that "industry is 'loaded' with run-down, worn-out technical graduates; people who are about to become a disgrace to their profession, a drag on industrial output and a burden on society." He believes that most of the older graduate engineers qualified for their current positions through diligent, competent job performance. They perform the present job assignment to the satisfaction of their employer and seek new knowledge as the need arises.

There are indications that the older employe has some advantages over the new hire. Jack W. Taylor (1968) presents the results of observations and concludes that older employes are productive, able to assimilate new knowledge, and compare favorably with those under 40 years of age. He believes the more mature man has the tenacity and persistence needed for creative work as compared with the sometimes overly eager performance of younger employes who seek immediate results and are not known for their patience. Examples are given which show that many of the famous men throughout history have made significant contributions well after age fifty. Dappert (1965, p. 186) agrees and would be eager to obtain engineers over 40 years of age if it could be assumed that they have and will keep up-to-date in basic technology. The maturity and judgment resulting from twenty years of experience are extremely valuable.

The National Science Foundation (1961, p. 32) brings out an important issue connected with the engineering obsolescence problem. The study indicates that approximately 20 percent of the engineers employed by American industry do not have engineering degrees. If this is the case then it is probably true that this 20 percent do not have the basic engineering education necessary to master current technical subjects.

Factors related to the problem of engineering obsolescence have been graphically illustrated by a number of sources. The Joint Advisory Committee on Continuing Engineering Studies (1965, pp. 35-36) illustrates two important concepts with the aid of graphs which are shown in Figures 1 and 2. Figure 1 illustrates the exponential rise in technology which accelerated rapidly after the year 1940.

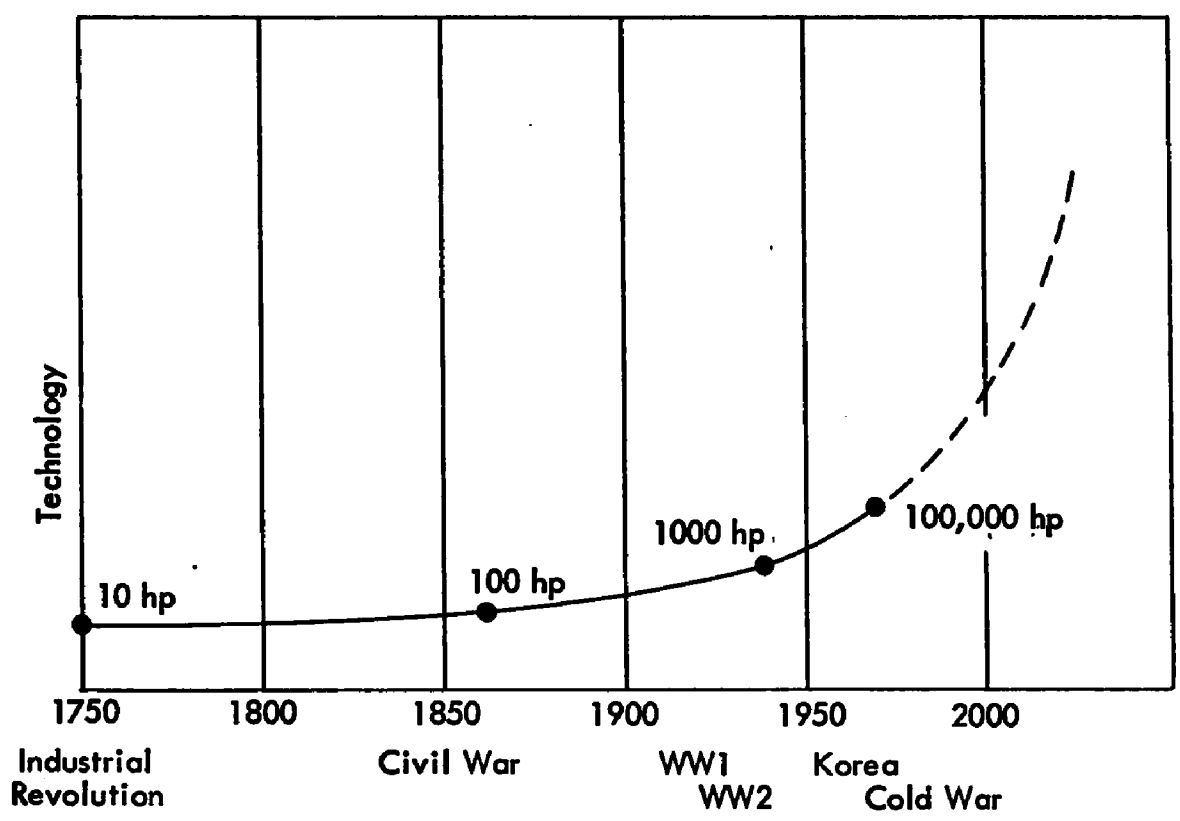


Figure 1. The Growth of Technology (Adapted)

In order to place the technology growth curve in the proper perspective, it is significant to note the four selected points which indicate the power availability (for propulsion) at various times in our history.

The projected technological growth rate indicates that technical obsolescence will be an even greater problem in the future.

Figure 2 portrays the function of education in developing the necessary capabilities in an individual so that he may cope with the increased growth of technology. This set of curves illustrates that continuing education is the means by which a person can avoid becoming obsolete. Experience alone cannot alleviate the problems associated with the advancing technology.

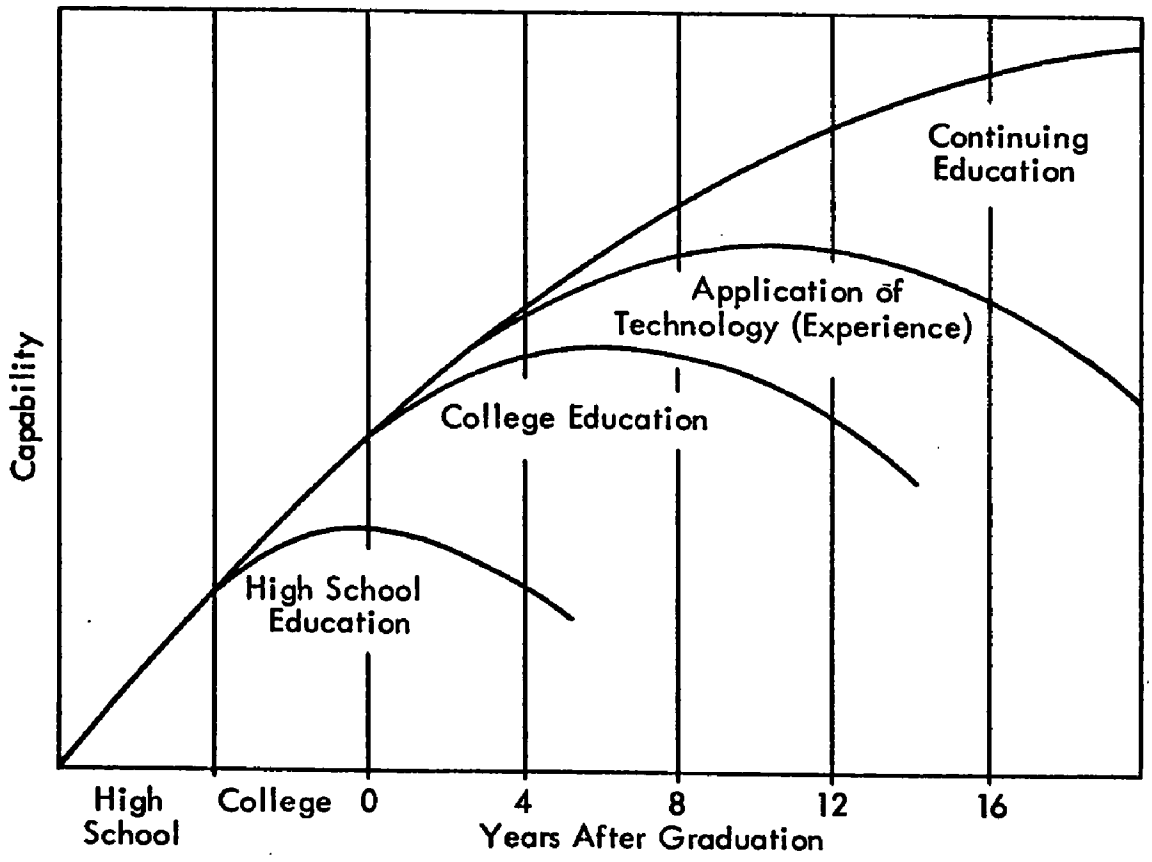


Figure 2. Capability Related to Educational Activities

Weber (1966a) feels that the life span of an engineering degree is primarily a responsibility of the individual. He presents the curves shown in Figure 3 to indicate various alternatives available to the engineer if he intends to stay in the

engineering profession. His view is that continuing engineering studies will permit the average engineer to maintain a relatively constant state of professional growth by allowing him to stay abreast of the continuous changes in technology.

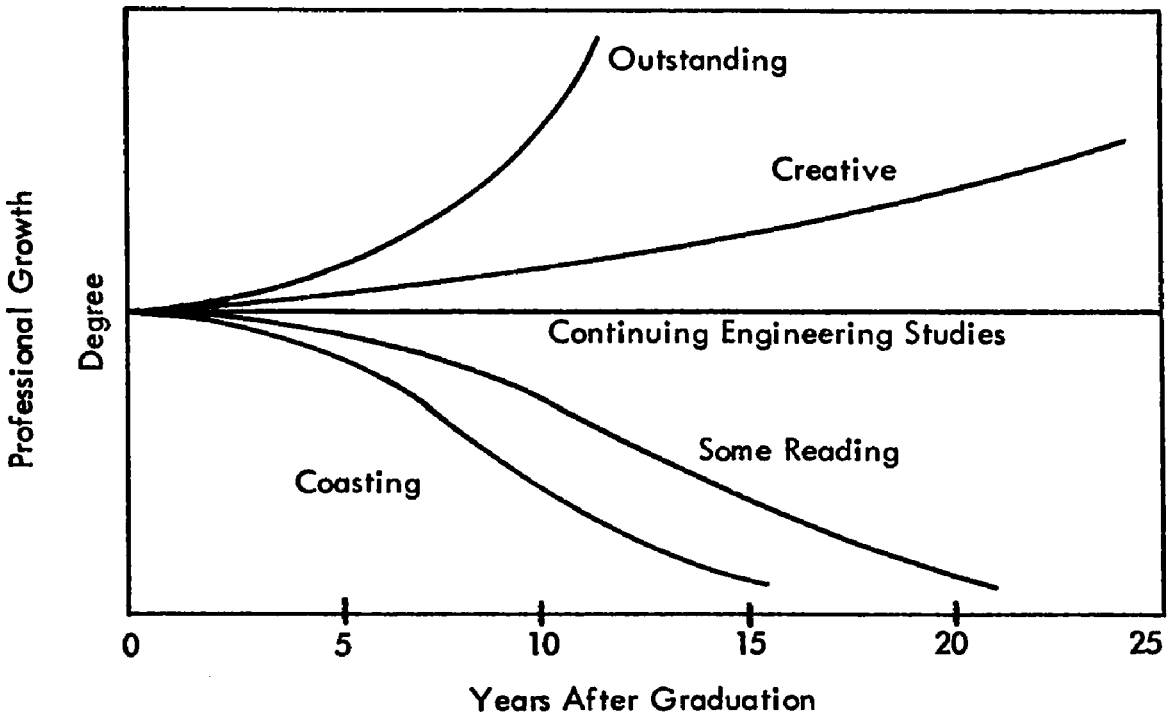


Figure 3. Professional Growth Related to Individuals

A few outstanding and creative engineers will lead the way and force all others into a catch-up game. Those engineers who do not make a significant effort in relation to engineering study can only expect to have a negative rate of professional growth. Another illustration by Weber (1966a, p. 2) is shown in Figure 4. The family of curves portrays the permanence of an engineering degree granted in the years 1960, 1930, and 1900. If each degree is evaluated in terms of currently useful knowledge at a given period in time, with the initial worth being 100 percent, then the knowledge associated with an engineering degree will become less usable

with the passage of time. If an arbitrary level of 50 percent is established as a reference level for the amount of knowledge still valuable at a given point in time, then it is apparent that each degree pictured has a different half-life. The 1900 degree reached the 50 percent mark in about thirty-five years, the 1930 degree in twenty years, and the 1960 degree in about ten years. Again the impact of the increased rate of technological development is evident.

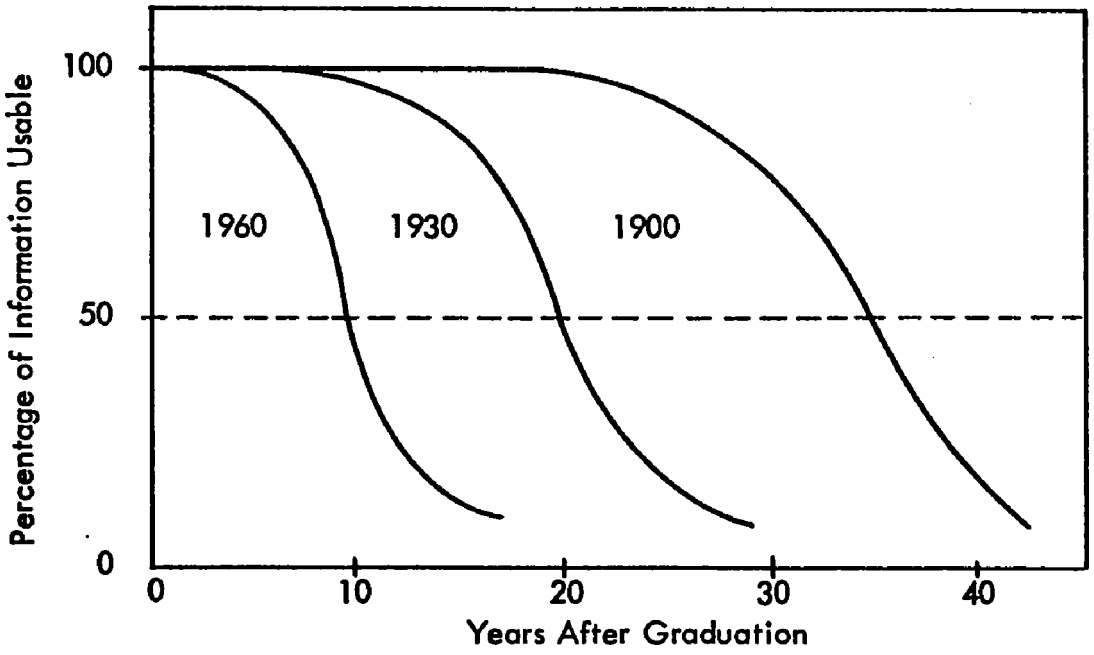


Figure 4. Amount of Information Usable After Graduation

The repeated but not verified reference to the half-life of an engineer caused Steven B. Zelikoff (1969) to conduct a study to determine the changes occurring in the engineering curricula over the years. The basis for the study was the evaluation of the curriculum content of five engineering areas: aeronautical, chemical, civil, electrical and mechanical. Five well-known engineering schools were selected for the sample. Although the yardstick of

curriculum content does have some drawbacks, it can be assumed with some degree of certainty that most faculties install or remove specific subject matter from a curriculum based on valid reasons. Figure 5 (Zelikoff, 1969a, p. 47) shows the composite erosion curves for five engineering curricula over a period of 30 years.

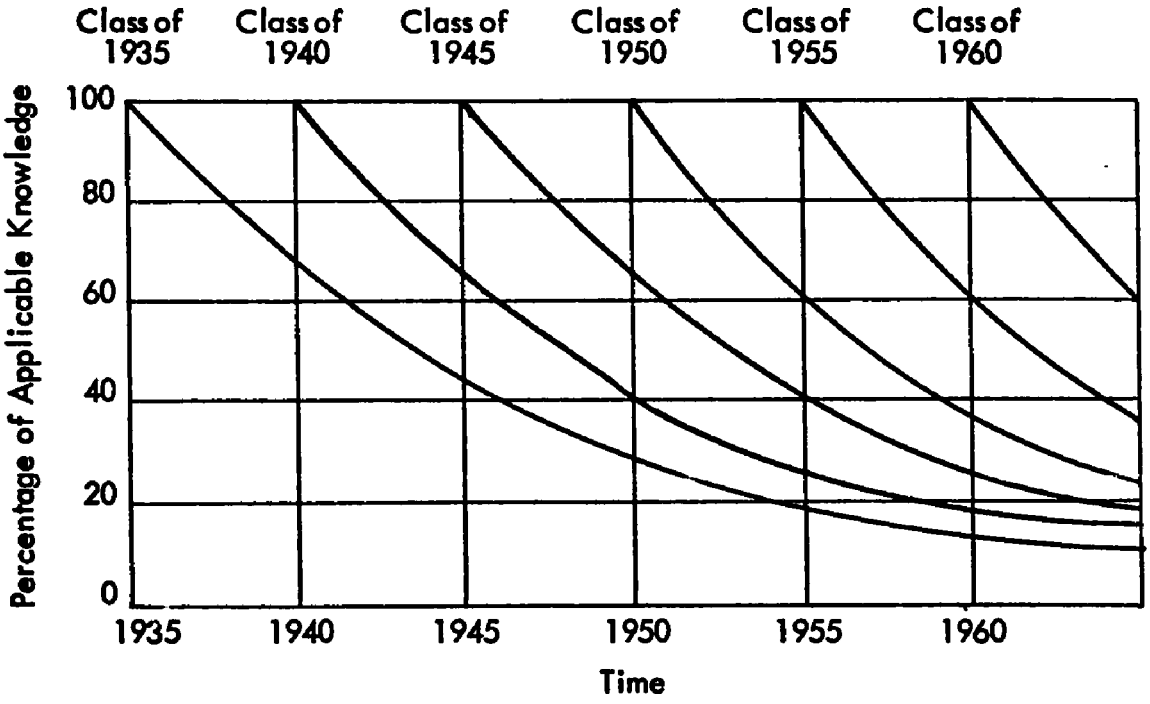


Figure 5. Knowledge Erosion Curves Derived from Curricula Study

It can be seen that only 35 percent of the courses taken by a 1950 graduate were being offered to a 1960 engineering graduate. This accentuates the problem of an engineer's susceptibility to obsolescence due to nonexposure to newer courses and the related content.

After reviewing the various curves it is the writer's feeling that something is missing. In a capitalistic society a person's capability is rewarded by an appropriate salary and the employer is not likely to pay an individual more than what his services would bring on the open market. The individual may show some

degree of obsolescence in any one of a number of ways but his salary should be an indication of his total worth to the system. The Engineers Joint Council (1969a) has conducted engineering salary surveys since 1953 and has observed that the annual rate of salary increase has averaged between five to seven percent over a 16 year period. This average annual increase has not fluctuated regardless of war, peace, sufficiency or shortage of engineers. The continued lament about the shortage of engineers should be tempered by this revelation. The Engineers Joint Council (1969a) salary curves for engineering supervisors (Fig. 6) and engineers (Fig. 7) show clearly that the "dual ladder" system does not work. It is more advantageous from a salary viewpoint for an engineer to go into management rather than to try and succeed financially in the technical end of the business. There are probably exceptions to these curves but the overall picture is clear. Why should an engineer strive to maintain technical competence when managerial expertise provides greater financial rewards?

Since salary is an indication of capability, as viewed by the employer, it would seem logical that the inverse of the salary curve would present a realistic picture of the obsolescence problem. Figure 8 shows an obsolescence curve obtained by inverting the median salary curve for engineers found in Figure 7. This obsolescence curve is much different than those suggested by others but may be more accurate since a great deal of evaluation has gone into the determination of the salaries for the over 20,000 engineers involved in the salary survey.

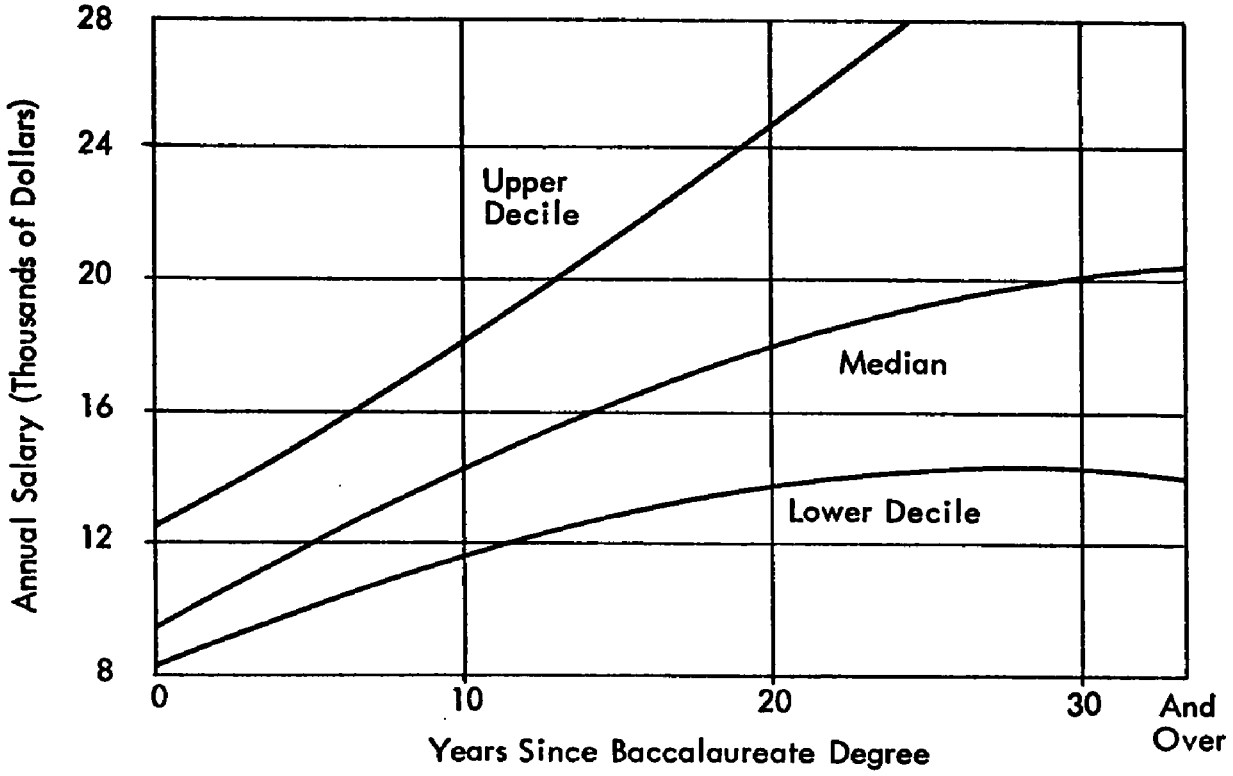


Figure 6. Engineering Supervisors' Salaries (1968)

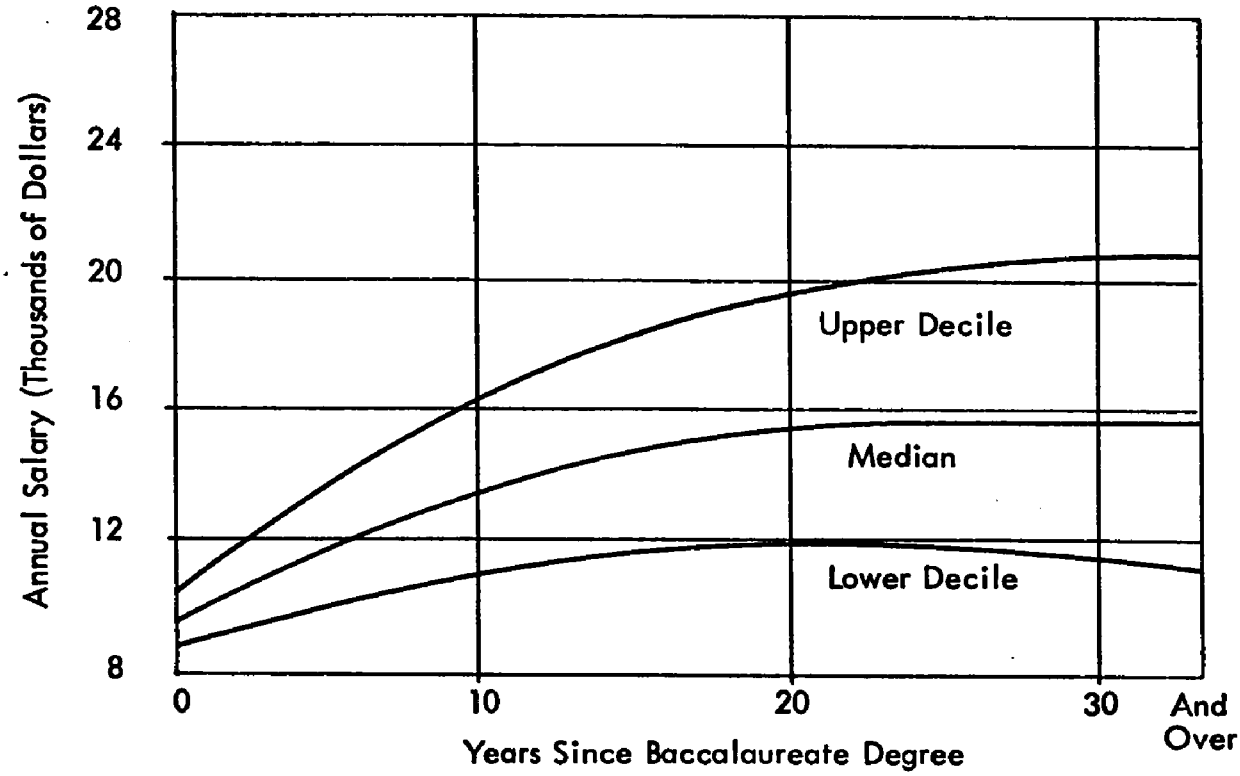


Figure 7. Engineers' Salaries (1968)

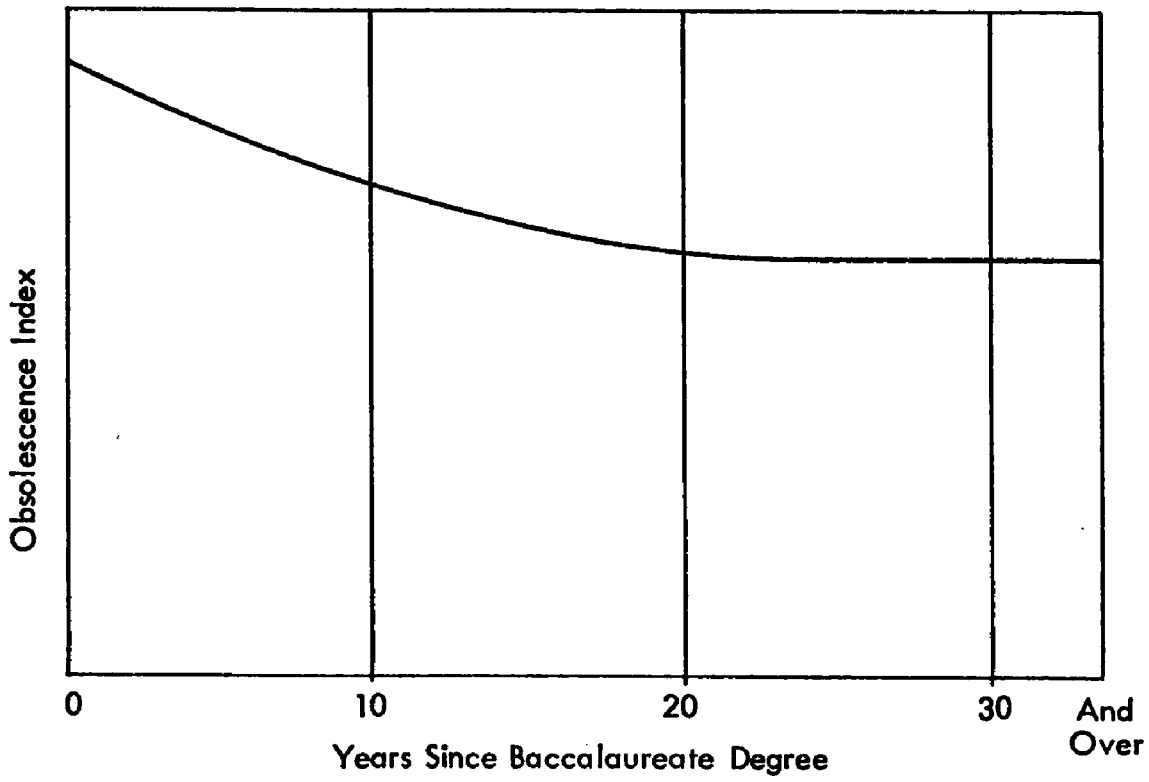


Figure 8. Obsolescence Index for Engineers

Figure 9 represents another pair of curves which compare the salaries in two sections of the country. It would not be unreasonable to assume that the Los Angeles area curve represents typical aerospace activity, while the South Central States curve would probably be diversified. It is not difficult to infer that the engineering obsolescence problem is greater in the Los Angeles area than in the South Central States.

Engineering obsolescence represents a problem to the individual engineer and the nation. The development of effective educational systems to enhance the capabilities of the nation's engineers must be considered a part of the manpower planning activity.

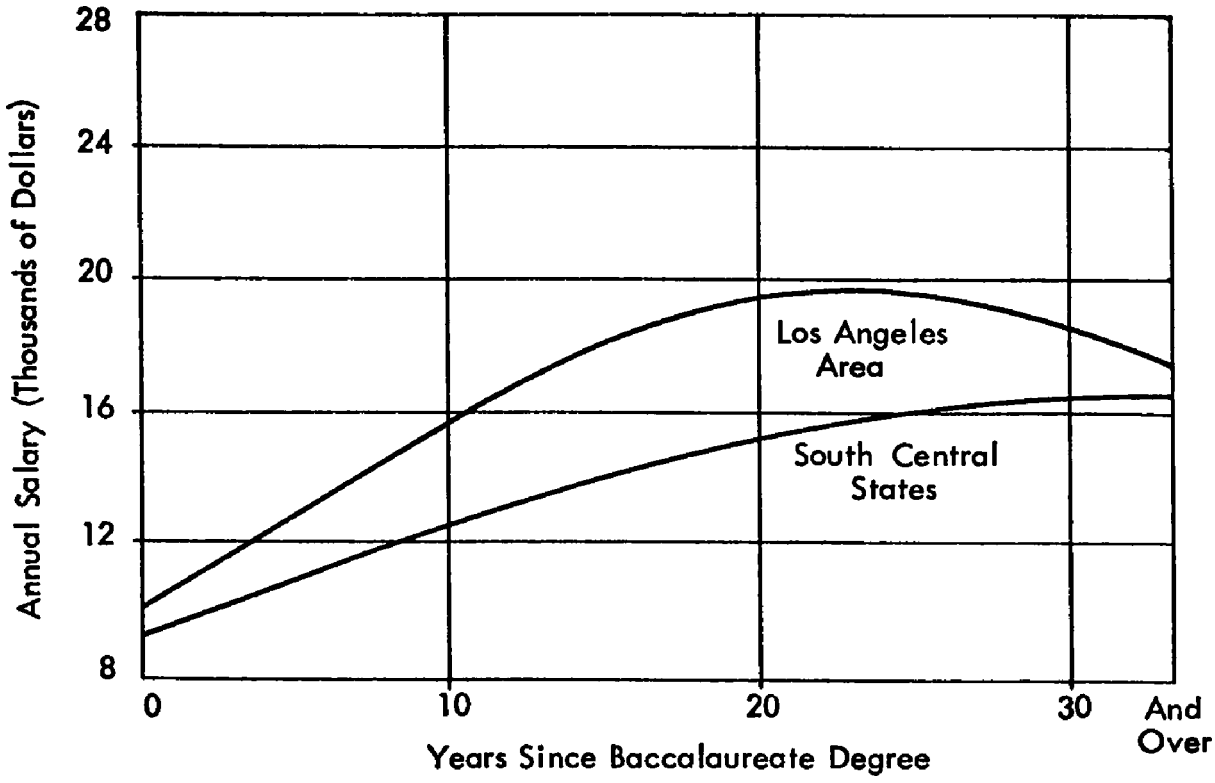


Figure 9. Engineers' Salaries by Area (1968)

Environmental Pressures

The present-day engineer is subjected to a variety of environmental pressures which affect his professional and societal performance. Asch (1967, p. 577) notes that prior to World War II a person going into the field of engineering could expect to attend college for four years and then begin his working career. The technology evolved at a pace which presented little if any problem to the practitioner. Today, the student can expect four years of undergraduate work and probably an additional amount of time in a program directed toward the master's degree. After graduation the engineer is faced with the continual problem of keeping up with the revolution in technology. Techniques and

concepts are changing so rapidly that the engineer is confronted with the prospect of a cradle-to-the-grave educational program.

Dappert (1965, p. 186) expresses the view that many engineers intend to participate in continuing education but never seem to find the time since children, family chores, and church work make it almost impossible. Davis (1963, p. 70) notes that studies have shown family responsibilities and financial worries can play havoc with educational plans. Many older engineers also feel that they are too old to learn and are reluctant to return to the classroom.

Mali's (1969) study shows that engineers had many opportunities to upgrade their technical background but didn't. The most important factor mentioned for not pursuing off-working hours courses was the pressure of family problems. A second reason was that his primary work assignment conflicted with the desired course schedule. Julian C. Smith describes a hypothetical engineer's situation:

> Let us take the case of James Callahan, a bright young engineer a few years out of school, who is anxious to continue his professional and personal development. Jim was married three years ago and already has one child and another on the way. He has just bought a new home. He is in charge of a small process development group in a chemical manufacturing company.
>
> What does the company management expect from such a man? All too often it seems to Jim to be about as follows: two nights a week, on his own time, in technical self-education; two nights a week broadening himself through general reading, plays, concerts, public lectures; two nights a week in civic work of some kind; two nights a week on company problems.
>
> He also has a strong suspicion that his wife, if not his company, expects him to devote some nights a week to family activities!
>
> Jim's immediate supervisor may very well have another opinion of what he should be doing. General company policy may be in favor of continuing study, but often the supervisor's policy is to keep a young man as busy as possible. The demands of the job come first. (Smith, J. C., 1967b, pp. 140-141)

This example may be exaggerated but it does focus attention on the complexity of an individual's role in our society. Evan's (1962) study also brings out the organizational pressures felt by the individual, and Lufkin (1966, p. 181) concludes that it is a wonder that engineers read and study as much as they do.

Dubin and Marlow (1965, p. 65) found that four of the primary reasons for not pursuing degree programs were:

1. Did not have the time.
2. Too far from education center.
3. Job does not demand more education.
4. Not interested.

The Professional Engineers in Industry (1966, p. 27) found somewhat similar reasons for not participating in continuing education programs:

1. The courses offered or subject matter covered were not within your interests.
2. You did not feel that an advanced degree would be of any use to you.
3. You did not feel that additional training would help you receive a raise, promotion, or transfer.
4. The programs were conducted out of town for several weeks or months at a time.
5. You preferred to spend your evenings with your family.

Loomba (1965, pp. 71-74) brings out another critical problem faced by engineers employed by firms that do not offer steady employment. He points out that during the years 1963 and 1964, 30,000 engineers and scientists were subjected to layoffs in this country. The San Francisco Bay area was studied during this period and it was discovered that this one area alone had approximately 2500 engineers and scientists laid off during this interval. In many cases the individuals involved were given little if any advance notice of the impending layoffs even though some of the involved companies had knowledge of the situation as much as a year prior to the reduction in work force. Rizzardi (1971) and Ingersoll (1971) discuss similar problems which took place in the period 1969-1970.

In addition to the variety of pressures felt by the engineer, there is the overall view that he is a part of management and has aspirations to succeed. In attempting to fulfill his role in the organization, he is caught between two forces. Robert Kahn notes:

> The fact that role conflict is experienced at middle management levels somewhat more frequently than at the top level is likely the result of interaction between these job demands and the intense but as yet unsatisfied mobility aspirations of middle-management men. (Kahn, 1964, p. 149)

The pressure to go into management positions is accentuated by the fact that many companies offer more management than technical courses (Franks and Hastings, 1969).

Motivation

The engineer, as any individual, is motivated by many factors. Motivation is an elusive subject which has been researched considerably. Herzberg (1967) proposed a technique for motivation based on job related satisfiers and dissatisfiers. Some of the key elements which bring satisfaction are achievement, recognition, the work itself, responsibility, and advancement. Dissatisfiers include company policy and administration, supervision, salary, interpersonal relations, and working conditions. Herzberg's theory has been substantiated to some degree by the work of Paul (1969, pp. 69-70) which indicated that job enrichment encouraged design engineers to be more productive and that a person's work is a primary vehicle for individual development.

The opportunity for achievement and advancement are important factors in an engineer's motivation. Vroom and MacCrimmon (1968, p. 27) conducted a study of managers and professionals in order to develop a model to be used in the evaluation of evolving careers. The employe with initiative seeks to improve his

future career but in most cases does not have a clear path to follow:

> Thus, his attitude toward his position may be more affected by information about the properties of expected future positions than by the intrinsic properties of his present position. The choices he makes, such as whether to join an organization, whether to transfer to another location or function, or whether to leave to join another organization, may depend less on the properties of the immediate position, than on the expected rewards connected with future positions. (Vroom and Mac-Crimmon, 1968, p.27)

Kahn (1964, p. 143) found that the higher occupational status employe has a great need for job satisfaction and the criteria for satisfying these aspirations are extremely complex. Job satisfaction is less likely to be stable for high status professional occupations than for lower status positions. Reif and Strauss (1965, p. 304) indicate the need for recognition producing work assignments in order to satisfy the inner demands of the engineer in fulfilling his internalized role model.

Ginzberg (1966, p. 209) observes that organizations have tended to set high entrance standards for beginning positions with the belief that future growth in the system will depend upon the capacity to advance. But in many cases the opportunity to move ahead is limited with the result that employers become frustrated and operate at a low level of performance in their present positions. This condition is typical of situations where engineers are employed to do technician-level or non-engineering functions. The Engineer-in-Industry Committee (1955, pp. 39-40) published a report which indicated that engineers are not always used in an engineering capacity but are given many nontechnical assignments which could be handled by non-engineers. The misuse of engineers poses a real problem in terms of the individual's development. If his job is not stimulating, then it is doubtful that he will be motivated to continue his education (Katz, I., 1967, p. 565). A development plan which integrates the work assignment with an educational program would optimize an individual's professional growth (Nypan, 1968, p. 4).

Continuing education is an acceptable activity with the engineer when he is encouraged to engage in such programs. Social Research, Inc., (1969, p. 178) found that only 61 percent of the scientists and 49 percent of the engineers in research and development organizations believe that their immediate supervisor stimulates and assists them in keeping up-to-date. One-third of the scientists and just under one-half of the engineers state that their immediate supervisor takes a noncommittal view toward continuing education. This attitude usually reflects the possible loss of productive work time due to such activities.

> That management is not interested in education, per se, is shown by the fact that there is extreme reluctance (at least on the part of the immediate supervisor) to grant any time off during working hours. If any particular values were attached to the results of the continuing educational process, there would be management encouragement for study rather than the attempt to relegate it to evenings when a student is worn out after a full day's work. (Hunter, 1966, p. 134)

Raudsepp (1967, p. 172) indicates that many supervisors' attitudes toward continuing education range from neutral and lukewarm to being negative and resentful. Dubin and Marlow (1965, p. 9) show that 64 percent of the engineers surveyed indicated that their supervisors do not encourage participation in CES programs.

In spite of seemingly little encouragement from their supervisors, engineers do participate in CES programs for a variety of reasons. The Professional Engineers in Industry (1966, p. 25) conducted a study into the continuing educational activities of engineers and found the following three reasons to be foremost in the minds of the participating engineers:

1. Desire to broaden technical background for personal satisfaction.
2. Desire to advance in a specialty field.
3. Felt that additional training would help to insure raise in salary or promotion.

Motivation to stay in the technical part of engineering is difficult to muster when it is evident to most engineers that the financial rewards are greatest in management. Some companies have attempted to set up the dual-ladder concept whereby engineers are able to obtain equivalent financial rewards in either the technical or management end of the business (Schneider, 1960, p. 214). However, one study in a dual-ladder system, has shown that technical personnel still believe they receive lower salaries than do those of equal stature in management. Technical personnel also indicated that their prestige within the company was lower than those in management (Schoner and Harrell, 1965, pp. 56-57).

A number of studies have brought out many of the factors which influence engineers in their work. Raudsepp (1963a) surveyed 1000 engineers and engineering managers to determine the factors which influence engineers when seeking new employment. The results of the survey indicate that challenging work, professional-organizational recognition for achievement, opportunity for advancement, and self-realization are of prime importance in the engineer's criteria for employment. As the engineer becomes less involved in his work he attaches more importance to company policies, fringe benefits, supervisory practices, and working conditions. Advancement is seen as the necessary reward for technical competence. The engineer feels this plan is not followed in the industrial complex and that politics, favoritism, and discriminating seniority systems prevent high-level performance from achieving just rewards. Marcson (1960, pp. 72-85) observes that the professional worker needs recognition, involvement, and the opportunity to achieve self-realization.

The Opinion Research Corporation (1960) conducted a personal interview with 350 engineers and engineering managers. The results of the survey indicated the following factors related to motivation:

*Engineers and managers believe an individual would be better off in management.
*Engineers felt that they were not being utilized effectively.
*Companies could do a better job of encouraging engineers to find out how their work fits into the entire project.
*Companies could keep engineers better informed on company objectives, policies, and operations.
*Companies should give engineers challenging work -- not routine or highly specialized assignments.
*Companies could see that an engineer's salary progression fully reflects their contributions to the organization.
*There is reason to believe that engineers doubt management's acceptance of the professional status of engineering.
*Engineers strongly agree that increased wages would help the profession.

Porter and Lawler (1968, p. 122) and Raines and Missar (1965, p. 42) contend that outstanding performance must be rewarded by the organization if the employe is expected to perform at a high level over the years. This is especially true in engineering where the engineer is under constant pressure to keep up with the new developments.

Wages can never be overlooked in the motivation picture. The Engineer-in-Industry Committee (1961, pp. 24-25) has shown that the ratio between median annual salaries for experienced engineers to starting salaries for graduate engineers has decreased over the years. In 1960 an average engineer with 25 years of experience earned approximately twice as much as a beginning engineer. In 1939 the ratio was four to one. Although the wage structure for engineers has not improved over the past three decades, there is no evidence to suggest that professional engineering societies have been pressing for higher salaries. Instead the societies have sought to increase the number of engineers by constantly proclaiming a shortage when the engineering salaries indicate the contrary (New England Consultants, Inc., 1962, p. 8).

In order to develop an effective engineering manpower planning system, it is evident that a great many motivational factors must be considered.

Guidance

In today's rapidly expanding technology it becomes increasingly difficult for the engineer to keep abreast of the latest developments. When the total spectrum of knowledge is viewed by an individual, it becomes evident that he must focus his attention on those parts of the spectrum which are most beneficial. Although the final responsibility for personal development rests with the individual engineer, it is necessary to provide the proper environment to facilitate the developmental process (Boehm, M. G., 1963, p. 4).

The engineer faces a motivational problem which can be overcome to some degree when the engineer and his employer can relate educational plans to organizational or career advancement (Krum, 1969, pp. 2-3). Phelps (1962, p. 130) observes that the engineer can branch off into many sectors of the industrial organization and each branch requires a somewhat different developmental pattern. His abilities are valuable in research, development, manufacturing, sales, production, and many other areas. Counseling and guidance in the selection of career paths can be mutually beneficial to both the organization and the engineer.

It becomes clear that some of the old management philosophies must be abandoned if organizations are to develop capable managers:

> Many men have been carried to the top by just being available at the right time. Management assumed that talent would automatically develop through application of hard work from exposure to various job assignments. This slightly revised natural law of selection suggested that the most capable people would reveal themselves, much as oil rises to the surface of water. (Meader, 1968, p. 3)

Human resource development is a proper concern of the organization. The work assignments and educational activities of a manager should be designed to permit

him to reach his highest potential in as short a time as permissible. Management development must be individualized and applied to all personnel who have potential (Blake and Mouton, 1969, p. 21). Individual counseling and guidance are a necessary part of individual development since the engineer is often uncertain of the future plans of his organization. The supervisor must be able to provide information which can direct the engineer to the most fruitful areas of study (Popper, 1967, p. 147). Singer (1969, p. 53) has observed that many employes are overwhelmed at the massiveness of today's organizations. The dehumanization of the employe by the large organization can be minimized if personal guidance is provided for each individual.

Johnson (1964, p. 3) believes that guidance can only be accomplished if an individual's past performance and achievement can be evaluated effectively. Torpey (1962, p.48) regards the process of individual development to be dependent on a continuous evaluation which can best be accomplished with the aid of detailed personnel records. These records should include all items of interest such as: (1) skills, (2) work experience, (3) educational background, and (4) professional society activity. Phelps (1962, p. 125) asserts that industry must match the engineer's capability with the company's needs. Management must consistently review the professional employe's status and jointly seek a plan which will accomplish the interface between man, job, and mutual development. Management must acknowledge its responsibilities:

> Indeed any change in engineer utilization must start with management; utilization determines engineer career possibilities. Management must squarely determine the role of engineering in attaining the objectives of the enterprise. (Miller, H. M., 1969, p. 1113)

> Since it is really essential to the engineer's employers that they keep abreast of current technological advances through these various training media, it has been made the responsibility of management and supervision to ensure that their personnel are counseled, encouraged, and advised on the necessary training and that a plan is developed and followed to accomplish these goals. (Franks and Hastings, 1969)

Best (1966, pp. 51-52) notes that even the well motivated engineers need assistance in formulating long-range developmental plans. The continuing education and development of the engineer is not a hobby.

The need for guidance has been noted by many concerns. Grimm (1966, p. 27) discusses a public utility which places the responsibility for training the engineer directly upon his immediate supervisor. Schneider (1960, pp. 214-215) notes that one chemical company designates the development of the engineer as a departmental responsibility through the supervision. This policy allows greater flexibility than what would be possible if the responsibility were at a less concerned higher level of management. Hopefully this type of a policy will prevent an engineer from becoming pigeon-holed.

Raines and Missar (1965, p. 40) examine the formation of a Professional Advisory Board within an organization to deal with problems related to professional personnel. The Board is selected by the engineers and is usually made up of respected senior engineers. The functions of the Board are: (1) coordinate engineering educational programs, (2) keep abreast of changes in the college engineering curricula, (3) provide advice and assistance to engineers, and (4) to encourage a professional atmosphere in the organization. The professional climate can greatly enhance the effective utilization of professional employes (Jones, D. E., 1964).

Freiburghouse (1964, pp. 80-81) illustrates the possibilities of personalized guidance by giving an example of an engineer seeking assistance to plan an educational program. The engineer was motivated by an engineering refresher course to learn more about areas covered briefly in the course. An individual plan was developed to permit the engineer to follow a diversified educational program. The program included programmed instruction, supplementary reading, problem solving, pertinent lectures, a two-week seminar at an engineering college, films, and college credit courses. The engineer was contacted frequently in order to make sure that he disciplined himself to keep up with the study plan. This type of individualized program can only be accomplished if competent guidance personnel are available and management provides support and encouragement.

Reading

Printed materials offer the most convenient method for transmitting information since books, magazines, etc., can be utilized at the reader's convenience. Engineers consistently indicate that reading is the most frequently used method for staying current in the technology.

Lebold (1966, p. 252) surveyed 3000 engineers in 143 organizations to determine the various educational needs of engineers. One of the questions on the questionnaire was:

> During the past year, have you engaged in these technical activities? Please check all that apply.

The results are indicated below in terms of the percentage of respondents indicating they engaged in that particular activity:

96% I read about new developments in engineering in newspapers and magazines.
88% I discussed new engineering developments with my associates.

80% I subscribed to engineering or scientific periodicals.
58% I attended local technical meetings on engineering subjects.
56% I read new books about engineering or science.
43% I purchased new books on engineering.
37% I attended national technical meetings on engineering subjects.
27% I took short courses or extension courses in engineering subjects.
20% I wrote technical papers.
14% I applied for or was granted patents.
12% I completed graduate courses in engineering or science.
11% I presented technical papers.

Three out of the five top choices relate to reading with the reading of newspapers and magazines indicated as the most prevalent activity.

An informal survey conducted by the periodical Electro-Technology ("Opinion Poll Results," 1969) asked the question, "Which of the following do you find most useful for keeping up with technological developments in your specialty area?" The results, expressed in terms of the percentage of the respondents making that particular choice were:

73% Technical magazines
10% Personal contacts
8% University or technical school courses
4% Company seminars or courses
4% Trade shows and society meetings
1% Other

Technical magazines are most frequently used by this sample to keep up.

Dubin and Marlow (1965, pp. 66-67) conducted a questionnaire survey of over 2000 engineers in the state of Pennsylvania and found that the engineers' sources of information were, in order of preference: (1) scientific and technical journals, (2) technical books and reports, (3) manufacturer's literature, (4) lectures and conferences, (5) company and industry practices, (6) technical abstracts and indexes, (7) professional society meetings, (8) business reports, (9) local company in-service courses, (10) use of consultants, (11) workshops on specific topics, (12) college and university night courses, (13) one-week seminars on specific topics, (14) engineering refresher courses, and (15) college and university day

courses. Raudsepp (1967, p. 168) also found that technical magazines and journals were the preferred sources of information used by respondents to his survey.

Social Research, Inc., (1969, p. 114) noted that reading plays a very important role for scientists and engineers in large research and development organizations in permitting them to keep up on new developments:

> Reading the scientific and technical literature is the most used, most emphasized, most frequently mentioned and highest-ranked mode of continuing education . . . 68 percent of the scientists and engineers questioned ranked reading the literature as the most important mode of keeping themselves up-to-date. An additional 17 percent ranked it second. Thus, a total of 85 percent rank reading the literature as either first or second in importance in keeping themselves up-to-date.

All of the studies are in agreement and one must conclude that reading is fundamental to keeping up-to-date.

The great volume of literature being printed these days makes the choice of reading material extremely critical (Hanson, 1960). The "knowledge explosion" has been accompanied by an exponential growth in the literature (Price, 1961, p. 100). Under the present conditions it is becoming impossible to keep up with the new literature and it has been suggested that new coding systems be devised to aid in the retrieval of information (Ingersoll, 1963, p. 21). Foecke (1966, p. 880) observes that many of the forecasts are exaggerated:

> We stand in awe of the so-called "information explosion," sometimes not appreciating that most measures of this are in terms of quantities of paper, without reference to the decreasing number of significant ideas per printed page.

This suggests that editors be more critical in accepting material to be published.

Although reading is the most important factor in continuing education, problems do exist. Schwarz (1964) reports on a survey which indicates that more than one-half of all the respondent electronic engineers spend less than three

hours per week reading technical literature at work. He notes a similar study of British scientists which also showed a relatively small amount of time being spent reading the technical literature during working hours. Lufkin and Miller (1966) surveyed 1,765 engineering personnel employed by two aerospace-avionic firms. Two of the findings were: (1) 75 percent of the respondents spent less than one hour per week reading technical reports issued by government agencies or other firms, (2) over 50 percent of the engineers spend less than one hour per week reading professional society journals in their specialty.

Reading certainly is an important part of the engineer's educational program; however, it is doubtful whether the available literature is appropriate. Ferdinand observes that:

> The average engineer, therefore, by virtue of his specific responsibilities, is drawn relentlessly away from abstract theories and general principles toward the concrete and pragmatic. As he continues in his profession and gathers experience, he often becomes an accomplished master of manipulating the concrete -- but he also often becomes increasingly illiterate as far as theoretical explanations of his accomplishments are concerned. This means that one channel that might help him remain broadly current in his profession, i.e., the technical literature, is gradually closed to him as he slowly loses an ability to comprehend what it is trying to tell him. Moreover, the fact that the technical literature is dominated to a large extent by engineers in the great centers of engineering education compounds the problem, because the emphasis in these centers is swinging more clearly in a scientific, theoretical direction. (Ferdinand, 1966, p. 54)

Thus, the average engineer is caught in the position of constantly falling behind technically in his profession. Even the literature which is available becomes increasingly difficult for him to comprehend.

Summary

In order to establish effective programs in the area of continuing engineering studies, one must be aware of the agents which influence the adult student.

Current problems are brought to the classroom by the adult student for which he seeks immediate solutions. Besides these current problems, there are a host of other factors which contribute to his overall behavior.

The economic situation, as related to the nation, the organization, or the individual engineer, determines many of the practices which affect the utilization of the engineer. The economic policies define the manpower planning programs generated at the various levels in the economic system. Hence, engineering employment is closely related to the relative strength of the economy.

The increased rate of technological growth presents the engineer with the specter of obsolescence. The engineer's motivation to keep abreast of the evolving technology greatly depends upon his view of the future as shaped by a variety of environmental factors which include his family, community and organization. Guidance is needed by the engineer so that he may plan his future in harmony with his organization's short and long-range plans. An integration of work and continuing education is imperative for successful career planning.

Although there are a variety of CES programs, engineers consistently mention reading as the most prevalent mechanism for maintaining currency in their field. Problems associated with reading include the increased volume of technical literature and the slow deterioration of an individual's ability to comprehend the increasingly abstract character of the material.

Effective CES programs are a result of a developmental system which incorporates the planning, execution, and evaluation functions. The remainder of this report concentrates on the evaluation phase of the system. The results of the study will be useful to those persons involved in the future development of continuing education programs.

CHAPTER II

METHODOLOGY

The absence of evaluative literature pertaining to the area of CES led to the formulation of this study. Although most continuing education programs conduct a course-end evaluation related to course content, instructor performance, and other environmental factors, little information is available which describes the benefits derived from programs by the participants. The type of program selected for this study was designed for engineering managers and supervisors to increase their awareness of modern engineering concepts and techniques. The program has been presented under different titles but in this report is referred to as the Modern Engineering Course, or MEC.

Origin of MEC

While attending the American Society for Engineering Education's annual meeting in 1959, Stanley M. Little of the Boeing Aerospace Division noted that there were plenty of management training courses available, but no courses designed specifically to enhance the technical competence of the engineering manager. J. Morley English of U.C.L.A. responded to the challenge by developing a course to remedy the situation.

The MEC developed by U.C.L.A. was first offered during June and July of 1961. The program was held at the Ojai Valley Inn and Country Club which is located about seventy-five miles northwest of Los Angeles. The intensive six-week course included topics such as probability, statistics, solid state physics,

computers, and information theory (Boehm, G.A.W., 1963). The immediate reaction of the participants was favorable. Subsequently, other educational and business organizations developed similar programs to meet the requirements of their clientele (Rodes, 1964, p. 28; Ellwood, 1967, pp. 132-133; Jones and Hughes, 1967; Madlon and Wong, 1967; Biedenbach, 1968). The MEC has received considerable publicity on its ability to update engineering managers. It has generally been regarded as a successful program.

Objectives of MEC

Although the various MEC-type programs offered by educational and business organizations are designed to meet the specific needs of the participants, the following general objectives permeate the literature and brochures related to all variations of the original MEC:

1. Become aware of the modern techniques and concepts that are a part of modern engineering practice.
2. Develop a confidence in modern engineering methods and concepts so as to make or suggest their application to engineering problems.
3. Enhance the ability to communicate, guide, and stimulate technical personnel.
4. Reinforce skills learned in the past but forgotten due to nonuse.
5. Develop an awareness of the interrelations that exist between different technical areas.
6. Increase the ability to comprehend the technical literature and encourage independent study.

7. Provide motivation to take other courses in areas highlighted by the MEC.

The objectives for the MEC are general and no claim is made for specific results. However, it can be assumed that the employer must expect a participant to derive some benefits from the program which directly or indirectly benefit the employer.

Programs Evaluated

The five programs included in this study were selected so as to obtain diversity with respect to the sponsoring industry, the program format, and the program administrator. The participants in all the programs are mainly engineering managers. Refer to Appendix E for more detail on programs.

Program A

Time Schedule: Nine monthly meetings. Each meeting consisted of a Friday afternoon, Friday evening, and Saturday morning session.

Conducted by: Educational division of industrial organization.

Instructors: Professional staff of educational division.

Held at: Educational division of industrial organization.

Total Class Time: 81 hours.

Usual Class Size: 23.

Sample Year and Size: 1965 (65), 1967 (71).

Student's Industry: Mainly automotive manufacturing.

Course Materials: Printed notes.

General Subject Areas: New materials, energy conversion, measurement, digital and analog computers, new

processes, mathematical notations, control systems, fluid mechanics, experiments and evaluation, and human communications.

Program B

Time Schedule: Six weeks, 5.5 days per week, six hours per day.

Conducted by: Corporate educational personnel of industrial organization.

Instructors: Mainly professors from colleges and universities which are supplemented by industrial specialists.

Held at: Resort type of location.

Total Class Time: 175 hours.

Usual Class Size: 25.

Sample Year and Size: 1965 (48), 1967 (22).

Student's Industry: Electrical-electronics-aerospace.

Course Materials: Printed notes and approximately 25 textbooks.

General Subject Areas: Mathematics, information processing, probability, statistics, modern physics, analog and digital computers, control theory, materials and their application, information theory, decision theory, optimization theory, transport phenomena, reliability, economics, ecology, polymer chemistry, solid state physics and devices, vibration analysis, and mechanics.

Program C

Time Schedule: (1) five afternoon-evening weekly sessions at the plant, (2) two weeks on campus (five days per week, eight hours per day), (3) fourteen afternoon-evening weekly meetings at the plant, (4) two weeks on campus, (5) fourteen afternoon-evening weekly meetings at the plant, (6) two weeks on campus.

Conducted by: University in cooperation with industry.

Instructors: Professors of university.

Held at: Sponsoring industrial organization's plant and university campus.

Total Class Time: 304 hours.

Usual Class Size: 17.

Sample Year and Size: 1965 (14), 1967 (14).

Student's Industry: Chemical.

Course Materials: Printed notes, approximately six textbooks, and a book allowance for additional books.

General Subject Areas: Probability, statistics, modeling, mathematics, computers, thermodynamics, bioengineering, processes, heat-mass-momentum transfer, chemical kinetics, fluid mechanics, reaction kinetics, pollution, separations, linear programming, state of the art in other fields, and a design project.

Program D

Time Schedule: Nine monthly meetings. Each meeting consisted of a Friday afternoon and Saturday morning session with an after-dinner speaker on Friday evenings.

Conducted by: University in cooperation with industry.

Instructors: Mainly university professors supplemented with outside industrial specialists.

Held at: University continuing education center.

Total Class Time: 72 hours.

Class Size: 40.

Sample Year and Size: 1967 (40).

Student's Industry: Mainly automotive manufacturing.

Course Materials: Printed notes.

General Subject Areas: Mathematics, modern physics, chemical physics, materials science, processing, modern mechanics and structures, systems engineering, control and optimization techniques, dynamics, vibration, sound, heat and mass transfer, and lubrication.

Program E

Time Schedule: Six weeks, six days per week, 5.5 hours per day.

Conducted by: University.

Instructors: University professors.

Held at: Resort type of location.

Total Class Time: 144 hours.

Usual Class Size: 32.

Sample Year and Size: 1965 (30), 1967 (32).

Student's Industry: Government agency (35), aerospace (9), electrical-electronics (8), computer (4), metals (4), oil (2), private engineering company (1).

Course Materials: Printed notes and approximately ten textbooks.

General Subject Areas: Modern mathematics, modern solid state physics and electronics, structures, dynamics, random vibrations, control theory, biomedical engineering, energy conversion, electromagnetics, theory of relativity, probability, statistics, decision making, digital-analog-hybrid computers, computer science, communication theory, queueing theory, systems engineering, economic analysis, and nuclear engineering.

Development of Questionnaire

After reviewing the literature pertaining to the MEC, an open-ended interview schedule was developed to explore factors related to the program under study. Four former participants from three of the five sample programs were interviewed early in 1970. An initial questionnaire was developed which incorporated

many of the factors defined by the personal interviews. A pilot mail questionnaire survey was conducted in the early fall of 1970. The sample for the pilot study involved 65 former participants in four of the five study programs. This sample was drawn from program years not covered in the final survey. The final questionnaire incorporated minor changes suggested by the pilot study.

The final questionnaire had the appearance of a four-page booklet and was printed black on white. The appearance of the questionnaire was enhanced by not including any coding information except for a hand-written serial number at the top of the first page. There were a total of 39 questions with the opportunity for some write-in answers. A separate lined sheet was also provided to facilitate additional comments. A cover letter was developed to explain the purpose of the study to the former participants. See Appendices A, B, and C for the questionnaire and cover letters.

Mailing of Questionnaires

The first mailing of the questionnaires was accomplished on October 6, 1970. The questionnaire, cover letter, additional comment sheet, and a self-addressed, regularly stamped envelope were included in the mailing. An additional letter was sent by one of the cooperating organizations to their participants on October 1, 1970 (see Appendix D). On November 2, 1970 a second follow-up mailing was made which included the same materials as in the first mailing except for a modified cover letter. During the remainder of November, 1970, telephone calls were made to many of the nonrespondents encouraging an early response. The final cut-off date for the questionnaires was December 31, 1970.

Response to Questionnaire

The response data for the mail questionnaire are shown in Table 1.

TABLE 1

RESPONSE TO THE QUESTIONNAIRE

	Individual Sample (Number)	Usable Returns (Number)	Usable Returns (Percent)
Program A	136	101	74.3
Program B	70	59	84.2
Program C	28	24	85.7
Program D	32	26	81.3
Program E	62	46	74.2
Total	328	256	78.0

The overall response of 78 percent is well above the 40 to 60 percent figures which are quoted as being normal and approaches the 80 percent response level which is seldom exceeded (Oppenheim, 1966, p. 34).

Data Handling

All the data from the questionnaires were transferred to IBM cards by the use of a coded transparent mask which was placed over each questionnaire. The data were then processed on IBM equipment using modified standard IBM library programs. The data were printed out in terms of number, percent, means and standard deviations.

In order to determine if the five different samples utilized in the study are from the same population, the k independent sample chi-square test was utilized. This test does not necessitate the limiting assumptions required when using other

statistical tests based on normal distributions. When applying the k independent sample chi-square test it is necessary that: (1) no expected value cell in the contingency table be less than one, and (2) no more than 20 percent of the expected value cells be less than five. When the contingency table does not meet these requirements, it is possible to combine adjacent response classifications when such action is meaningful (Siegel, 1956, pp. 174-179). This collapsing process has been utilized in applying the chi-square test and is so noted in the presentation of data.

Hypotheses

Although the main purpose of this study is to determine the benefits derived by the participants from the program, it is of interest to compare the responses of the groups to various questions. Since the programs are different in terms of total class hours, industry, exact subject matter and format it would seem logical to assume that the programs would elicit different responses from the various groups involved in the study. To test this assumption the following general null hypothesis is stated:

> There will be no significant difference between the responses given by the different groups to the questions posed in the questionnaire. The significance level will be 0.05.

Summary

The questionnaire survey (Fall, 1970) solicited the opinions of engineering managers and supervisors who attended five different programs of the Modern Engineering Course type of CES activity during the years 1965 and 1967. The former participants are associated with the automotive, chemical, aerospace-electrical-electronics, and government sectors of the economy.

The programs included in the study are similar in general objectives but vary considerably with respect to total instructional hours, teaching staff, and format. The data presented in the following chapter show the reactions of the participants to the separate programs. The chi-square statistical test is applied to determine if significant differences exist between the programs as perceived by the former participants.

CHAPTER III

RESULTS OF THE STUDY

The findings of the questionnaire survey are presented by grouping the data from questions which pertain to the area under consideration. The tables have all been derived from the data obtained from specific questions found in the questionnaire. The caption for each table refers the reader to the number of the question under consideration.

The various response categories found in each table are followed by a number in parentheses. This number is utilized to calculate the mean response and standard deviation for each set of data where applicable. Since some respondents did not answer each item on the questionnaire, a no response category is included in the tables.

The response of the former participants is presented in terms of a percentage of the total group under consideration.

Some of the write-in responses which are associated with numerical data are included in this chapter. The write-in responses are keyed to a specific program by including the program letter designation in parentheses after each comment. The complete set of write-in responses is found in Appendix F.

The chi-square test was performed on all data where applicable. The chi-square value, the related degrees of freedom (d.f.) and whether or not the null hypothesis has been accepted are indicated at the bottom of each table. The null hypothesis is: There will be no significant difference between the responses

given by the different groups. The 0.05 level of confidence is utilized to determine the acceptance of the null hypothesis.

Participants in the MEC

The respondents were asked to write in their present job classification. Since job classifications vary greatly in business organizations, it is difficult to group the respondents precisely. After hand coding and analyzing the various job classifications, it can be assumed that almost 100 percent of the respondents can be classified as:

Engineering Managers

Engineering Supervisors

Senior Engineers

The former participants were asked to indicate the general category into which the major portion of their job responsibility falls. Table 2 indicates that 57 percent of the total sample consider their responsibility mainly in the area of development for production. Only 14 percent classify their activities in basic research and design. Those considering their work mainly in the production area (25 percent) are almost double those in basic research and design. The chi-square test indicates that differences exist between the various program participants' job responsibilities.

Table 3 indicates the last academic degree received by the respondents. The bachelor's degree predominates in all programs with 70 percent of the total in this category. Program C (the chemical industry) has the largest percentage of participants with the master's or doctor's degree. The chi-square test indicates a great deal of similarity between groups with respect to degrees.

TABLE 2

JOB CATEGORIES OF PARTICIPANTS (Q35)*

Category	Participant Response (Percent)					
	Program					All Programs
	A	B	C	D	E	
Basic research and design (1)	3	14	29	15	28	14
Development for production (2)	59	69	42	70	41	57
Production and related functions (3)	34	17	21	15	24	25
No response	4	0	8	0	7	4
N	101	59	24	26	46	256

$\chi^2 = 31.15$ d.f. = 8 Reject the null hypothesis at the 0.05 level.

*Indicates that the data for the table was derived from question Number Thirty-Five on the questionnaire.

TABLE 3

PARTICIPANT'S LAST DEGREE (Q36)

Degree	Participant Response (Percent)					
	Program					All Programs
	A	B	C	D	E	
Bachelors (1)	69	77	54	77	67	70
Masters (2)	20	20	34	19	31	23
Doctors (3)	2	3	4	4	2	3
No response	9	0	8	0	0	4
N	101	59	24	26	46	256
Mean response	1.26	1.27	1.45	1.27	1.35	1.30
Standard deviation	0.49	0.52	0.60	0.53	0.52	0.52

$\chi^2 = 3.87$ d.f. = 4 Accept the null hypothesis at the 0.05 level.

Steven B. Zelikoff (1969) proposed that a measure of engineering obsolescence is the number of years since receiving a degree. The participants were asked to indicate how many years had elapsed since receiving their last degree. Table 4 shows that 51 percent of the total sample received the last degree more than 20 years ago. It is interesting to note that Program A (automotive manufacturing) has the greatest percentage of recent diplomas (15 or less years since receiving last degree). The chi-square test indicates that differences do exist between groups for this item.

TABLE 4
NUMBER OF YEARS SINCE LAST ACADEMIC DEGREE (Q37)

Number of Years	Participant Response (Percent)					
	Program					All Programs
	A	B	C	D	E	
0 - 10 (1)	13	3	4	0	7	7
11 - 15 (2)	14	7	4	8	7	9
16 - 20 (3)	25	26	26	38	33	28
21 or more (4)	41	64	58	54	52	51
No response	7	0	8	0	2	4
N	101	59	24	26	46	256
Mean response	3.01	3.51	3.50	3.46	3.33	3.28
Standard deviation	1.07	0.77	0.80	0.65	0.88	0.93

$\chi^2 = 16.24$ d.f. = 8 Reject the null hypothesis at the 0.05 level.

The number of years with the respondent's present employer is shown by Table 5. The majority of the total sample (73 percent) have more than 15 years with their present employer. The participants in Programs D and E appear to have considerably less seniority with their present employer than do the other groups. The chi-square test indicates that significant differences exist between program groups with respect to seniority.

TABLE 5

NUMBER OF YEARS WITH PRESENT EMPLOYER (Q38)

Number of Years	Participant Response (Percent)					
	Program					All Programs
	A	B	C	D	E	
0-10 (1)	6	5	0	23	30	11
11-15 (2)	13	12	21	19	22	16
16-20 (3)	26	19	29	35	22	25
21 or more (4)	54	64	50	23	26	48
No response	1	0	0	0	0	0
N	101	59	24	26	46	256
Mean response	3.29	3.42	3.29	2.58	2.43	3.09
Standard deviation	0.91	0.89	0.81	1.10	1.19	1.04

$x^2 = 42.36$ d.f. = 12 Reject the null hypothesis at the 0.05 level.

When considering the participant and his relationship to the MEC, it is desirable to know why he attended the program. Table 6 indicates what initiated the respondents' attendance at the program. Of the total sample, 67 percent were asked by their supervisor if they would care to attend the program. Only about one-third of the total (34 percent) initiated attendance themselves. The chi-square test indicates differences between groups.

TABLE 6

REASON FOR ATTENDING PROGRAM (Q32)

Reason	Participant Response (Percent)					
	Program					All Programs
	A	B	C	D	E	
Personally initiating a request to attend (1)	28	22	42	31	61	34
Being asked by my supervisor if I would care to attend (2)	70	76	54	65	35	64
Other	2	2	0	4	4	2
No response	0	0	4	0	0	0
N	101	59	24	26	46	256

$\chi^2 = 22.70$ d.f. = 4 Reject the null hypothesis at the 0.05 level.

The write-in responses included other reasons for attendance:

> Part of a planned individual training program established by my management. (A)
>
> Searched personally for program. (E)
>
> An advertisement came to our Personnel Office which suggested participation. (E)
>
> I requested permission to take this course at my own expense. My college background was B.S. -- Physics, M.S. -- Astrophysics, M.S. -- Aeronautics. As Manager of the Facilities Office (construction of technical and institutional facilities) this course had little direct application. It was my desire to bring up-to-date my knowledge of scientific and engineering subjects and expose myself to new fields that might offer new avenues of work or career for me. In this it was successful, and I thought it was a valuable experience. However, at my age, middle 50's then, it was not easy nor prudent to make job or career changes. Now as I approach 60, I contemplate retirement rather than a new job. However,

> I believe the course did introduce me to many new ideas and developments and may assist me in selecting some individual projects to work on as soon as there is no longer a necessity to work at a job. The course was very well done. (E)

Since the MEC is not attended by all engineering personnel, it is logical to assume that participants were selected on the basis of need. One measure of this selectivity may be the relationship between attendance and later promotion. Table 7 shows that 63 percent of the respondents were either promoted or given an increase in job responsibility after attending the program. This is not to say that the program provided the basis for promotion. The chi-square test indicates a similarity between groups in this respect. It is interesting to compare Table 7 with the information given in Table 8. Table 8 reflects the feelings of the participants about the relationship between attendance at programs of this type and promotions, salary increases, or increased responsibility. The majority of the total sample (78 percent) indicates either a slight or zero relationship. The chi-square test indicates that there is a similarity between group responses in this area.

TABLE 7

PARTICIPANT JOB PROMOTION OR INCREASE IN RESPONSIBILITY SINCE COMPLETING PROGRAM (Q33)

Promotion or Increase in Job Responsibility	Participant Response (Percent)					
	Program					All Programs
	A	B	C	D	E	
Yes (1)	71	58	58	62	54	63
No (2)	27	35	29	34	39	32
Other (3)	2	7	13	4	7	5
No response	0	0	0	0	0	0
N	101	59	24	26	46	256

$\chi^2 = 3.66$ d.f. = 4 Accept the null hypothesis at the 0.05 level.

TABLE 8

PERCEIVED RELATIONSHIP BETWEEN PROGRAM ATTENDANCE AND JOB PROMOTION, SALARY INCREASES, OR INCREASED RESPONSIBILITY (Q20)

Perceived Relationship	Participant Response (Percent)					
	Program					All Programs
	A	B	C	D	E	
None (1)	37	24	25	46	17	30
Slight (2)	43	60	45	39	50	48
Moderate (3)	15	12	17	15	24	16
Strong (4)	3	2	13	0	7	4
No response	2	2	0	0	2	2
N	101	59	24	26	46	256
Mean response	1.84	1.91	2.17	1.69	2.20	1.94
Standard deviation	0.79	0.66	0.96	0.74	0.81	0.79

$\chi^2 = 15.38$ d.f. = 8 Accept the null hypothesis at the 0.05 level.

The participants included in this sample exhibit a diversity in terms of most of the factors discussed in this section. Although the respondents are mainly senior personnel in engineering positions, they undoubtedly brought many different individual problems to the program. It is not difficult to imagine the many problems faced by program coordinators in attempting to satisfy all the participants. Respondents made these pertinent comments:

> Material well presented but at a relatively elementary level. It does not seem practical to tailor a program such as this to meet the needs for all levels of interest and technical background. As a result of trying to do so, parts of the class are completely lost and others are bored. Persons taking such a course might be expected to be fairly up-to-date in their own field but should be exposed to more challenging ideas and concepts in other fields. (A)

> Program was very beneficial to me as an individual and gave me a much better feel for what can be done even though I do not personally carry out the details. It would have been better if the selection of subjects was a little more oriented toward my interests, but I don't know how you do this without running more classes and smaller groups. (B)

> . . . The group was diversified in its make-up, and yet a great deal of time was spent on the chemically oriented topics. State of the arts lectures were somewhat of a departure from the chemical engineering aspect, but here was an area where better organization and advance planning as to what the group make-up was and the purpose of the program could have been vastly improved. (C)

> My mathematical background as an engineer was very strong. As a result, some (even most) of the "new" mathematical concepts presented were taken for granted in my own college training ending in 1949. (D)

> About half of the participants were from government agencies (including the military) using engineering hardware or its development. Those individuals working in government contract areas had an excellent opportunity to become better acquainted with the government people and vice versa, which should have been helpful to both. There was a very little overlap of work interest between me and most of the other participants in the course. (E)

The wide range of participant interest and background makes it difficult to develop one program which will satisfy all persons. The general objectives for a program may be acceptable to many, but the detailed subject matter will not satisfy everyone.

Objectives and Effectiveness of Program

The general objectives for the MEC have been presented in Chapter II. An open-ended question was placed on the questionnaire to determine what the participants felt the program would accomplish. After hand coding the responses, the following list of objectives were obtained from the five programs surveyed:

1. Update self on modern engineering concepts and techniques.
2. Learn how to use new concepts in solving engineering problems.
3. Become aware of material in present engineering curriculum which will aid in the understanding and utilization of new graduate engineers.
4. Obtain specific knowledge that could be used in job performance (computers, mathematics, electronics, etc.)
5. Help person to become a more effective manager, to gain confidence.
6. Improve ability to communicate with others on new engineering concepts.
7. Learn enough about new engineering concepts to suggest use in the organization. Did not expect to become personally adept at using new concepts.
8. Stimulate intellectually and encourage analytic thinking.
9. Evaluate program and staff to see if it would be useful to others in organization.
10. Provide a non-engineer with some engineering background.
11. Review basic engineering fundamentals and examine in the light of experience.

12. Did not know what to expect.
13. Broaden background into fields other than own.
14. Stimulate further study and self-development.
15. Help engineering manager look into future.
16. Acquire reference materials (books, notes, etc.).

The next question requested an indication of how effective the respondent thought the program was in accomplishing what he thought it would before attending the program. The results for this question are indicated in Table 9. The mean response for all groups indicates that the programs were a little better than moderately effective. The largest percentage of responses (31 percent) tended to be somewhat more favorable in attitude. The chi-square test indicates a similarity between groups on this item.

In order to obtain the feelings of the respondents to the program as related to the number of years out of school, four separate questions were posed. How beneficial do you feel the program would be to engineers that had been out of school for differing amounts of time (four categories)? The results for this query are shown in Tables 10, 11, 12 and 13. The mean response for all programs indicates that the program is more beneficial for those out of school for the greater number of years. The chi-square tests indicates similarity between groups only in the five to nine year category. While compiling the data, it was observed that quite a few of the respondents indicated a trend opposite to that just stated. Some felt that the program became less valuable as the years out of school increased. The writer speculates that these persons may have felt that the material covered is more difficult to comprehend as the years roll by. This

TABLE 9

EFFECTIVENESS OF PROGRAM IN TERMS OF PERCEIVED OBJECTIVES (Q2)

Effectiveness		Participant Response (Percent)					
		Program					All Programs
		A	B	C	D	E	
Slightly effective	(1)	1	0	0	12	0	2
	(2)	0	3	4	0	4	2
	(3)	5	3	8	19	0	5
	(4)	5	3	8	12	4	5
Moderately effective	(5)	9	8	13	4	10	8
	(6)	18	16	21	15	15	17
	(7)	15	25	13	15	15	17
	(8)	37	29	25	23	28	31
	(9)	7	10	4	0	17	9
Extremely effective	(10)	3	3	4	0	7	4
N		101	59	24	26	46	256
Mean response		6.82	6.90	6.21	5.19	7.15	6.68
Standard deviation		1.75	1.78	2.04	2.40	1.90	1.95

$\chi^2 = 24.33$ d.f. = 16 Accept the null hypothesis at the 0.05 level.

TABLE 10

VALUE OF PROGRAM TO ENGINEERS OUT OF SCHOOL ONE TO FOUR YEARS (Q39a)

Value	Participant Response (Percent)					
	Program					All Programs
	A	B	C	D	E	
Not at all beneficial (1)	35	39	42	39	24	34
Slightly beneficial (2)	36	46	58	35	44	41
Moderately beneficial (3)	15	5	0	4	28	13
Considerably beneficial (4)	4	3	0	8	2	4
Extremely beneficial (5)	4	2	0	14	0	4
No response	6	5	0	0	2	4
N	101	59	24	26	46	256
Mean response	2.01	1.77	1.58	2.27	2.09	1.96
Standard deviation	1.05	0.85	0.50	1.46	0.79	0.99

$x^2 = 16.46$ d.f. = 8 Reject the null hypothesis at the 0.05 level.

TABLE 11

VALUE OF PROGRAM TO ENGINEERS OUT OF SCHOOL FIVE TO NINE YEARS (Q39b)

Value	Participant Response (Percent)					
	Program					All Programs
	A	B	C	D	E	
Not at all beneficial (1)	2	2	0	8	2	2
Slightly beneficial (2)	19	27	45	26	24	25
Moderately beneficial (3)	52	45	42	50	54	50
Considerably beneficial (4)	15	19	13	12	20	16
Extremely beneficial (5)	8	2	0	4	0	4
No response	4	5	0	0	0	3
N	101	59	24	26	46	256
Mean response	3.08	2.91	2.67	2.77	2.91	2.94
Standard deviation	0.87	0.79	0.70	0.91	0.72	0.82

$x^2 = 7.13$ d.f. = 8 Accept the null hypothesis at the 0.05 level.

TABLE 12

VALUE OF PROGRAM TO ENGINEERS OUT OF SCHOOL TEN TO FOURTEEN YEARS (Q39c)

Value	Participant Response (Percent)					
	Program					All Programs
	A	B	C	D	E	
Not at all beneficial (1)	0	0	0	8	2	1
Slightly beneficial (2)	6	2	0	19	2	5
Moderately beneficial (3)	29	30	46	50	39	35
Considerably beneficial (4)	44	46	46	23	39	41
Extremely beneficial (5)	19	17	8	0	18	16
No response	2	5	0	0	0	2
N	101	59	24	26	46	256
Mean response	3.77	3.82	3.62	2.88	3.67	3.66
Standard deviation	0.83	0.74	0.65	0.86	0.87	0.84

$x^2 = 18.24$ d.f. = 8 Reject the null hypothesis at the 0.05 level.

TABLE 13

VALUE OF PROGRAM TO ENGINEERS OUT OF SCHOOL FIFTEEN OR MORE YEARS (Q39d)

Value	Participant Response (Percent)					
	Program					All Programs
	A	B	C	D	E	
Not at all beneficial (1)	2	2	0	15	4	4
Slightly beneficial (2)	8	7	4	12	2	6
Moderately beneficial (3)	9	15	29	35	18	16
Considerably beneficial (4)	39	37	50	19	35	37
Extremely beneficial (5)	39	34	17	15	41	34
No response	3	5	0	4	0	3
N	101	59	24	26	46	256
Mean response	4.07	4.00	3.79	3.08	4.06	3.93
Standard deviation	1.00	0.99	0.78	1.29	1.04	1.06

$\chi^2 = 23.84$ d.f. = 8 Reject the null hypothesis at the 0.05 level.

thought was expressed by some respondents in their additional comments:

> The program should be divided in levels corresponding to the number of years a person has been away from technical education. The rate of technological growth in the past fifteen years has been drastic and to fill the fifteen or even ten-year gap in one step is not feasible. (A)

> Having been out of college 25 years prior to taking this course, I found the instructors covered the theory too fast for me to comprehend, especially in advanced mathematics. (C)

> I thought that this program would give me a general overview as to new engineering techniques, theories, and applications. Instead, I believe it was too much in depth and detail and beyond the capabilities of all except those participants just out of school or those who have remained active in practicing engineering. (D)

The objectives for the program, as stated by the participants, tend to indicate an attitude which is pragmatic. The participants tend to look for some type of pay-off after attending the program. The senior engineering personnel attending programs of this type are busy people and are interested in improving their job performance. At this point it can be assumed that the programs are more than moderately effective, although they may tend to be oriented such that the older engineers have difficulty with the subject material, especially if mathematical.

Specific Benefits from MEC

As pointed out in the previous section, most of the participants expect some tangible benefits from the program. A number of items on the questionnaire seek to establish some concrete benefits derived from the program. Table 14 shows what the respondents felt were the most beneficial areas covered in the programs. The general category of new engineering methods and techniques

TABLE 14

AREA OF KNOWLEDGE MOST BENEFICIAL TO WORK (Q9)

Area of Knowledge	Participant Response (Percent)					
	Program					All Programs
	A	B	C	D	E	
Mathematical concepts and techniques (1)	3	15	21	19	7	10
Use of computers (2)	14	24	21	0	9	15
New engineerings methods and techniques (3)	65	42	33	62	56	54
All material equally beneficial (4)	13	17	17	19	24	17
Others (5)	4	0	8	0	4	3
No response	1	2	0	0	0	1
N	101	59	24	26	46	256

received the greatest support (54 percent). Some of the write-in responses are given below:

> Knowledge concerning abilities of young engineers. (A)
>
> Better awareness about what assistance could be expected from experts in each engineering specialty. (A)
>
> Man-made materials. (A)
>
> Statistical testing techniques. (A)
>
> Have not used any new knowledge except in a background sense. (C)
>
> It renewed my problem-solving technique. (E)

A more general question asked how many ways the program helped the participant. Table 15 indicates the response data. The total for all programs

indicates that the following benefits were foremost:

> Improved ability to communicate with others in the organization in technical matters. (5)
>
> Broadened engineering viewpoint to include the interrelations of various specialties. (8)
>
> Became aware of modern engineering techniques and concepts which have proved beneficial to job performance. (7)

When asked to rank the top three items which proved most beneficial, the same three items as indicated above were rated above all others.

Some of the write-in responses included:

> Made me aware of school's good facilities and the competence of the teaching staff. (A)
>
> Gave me an increased awareness of personnel in my own company. (A)
>
> Helped me to challenge younger engineers to use new techniques. (A)
>
> Provided some time and environment to review personal goals and philosophies. (B)
>
> Improved level of competence in chemistry and physics to better aid children in understanding high school sciences. (B)
>
> Learned enough algebra "set theory" or calculus to help my eighth grade children. (C)
>
> Gained insight into modern engineering teaching methods. (D)
>
> Provided a big improvement in my self-confidence in dealing with engineering problems. (E)
>
> Increased confidence in technical ability. (E)

The use of computers and modern mathematical techniques was a part of all the programs in the survey. The respondents were asked to indicate if

TABLE 15

WAYS PROGRAM HELPED PARTICIPANTS (Q12)

Way	Participant Response (Percent)					
	Program					All Programs
	A	B	C	D	E	
Provided encouragement to take other courses (1)	18	15	29	4	13	16
Encouraged further reading and study in specific areas (2)	46	76	38	39	48	52
Gained specific knowledge which could be directly applied to work (3)	34	51	46	8	35	36
Reviewed material once known so as to be usable again (4)	47	58	63	39	52	51
Improved ability to communicate with others in the organization in technical matters (5)	72	64	63	46	78	68
Provided personal contacts with participants which have been useful to job function (6)	33	58	42	42	28	40
Became aware of modern engineering techniques and concepts which have proved beneficial to job performance (7)	55	63	54	46	61	57
Broadened engineering viewpoint to include the interrelations of various specialties (8)	60	61	42	54	76	61
Helped to develop an attitude which encourages the use of modern engineering concepts (9)	58	54	46	50	54	55
Other (10)	5	5	13	4	4	6
N	101	59	24	26	46	256

the program had resulted in an increased use of computers or mathematics in their area of responsibility. Table 16 indicates that 75 percent of the total sample felt the program caused only a slight increase or no increase.

TABLE 16

EFFECT OF PROGRAM ON THE USE OF COMPUTERS (Q3)

Effect	Participant Response (Percent)					
	Program					All Programs
	A	B	C	D	E	
No increase (1)	39	31	29	65	61	43
Slight increase (2)	41	27	38	23	24	32
Moderate increase (3)	17	25	21	12	11	18
Great increase (4)	3	17	8	0	4	7
No response	0	0	4	0	0	0
N	101	59	24	26	46	256
Mean response	1.85	2.29	2.09	1.46	1.59	1.89
Standard deviation	0.82	1.08	0.95	0.71	0.86	0.93

$\chi^2 = 26.44$ d.f. = 8 Reject the null hypothesis at the 0.05 level.

A moderate or great increase is suggested by 25 percent of the sample in the use of computers. Write-in responses, placed in the margin of the questionnaire, suggest that in some cases the minor increase could be attributed to an existing significant use of computers. The chi-square test indicates a difference between groups on this item. Table 17 shows that 84 percent of the respondents indicate only a slight increase or no increase in the use of mathematics. Only 16 percent indicate a moderate or great increase. Whether or

not an increased use of mathematics is necessary for improved job performance is another question. The chi-square test indicates that all the programs responded similarly on this item.

TABLE 17

EFFECT OF PROGRAM ON THE USE OF MATHEMATICS (Q4)

Effect	Participant Response (Percent)					
	Program					All Programs
	A	B	C	D	E	
No increase (1)	47	31	38	58	46	43
Slight increase (2)	38	51	42	30	39	41
Moderate increase (3)	13	18	16	12	15	15
Great increase (4)	2	0	4	0	0	1
No response	0	0	0	0	0	0
N	101	59	24	26	46	256
Mean response	1.71	1.88	1.88	1.54	1.70	1.75
Standard deviation	0.78	0.70	0.85	0.71	0.73	0.75

$\chi^2 = 7.28$ d.f. = 8 Accept the null hypothesis at the 0.05 level.

In Chapter I, the engineer's difficulty in keeping up with the technical literature was discussed. It has been proposed that one of the engineer's difficulties is his inability to understand the newer terminology and mathematics. The respondents were asked if the MEC increased their ability to understand technical articles related to their work. Table 18 shows that 64 percent of the total sample felt the program caused a moderate increase or great increase in the ability to understand technical articles. A slight or no increase is indicated

by 36 percent of the total. The chi-square test indicates no significant differences in the responses from the different programs.

TABLE 18

EFFECT OF PROGRAM ON ABILITY TO UNDERSTAND TECHNICAL ARTICLES (Q5)

Effect	Participant Response (Percent)					
	Program					All Programs
	A	B	C	D	E	
No increase (1)	5	9	0	8	4	6
Slight increase (2)	30	22	50	39	26	30
Moderate increase (3)	49	62	37	49	63	53
Great increase (4)	16	7	13	4	7	11
No response	0	0	0	0	0	0
N	101	59	24	26	46	256
Mean response	2.76	2.68	2.63	2.50	2.72	2.70
Standard deviation	0.78	0.73	0.71	0.71	0.66	0.73

$x^2 = 11.59$ d.f. = 8 Accept the null hypothesis at the 0.05 level.

The MEC is designed to give the participants a broad overview of modern engineering concepts and techniques. If the program makes the engineering manager aware of the new subject material, it is likely that he would suggest the use of particular information in his organization. The respondents were asked to indicate to what extent the program resulted in the application of new concepts or techniques in their organization. Table 19 illustrates the response to this question. Of the total sample, 38 percent indicate application

to a little extent or not at all while 62 percent respond that material was applied to some extent or a great extent. The chi-square test indicates no significant difference between groups on this item.

TABLE 19

EXTENT PROGRAM ENCOURAGED APPLICATION OF NEW CONCEPTS OR TECHNIQUES IN ORGANIZATION (Q6)

Effect	Participant Response (Percent)					
	Program					All Programs
	A	B	C	D	E	
Not at all (1)	7	9	4	23	11	9
Little extent (2)	26	27	38	31	30	29
Some extent (3)	55	59	41	42	55	54
Great extent (4)	11	5	17	4	4	8
Very great extent (5)	1	0	0	0	0	0
No response	0	0	0	0	0	0
N	101	59	24	26	46	256
Mean response	2.73	2.61	2.71	2.27	2.52	2.62
Standard deviation	0.79	0.72	0.81	0.87	0.75	0.78

$x^2 = 10.06$ d.f. = 8 Accept the null hypothesis at the 0.05 level.

Another question asked how much of the material was made clear enough that the participant could suggest further investigation within the organization. Table 20 shows that 61 percent felt that at least one-half or more of the material was made clear enough to suggest further investigation. The chi-square test indicates no significant difference between programs. In order to search out

concrete examples of the program material stimulating organizational investigations, write-in examples were solicited. Although it is difficult to attach any specific value to the individual responses, the fact that the respondents were able to present specific cases is significant.

TABLE 20

AMOUNT OF PROGRAM MATERIAL MADE CLEAR ENOUGH TO SUGGEST FURTHER INVESTIGATION IN ORGANIZATION (Q7)

Amount	Participant Response (Percent)					
	Program					All Programs
	A	B	C	D	E	
Practically none (1)	2	3	8	15	4	5
Little (2)	27	31	54	39	30	32
About half (3)	34	35	17	34	25	31
Much (4)	27	24	17	8	37	25
Practically all (5)	7	5	0	4	4	5
No response	3	2	4	0	0	2
N	101	59	24	26	46	256
Mean response	3.10	2.96	2.43	2.46	3.06	2.94
Standard deviation	0.96	0.95	0.90	0.99	1.02	0.99

$x^2 = 20.20$ d.f. = 12 Accept the null hypothesis at the 0.05 level.

The following compilation shows the number of examples given by the respondents for each program along with some of the write-in statements.

Program A: Examples given by 38 respondents.

Statistical analysis applied to tolerancing specific components in an assembly may reduce costs by reducing tight tolerances which are held for no valid reason.

Improved knowledge in specialized electronics helpful in new product design.

Use of computer in designing heat exchanger for new engine was applicable to our heat exchanger design for preheating cupola blast air.

Session on analog computers led to a direct suggestion and follow-up which incorporated analog principles into a program that was underway. Consultation with program staff personnel helped us.

Use of new plastic forming processes. Use of new metal forming processes. Use of reclamation processes.

Use of statistical methods in planning and evaluation of experiments and testing.

Manufacturing process monitoring by means of computers.

Plastics processing. We sent a man to school for a week program to learn more.

Matrix test selection techniques are now used routinely. Ceramic materials are now being considered for high-volume production.

Hot flowability of steel.

X-ray viewing and photography of dynamic phenomenon. Lasers.

Suggested specific line of investigation in the solution of a gun mount seal problem involving a materials processing and testing review.

Construction of a test matrix to reduce number of tests required to obtain required test data.

Proposed fluidics to the physical test lab for consideration.

Laser measurement. Numerical control for layout inspection.

Program B: Examples given by 36 respondents.

Use of time-sharing computer was accelerated because it was introduced on our course.

Used time share and Fortran to program software for computer controlled tandem mill and BOF systems for steel industry.

Probability and statistics led to better understanding of computer runs of existing analytical programs. I was also more competent in the instruction of my subordinates in analyses.

High-temperature plastics -- now applied in production heaters for synthetic fibers.

Used digital sampling techniques to develop a new turbine start-up system. The program was not the sole source of ideas but suggested some new approaches.

The use of the computer in areas in which we had not previously seen the need or application. The calculation of the calibration of a new radio dial, for example.

Use of decision analysis in evaluating a make or buy problem with mineral insulated cable.

Greater application of time sharing and investigation of interactive computer graphics for our design and analysis work. Significant advances have been made recently in application of interactive computer graphics in our department.

Found all data on "probability and statistics" very useful. Used this data, in my office, for application to factory facility planning.

Lectures on eye-brain sensory system led to increased emphasis in my group on multi-spectral sensor systems.

Have used experimental design in planning development test work.

Feedback control. Use of unit pulses in analysis of system response was a new concept which has been used as a result of the course.

We made additional use of probability theory in predicting M.T.B.F. of products from limited testing.

Use of matrix operations in analysis of product planning.

Program C: Examples given by seven respondents.

Application of computers to design heating and air conditioning duct systems.

Mathematical modeling of process system.

Requested the development of a comprehensive material and energy balance computer program.

Our use of computer time-sharing techniques was initiated as a result of this training. This has led to a greatly expanded facility making this mode of operation extremely easy for all to use.

Time sharing on the computer with remote teletype console is now common because our group became very strong advocate after MEC.

Program D: Examples given by five respondents.

Optimization -- Statistics (Reliability).

Kinetics of exothermic reactions.

Enabled me to suggest possible approaches to complex problems to which I had not previously realized were solvable problems.

Program E: Examples given by 16 respondents.

Stimulated development of computerized matrix calculation of stresses and strains in a complex machine structure.

Mathematical modeling; matrix analysis; adaptation of mini-computer to process control; new concepts of systems analysis.

Ability of hybrid systems; part of instructor's theory of communications systems also useful.

Information theory lead to recommendation in better use of military allocated frequency spectrum.

Use of large scientific computers for adjusting a global geodetic network.

Investigation of hybrid computers in test simulations work.

Matrix approach to analysis of structural problems.

The next question asked the respondents if the program resulted in a direct financial savings to their organization. Table 21 indicates that 69 percent of the sample felt that financial savings to the organization were accomplished due to participation in the MEC. Only 26 percent indicated no savings. The chi-square test indicates no significant difference between programs on this item.

TABLE 21

EXTENT PROGRAM RESULTED IN FINANCIAL SAVINGS TO ORGANIZATION (Q8)

Extent	Participant Response (Percent)					
	Program					All Programs
	A	B	C	D	E	
Not at all (1)	24	25	13	39	30	26
Little extent (2)	33	29	33	39	33	32
Some extent (3)	32	35	46	14	33	33
Great extent (4)	2	9	8	0	2	4
Very great extent (5)	1	0	0	0	0	0
No response	8	2	0	8	2	5
N	101	59	24	26	46	256
Mean response	2.17	2.28	2.50	1.75	2.07	2.17
Standard deviation	0.88	0.95	0.83	0.74	0.86	0.89

$x^2 = 10.13$ d.f. = 8 Accept the null hypothesis at the 0.05 level.

It is difficult for engineering personnel to determine if financial savings are accomplished, but a number of examples were indicated by the write-in responses.

Program A: Examples given by 20 respondents.

Information picked up in the program helped to develop a graphical technique for presenting budget requirements to management in a more effective manner.

My involvement in cupola emission control program allowed ideas gained to be applied for a substantial economic savings in capital investment.

Solid-state electrical control circuits for gaging and machine controls. Space and maintenance savings.

New plastic and reclamation processes.

Better techniques in experimental testing undoubtedly results in some savings.

Projects incomplete at this time. Anticipated gain is great.

Matrix concepts have reduced the number of tests and experiments required to "prove" design. Example: piston ring oil consumption tests to qualify vendor reduced from more than 100 to 32.

We made better use of our limited amount of numerical controlled machinery.

Informal relationship with faculty of program greatly expedited parts testing program I was working on.

Not yet, but some savings may occur as some techniques are implemented.

Increased use of static controls on mold lines. Probably reduced downtime up to five percent.

Developed first comprehensive computer scrap program at plant. Reduced losses, errors, and defects. Exception reporting utilized for the first time.

Program B: Examples given by 29 respondents.

Computer application to drive interactive displays which aided acquisition of new business.

Association with others in the class has fostered an exchange of information.

Through the use of probability and statistics we were better able to recognize process variables were a problem and could take action sooner before things went out of control.

The use of digital sampling techniques to develop a new turbine start-up system was patented. License agreements resulted in direct income.

The computer method mentioned above for the calculation of the calibration of a new radio dial is the best example here also. Long-hand calculations of calibration scales made for each capacitor have been computerized.

I am a more effective manager, because I have more self-confidence and a better grasp of unification of many branches of engineering.

Gave us confidence to embark on a design automation program.

We have made more use than before of statistical methods in the analysis of operating characteristics. One man has been assigned to obtain a reasonable degree of competence in statistical analysis.

Through ability to use time sharing to perform more complex calculations in hours instead of hiring more formal computing services outside.

I organized and conducted a course in time-shared computer use and also in related mathematical techniques for approximately ten associates.

Business planning venture using statistical analysis and decision making techniques allowed existing data to be used as decision to enter business.

Program C: Examples given by six respondents.

Possibly a better usage of "New Hires" engineers.

Early participation in use of programs (computer) for structural analysis by members of the group working for me.

We are now scheduling our manpower, materials, time keeping, and pay by computer. Probably replaced one man in the scheduling area.

Utilization of time sharing on the computer has more than returned the cost of the program in increased efficiency, not only in time, but in ability to solve complex problems.

Program D: Examples given by two respondents.

Greater variety of computer programming to solve problems.

Better organization of analytical work.

Program E: Examples by 15 respondents.

Design and development of highly efficient production systems.

Simulation has been substituted for material testing.

Access to instructors for consultant work.

Initiation of the use of PERT and engineering concepts not previously used.

I had a simulation program written to assist us in designing a unique type of electronic circuit. The program is still in use.

Specific example difficult to identify, however, I have persuaded company management to support tuition reimbursement for all engineers taking graduate courses as a direct result of attending this course. I believe this has significantly increased our overall technical capability.

> I became better able to direct the activities of young engineers in our company and to understand young engineers (often with doctorates) who are employed by our customers.

The considerable number of examples presented here indicate that the program did have a direct effect on many of the participants' organizations. Although it is difficult to express this effect in monetary terms, there is a strong suggestion that the program was beneficial to all the sponsoring organizations.

Course Materials

All of the MEC participants received notes or books which were a part of the total program. In order to determine the value of the program materials, a series of questions were posed.

The first question asked how many times the participant had referred to the program materials in the performance of his job responsibilities since completing the course. Table 22 shows that 91 percent of the sample have used the program materials since completing the program. Only 9 percent indicate no use. The chi-square test shows differences between programs in this respect. The three longer programs (B, C, and E) which issued books and notes tend to show a mean response greater than the two shorter programs (A and D) which issued notes only.

Table 23 presents data to illustrate how the program materials were utilized. Sixty-five percent of total sample indicated that the notes provided general information which provided a talking knowledge of a subject. The two other categories, specific information and useful references, received only about one-half of the response as that for general information.

TABLE 22

NUMBER OF TIMES PROGRAM REFERENCE MATERIALS REFERRED TO BY PARTICIPANT AFTER PROGRAM (Q13)

Number of Times Referred To	Participant Response (Percent)					
	Program					All Programs
	A	B	C	D	E	
0 (1)	8	3	13	31	4	9
1 - 4 (2)	49	22	25	42	33	37
5 - 10 (3)	34	46	28	23	30	34
11 - 25 (4)	6	17	21	0	24	13
26 or more (5)	3	12	13	0	9	7
No response	0	0	0	4	0	0
N	101	59	24	26	46	256
Mean response	2.46	3.12	2.96	1.92	3.00	2.70
Standard deviation	0.84	1.00	1.23	0.76	1.05	1.02

$x^2 = 39.87$ d.f. = 8 Reject the null hypothesis at the 0.05 level.

TABLE 23

USE OF PROGRAM REFERENCE MATERIALS (Q14)

Use	Participant Response (Percent)					
	Program					All Programs
	A	B	C	D	E	
Specific information directly applicable to work (1)	21	63	46	15	46	37
Useful references given to other sources (2)	40	37	33	23	35	36
General information which provided a talking knowledge of a subject (3)	69	68	50	42	70	65
Other	3	5	8	4	4	4
N	101	59	24	26	46	256

In one case the participant utilized the materials to conduct a class in his own organization. This would typify the ideal situation where one person is stimulated by a program to the extent that he will actively work to pass the new information along to others in the organization.

Table 24 illustrates the value of the program materials when they were utilized. Fifty-nine percent of the total sample indicate that the materials were moderately or greatly useful. Only one percent felt that the materials were not at all useful. The chi-square test indicates a similarity between groups on this item.

TABLE 24

VALUE OF PROGRAM REFERENCE MATERIALS (Q15)

Value	Participant Response (Percent)					
	Program					All Programs
	A	B	C	D	E	
Not at all useful (1)	1	0	0	4	0	1
Slightly useful (2)	37	22	42	31	33	32
Moderately useful (3)	47	55	32	27	52	47
Greatly useful (4)	8	20	13	12	11	12
No response	7	3	13	26	4	8
N	101	59	24	26	46	256
Mean response	2.67	2.98	2.67	2.63	2.77	2.76
Standard deviation	0.64	0.67	0.73	0.83	0.64	0.68

$x^2 = 11.06$ d.f. = 8 Accept the null hypothesis at the 0.05 level.

Table 25 shows how many times other personnel in the participant's organization utilized the program materials. Thirty-four percent indicate that no other personnel in the organization used their program materials. Sixty-four percent have had other personnel use the materials at least once. The chi-square test indicates a significant difference between programs on this item. It should be noted that Programs B, C and E provided books and notes while Programs A and D provided notes only. Programs B, C and E are ahead of the other two programs in this area.

TABLE 25

NUMBER OF TIMES PROGRAM REFERENCE MATERIALS REFERRED TO BY OTHERS AFTER PROGRAM (Q16)

Number of Times Material Used by Others	Participant Response (Percent)					
	Program					All Programs
	A	B	C	D	E	
0 (1)	35	25	46	46	30	34
1 - 4 (2)	52	44	25	42	44	45
5 - 10 (3)	11	20	25	0	13	14
11 - 25 (4)	0	9	0	0	7	3
26 or more (5)	1	2	4	0	4	2
No response	1	0	0	12	2	2
N	101	59	24	26	46	256
Mean response	1.79	2.17	1.92	1.48	2.09	1.92
Standard deviation	0.71	0.97	1.06	0.51	1.06	0.89

$x^2 = 20.94$ d.f. = 8 Reject the null hypothesis at the 0.05 level.

The participants were asked to make suggestions which might improve the utility of the program notes or other materials. Some of the comments were:

A "graduate" from the program might benefit from receiving updated material and notes from succeeding programs. (A)

Summarize the important information. (A)

Need a better index. Must rely on memory to find a specific piece of information. Takes too long to find it. (A)

Prepared abstracts should be distributed before class. (A)

They should cover all material presented in lectures and, if possible, additional material. In some cases the notes are too brief. (A)

Reduce the mathematical derivation of formulas. Relate formulas to practical uses. (A)

Outline and summary type notes proved most useful. (A)

Reduce mathematical presentation; add application samples; add names and addresses of engineers who have developed and/or used the techniques. (B)

Generally, the notes are too abbreviated to be helpful specifically. In-depth treatment in text must be used. (B)

I have never taken the time to index these notes. Such an index would be most valuable. (B)

Include as many numerical examples as possible. (B)

Notations should be defined and be more consistent between different speakers. (B)

Notes should be available in advance of lecture date, and should be followed by the lecturer. (B)

Shorten and simplify. (B)

More communication. Bibliographies with short descriptions of material. (B)

All courses to have printed notes. Personal notes not complete and difficult to review. (C)

Provide notes for all subjects covered. (C)

Provide notes earlier in program. (C)

Provide a transition between theory and practical applications. (C)

More practical examples and concise principles. (D)

Notes were of varying quality and were handed out by each instructor. Much better if booklets for notes and material were passed out each week. (D)

. . . Some of the prepared notes were much better than others. Some were too sketchy and others took the form of a manuscript for a book useful as a text perhaps, but not as notes. (E)

More bibliography. (E)

A widely known electronics engineering handbook or reference book would have been useful. (E)

Program notes of this type are more useful for future reference if attention is given to the organization of the set of notes. (E)

Overall index of subject material. (E)

These comments indicate some avenues for improvement in the notes handed out during a program. The utilization of program notes would appear to be a function of how well they are indexed.

The data pertaining to the program reference materials indicate that they are utilized to some extent after completing the program. The materials are used more by the individual participant than others in the organization. The materials are classified as being less than moderately useful and are mainly used for general information.

Course Content

When developing a course for a wide spectrum of participants, it is difficult to determine the subject material to be covered or the level at which

it should be presented. The participants were asked to express their opinions as to the type of material covered and the level of presentation. Table 26 shows that 17 percent feel that the material should be more related to their work and 50 percent tend to want the material to be of a wide variety. The chi-square test shows a difference between programs in this area. The mean response for the total sample also indicates that the subject material should tend to the wide variety.

TABLE 26

DESIRABILITY OF HAVING PROGRAM MATERIAL RELATED TO WORK OR OF THE WIDE VARIETY (Q29)

Desired Quality	Participant Response (Percent)					
	Program					All Programs
	A	B	C	D	E	
All material related to one's work (1)	0	0	0	4	7	2
Most material related to work (2)	13	14	17	15	20	15
About half and half (3)	36	20	54	50	24	33
Most of the wide variety (4)	37	42	21	23	29	34
All of the wide variety (5)	14	24	8	4	20	16
No response	0	0	0	4	0	0
N	101	59	24	26	46	256
Mean response	3.53	3.76	3.21	3.08	3.37	3.48
Standard deviation	0.90	0.97	0.83	0.86	1.20	0.98

$x^2 = 23.28$ d.f. = 12 Reject the null hypothesis at the 0.05 level.

Table 27 indicates the opinions of the respondents to the level of presentation. Fifty-one percent of the total sample feel that the presentation should be about half theory and half applied. Twelve percent lean to the theoretical side while 35 percent tend to want more application. The chi-square test shows a significant difference between programs.

TABLE 27

DESIRED BALANCE BETWEEN THEORETICAL AND APPLIED COURSE MATERIAL (Q30)

Desired Balance	Participant Response (Percent)					
	Program					All Programs
	A	B	C	D	E	
All theoretical (1)	0	0	4	0	0	0
Mostly theoretical (2)	8	20	17	4	11	12
Half theory - half applied (3)	52	51	54	39	61	51
Mostly application (4)	37	24	25	53	26	33
All application (5)	2	2	0	0	2	2
No response	1	3	0	4	0	2
N	101	59	24	26	46	256
Mean response	3.34	3.07	3.00	3.52	3.20	3.24
Standard deviation	0.65	0.73	0.78	0.58	0.65	0.69

$x^2 = 15.70$ d.f. = 8 Reject the null hypothesis at the 0.05 level.

Comments pertaining to this area of investigation include:

I liked the idea of covering a wide variety of material. There is just not enough time with a group to go into specific areas in sufficient detail to give anyone knowledge he can apply. (A)

The mathematical derivations were overdone, although not as much as many complained. Teachers seem to have an obsession with proving everything and deriving all the formulas. (A)

The variety of subjects were new and interesting. Many touched on new theories and concepts that were informative and current. Too much time was used to derive these concepts. Too little time was used to discuss how these concepts could be applied in resolving everyday engineering problems. (A)

Recommend consideration of several courses with each course to cover an engineering phase. Each course might include two or three closely related subjects. (A)

My greatest criticism is that the program included too much advanced mathematical work. The lecturers on these subjects took far too much time proving mathematical discussion in detail. There was little or no discussion on the relevance of much of this work. (B)

I felt that this program was too mathematical for managers and did not have enough references to people and papers written by experts in the field for technical specialists. It was presented in a manner which is used in the universities for teaching students and does not take into account that the course participants are skilled experienced people looking for information which they can use in their own fields of endeavor. (B)

I believe the MEC is slanted too heavily towards the theoretical. This is fine if the people attending are in the Research and Development area. However, I believe that a number of the subjects could have been eliminated and replaced with more application type work. (B)

To be most effective the instructors should be aware of the everyday problems that an engineer must solve in industry and his class materials and instruction should relate, to a considerable extent, to problem solving. (C)

> I felt that many of the lectures were too long and deep. Too much time was spent deriving fundamentals and very little time used to apply techniques. I would suggest that derivations be written ahead of time and a little time spent reviewing. More time should be spent on applications. (C)
>
> I believe one aspect that could stand improvement was the portion presented by the University Staff. Generally, their presentations tended to be too theoretical: too "cook-book" like in their delivery of the material. That type of presentation may be great for a college student, but is not adequate for experienced engineers who are keenly aware of the compromises and shortcomings of the purely theoretical approach. (D)
>
> It is obvious that all subjects cannot be presented with strong practical application; however, those instructors with the combined academic-practical backgrounds made the greatest contribution to understanding. (D)
>
> Although I enjoyed the course in modern engineering, it frankly did not come up to my expectations. I felt that too much class time was spent on solving complex equations and demonstration proofs of fundamental theorems. I would have preferred more discussions as to the meaning and uses of the fundamental ideas and equations. (E)
>
> One suggested improvement does come to mind. Most of the presentations were quite theoretical, and very good, but did not effectively bridge the gap into practical application. (E)

These comments reflect a negative attitude toward the use of too much theory or detailed derivations. The difficulty in balancing out theory and application is a problem faced by the course coordinator. Since the participants are pragmatic in their outlook, it would be wise to include a considerable number of applications which substantiate the theory.

Course Length

The five programs which form the basis for the survey are all different in terms of total class time. The objectives for the program are generally the

same, but a ratio of over four-to-one exists between the longest and the shortest course. Table 28 shows the opinions of the sample which rate the influence of the program on the individual in relation to the program length. Twenty-four percent tend to feel the program was on the long side with 11 percent indicating it was on the short side. The mean response also indicates a tendency towards the too long category. The chi-square test does not indicate a significant difference between programs on this question.

TABLE 28

ASSESSMENT OF PROGRAM VALUE IN RELATION TO ITS LENGTH (Q26)

Program Length	Participant Response (Percent)					
	Program					All Programs
	A	B	C	D	E	
Too long (1)	4	10	17	19	9	9
Somewhat long (2)	12	19	8	19	17	15
About right (3)	70	64	63	38	67	64
Somewhat short (4)	10	7	8	12	7	9
Too short (5)	4	0	4	4	0	2
No response	0	0	0	8	0	1
N	101	59	24	26	46	256
Mean response	2.98	2.68	2.75	2.58	2.72	2.80
Standard deviation	0.73	0.75	0.99	1.10	0.72	0.81

$\chi^2 = 12.38$ d.f. = 8 Accept the null hypothesis at the 0.05 level.

Time for Discussion

Table 29 indicates the feelings of the sample to the amount of time provided to answer questions or continue discussions on program subject material. Seventy-one percent indicate the amount of time provided was about right with 25 percent feeling that more time should be provided. The mean response also indicates a tendency to require more time for questions and discussions.

TABLE 29

ADEQUACY OF PROGRAM TIME DEVOTED TO QUESTIONS AND DISCUSSIONS (Q27)

Time Allotted	Participant Response (Percent)					
	Program					All Programs
	A	B	C	D	E	
Need a great deal more time (1)	4	9	4	8	4	6
Need somewhat more time (2)	19	17	38	23	15	19
About right (3)	75	70	54	61	79	71
Spent too much time discussing (4)	0	2	4	4	2	2
No response	2	2	0	4	0	2
N	101	59	24	26	46	256
Mean response	2.73	2.67	2.58	2.64	2.78	2.70
Standard deviation	0.53	0.66	0.65	0.70	0.55	0.59

Participants and Technological Change

Since the MEC was designed to update managers in the newer technology, it was deemed appropriate to ask questions related to this area. Does the participant feel that his greatest job difficulty is wondering whether or not up-to-date techniques and concepts are being utilized? Table 30 shows the response to this question. The greatest percentage of the sample (33 percent) felt that their greatest problem was getting others to accept new concepts. Determining job priorities and wondering about up-to-date concepts were next in problem areas.

TABLE 30

GREATEST DIFFICULTY IN PERFORMING JOB (Q22)

Greatest Difficulty	Participant Response (Percent)					
	Program					All Programs
	A	B	C	D	E	
Wondering whether up-to-date techniques and concepts are being utilized (1)	20	12	8	14	9	15
Communicating with people on technical matters (2)	8	8	0	8	15	9
Trying to stay within the budget (3)	8	10	8	8	15	10
Determining job priorities (4)	11	24	17	19	17	16
Getting others to accept new concepts (5)	37	27	29	39	33	33
Other (6)	13	17	38	12	9	15
No response	3	2	0	0	2	2
N	101	59	24	26	46	256

Other problem areas included:

Personnel problems (hourly rated employes). (A)

Knowing that new methods exist but lacking the time and assistance to put them into effect. (A)

Lack of defined responsibility. (A)

Managing and developing my people. (A)

Finding people who can follow through on new concepts. (A)

Getting people to do a thorough job. (B)

Necessary management paper work. (B)

Having sufficient time to explore and exploit all the things I know how to do, or think would be useful. (B)

Too heavy work load. (B)

Motivating people. (C)

Just what is the problem I'm supposed to be solving? Often it is not the problem I'm told. (C)

Getting enough information to define the problem accurately and completely. (C)

Getting people to reach their potential. (D)

Job assignments not related to career goals. (E)

Getting people to exhibit initiative. (E)

Technical problems concern the engineering manager, but there are many personnel and operational problems which give some degree of difficulty.

The literature on engineering obsolescence makes use of the term half-life to refer to the rapid decrease in the engineer's ability to solve problems with knowledge gained in the past. It has been suggested that after 10 years the engineer's repertoire would be only 50 percent usable. Table 31 exhibits the

sample's reaction to this problem. Fifty-six percent of the total indicate that three-quarters or more of the technology known 10 years ago is still applicable to their work today. Forty-three percent feel that only half or less of the technology is applicable today. The chi-square test does not indicate any significant difference between programs on this question.

TABLE 31

AMOUNT OF TECHNOLOGY KNOWN TEN YEARS AGO THAT IS STILL APPLICABLE TODAY (Q23)

Amount Still Applicable	Participant Response (Percent)					
	Program					All Programs
	A	B	C	D	E	
None (1)	1	0	4	0	0	1
One-quarter (2)	9	15	8	19	9	11
One-half (3)	28	29	38	27	39	31
Three-quarters (4)	34	32	29	31	30	32
Almost all (5)	26	24	21	23	22	24
No response	2	0	0	0	0	1
N	101	59	24	26	46	256
Mean response	3.77	3.64	3.54	3.58	3.65	3.68
Standard deviation	0.98	1.01	1.06	1.06	0.92	0.99

$\chi^2 = 4.92$ d.f. = 12 Accept the null hypothesis at the 0.05 level.

Table 32 illustrates the pressure felt by the respondent to learn new technical knowledge or skills. Only six percent of the total indicate no pressure while 70 percent feel a moderate to very strong pressure to keep up with new developments. The chi-square test shows no significant differences between programs despite the fact that the participants' work ranges from automotive manufacturing to aerospace projects.

TABLE 32

PRESSURE TO LEARN NEW TECHNOLOGY (Q24)

Pressure	Participant Response (Percent)					
	Program					All Programs
	A	B	C	D	E	
None (1)	7	7	0	8	2	6
Slight (2)	28	17	33	27	15	23
Moderate (3)	30	35	46	34	33	34
Strong (4)	21	24	17	23	41	25
Very strong (5)	12	17	4	8	9	11
No response	2	0	0	0	0	1
N	101	59	24	26	46	256
Mean response	3.03	3.27	2.92	2.96	3.39	3.13
Standard deviation	1.13	1.14	0.83	1.08	0.93	1.07

$x^2 = 15.25$ d.f. = 12 Accept the null hypothesis at the 0.05 level.

Table 33 shows the participants have managed to keep up with the changes in technology. Eighty-five percent indicate that self-study has been the means for keeping up-to-date. Company sponsored courses and professional society activities are next in order with non-credit and credit college courses being used to a lesser degree.

TABLE 33

METHODS UTILIZED TO MEET CHANGING TECHNOLOGY (Q25)

Method	Participant Response (Percent)					
	Program					All Programs
	A	B	C	D	E	
Non-credit college courses (1)	26	12	25	39	35	25
Credit college courses (2)	19	5	13	19	20	15
Company sponsored programs (3)	75	64	75	69	52	68
Self-study (books, periodicals, personal contacts, travel, etc.) (4)	83	98	96	54	85	85
Professional society activities (5)	52	36	50	50	46	47
Other	6	12	4	4	9	7
N	101	59	24	26	46	256

Other methods for keeping up-to-date include:

Contact with colleges. (A)

Conferences in other fields, at schools, etc. (A)

Exposure through job changes. (A)

Discussion with experts in new technologies. (B)

Own research and development work. (B)

Sending subordinates to both credit and non-credit courses. (D)

Various short courses. (E)

Field contact with contemporaries. (E)

Much of the effort made by the managers to keep up-to-date falls into the informal categories of self-study and on-the-job learning.

Attitudes Toward MEC

The attitudes of the participants to the program can be measured to some extent by their perceptions of the group's participation. What part of the group attending the program seemed to apply themselves and attempted to get the most out of the program? The opinions to this question are shown in Table 34. Thirty-two percent of the total sample felt that one-half or less were applying themselves. Thirty percent indicated three-fourths and only 36 percent noted that all participants were attempting to get the most out of the program. The mean response shows a tendency to the view that about three-fourths of the participants were actively involved in the program. The chi-square test indicates a significant difference exists between programs on this item.

Attitude Toward TV or Film

Since only a small percentage of engineering managers are able to attend programs such as the MEC, the reaction of the sample to television or film was tested. The participants were asked to indicate their opinions with respect to the effectiveness of a canned program as opposed to the live version. Table 35 shows that only six percent felt that TV or film would be at least as effective as

TABLE 34

PARTICIPANTS' OPINIONS RELATED TO GROUP'S EFFORTS TO GET THE MOST OUT OF PROGRAM (Q28)

Number of Participants Applying Themselves to Program	Participant Response (Percent)					
	Program					All Programs
	A	B	C	D	E	
None (1)	0	0	0	8	0	1
One-fourth (2)	11	9	13	19	11	11
One-half (3)	16	27	21	23	20	20
Three-fourths (4)	29	43	17	19	26	30
All (5)	39	19	49	31	43	36
No response	5	2	0	0	0	2
N	101	59	24	26	46	256
Mean response	4.02	3.74	4.04	3.46	4.02	3.90
Standard deviation	1.02	0.87	1.12	1.33	1.04	1.05

$x^2 = 23.28$ d.f. = 12 Reject the null hypothesis at the 0.05 level.

TABLE 35

PARTICIPANT REACTION TO PROPOSED VIDEO TAPED OR FILMED VERSION OF PROGRAM (Q31)

Participant Reaction	Participant Response (Percent)					
	Program					All Programs
	A	B	C	D	E	
More effective than live program (1)	1	3	8	0	2	2
About the same as live program (2)	6	3	4	4	2	4
Somewhat less effective than live (3)	23	26	26	31	22	25
Much less effective than live (4)	63	63	58	42	65	61
Of no value compared with live (5)	7	5	4	19	9	8
No response	0	0	0	4	0	0
N	101	59	24	26	46	256
Mean response	3.69	3.63	3.46	3.80	3.76	3.68
Standard deviation	0.73	0.78	0.98	0.82	0.74	0.78

the live program. Twenty-five percent indicated somewhat less effective while 69 percent exhibited a very negative reaction to the canned version. The mean response indicates the total sample tends to view canned programs as being much less effective than live. It should be noted that attitudes toward the media are probably not a measure of educational value. Studies have shown that there is only a small relationship between liking and learning (McKeachie, 1966, p. 282).

Personal Contacts and Motivation

One of the side benefits to attending a program such as the MEC is that the participants make personal contacts which may prove beneficial in their work. Table 36 shows that 32 percent of the sample indicate no personal contacts were made after the program with former participants which benefited them in their job performance. Sixty-seven percent noted that they made at least one beneficial contact. The mean response indicates the average number of contacts to be greater than two. The chi-square test shows a significant difference between programs. The four programs which involve people from the same organization (A, B, C and D) show a greater number of contacts than the program (E) which was attended by people from various organizations.

After attending a general program such as MEC, it is possible that the individual participant might be motivated to attend other courses or programs. Table 37 illustrates the investigation into this area. Sixty-two percent of the sample indicate that they were not motivated to take any additional courses or programs. Thirty-two percent note one or two activities while only five percent revealed taking three or more additional courses or programs. The chi-square test shows no significant difference between programs.

TABLE 36

PERSONAL CONTACTS WITH OTHER PARTICIPANTS AFTER PROGRAM (Q19)

Number of Contacts	Participant Response (Percent)					
	Program					All Programs
	A	B	C	D	E	
0 (1)	28	24	17	49	41	32
1 - 2 (2)	28	27	13	8	29	24
3 - 5 (3)	26	32	17	19	22	25
6 - 10 (4)	7	7	32	12	4	9
11 or more (5)	9	10	21	12	2	9
No response	2	0	0	0	2	1
N	101	59	24	26	46	256
Mean response	2.40	2.52	3.29	2.27	1.96	2.42
Standard deviation	1.23	1.22	1.40	1.48	1.02	1.28

$\chi^2 = 35.73$ d.f. = 12 Reject the null hypothesis at the 0.05 level.

TABLE 37

NUMBER OF ADDITIONAL COURSES TAKEN DUE TO PROGRAM (Q12)

Number	Participant Response (Percent)					
	Program					All Programs
	A	B	C	D	E	
0 (1)	52	73	54	69	65	62
1 - 2 (2)	41	27	29	23	28	32
3 - 5 (3)	4	0	13	8	7	5
6 or more (4)	0	0	4	0	0	0
No response	3	0	0	0	0	1
N	101	59	24	26	46	256
Mean response	1.50	1.27	1.67	1.38	1.41	1.43
Standard deviation	0.74	0.45	0.87	0.64	0.62	0.60

$x^2 = 6.98$ d.f. = 4 Accept the null hypothesis at the 0.05 level.

Effectiveness and Hindsight

Did the program give you a sense of feeling more in command of your total job responsibilities? The response to this question is shown in Table 38. Thirty-five percent show the program to have affected them to a little extent or less. Sixty-four percent indicate to some extent or more. The mean response indicates the tendency to be somewhere between little and some extent. The chi-square test shows a significant difference to exist between programs.

TABLE 38

EXTENT PROGRAM GAVE PARTICIPANT SENSE OF FEELING MORE IN COMMAND OF JOB RESPONSIBILITIES (Q18)

Extent	Participant Response (Percent)					
	Program					All Programs
	A	B	C	D	E	
Very little extent (1)	9	12	4	35	15	13
Little extent (2)	22	29	17	26	13	22
Some extent (3)	57	44	54	35	48	50
Great extent (4)	9	15	25	4	22	14
Very great extent (5)	0	0	0	0	2	0
No response	3	0	0	0	0	1
N	101	59	24	26	46	256
Mean response	2.68	2.63	3.00	2.08	2.83	2.66
Standard deviation	0.77	0.89	0.78	0.93	1.02	0.89

$\chi^2 = 20.15$ d.f. = 8 Reject the null hypothesis at the 0.05 level.

After the participants have had time (3-5 years) to reflect on the program, it is of interest to measure attitudes to the program by utilizing their hindsight. The respondents were asked: If you had it to do over again, and if your company were willing to invest an equivalent amount of time and money in any of the following alternatives, which one would you choose? Table 39 shows the response to this question.

Only 53 percent of the total sample indicate that they would prefer to attend the MEC in light of other alternatives. Non-credit college courses and professional society meetings rate high on the alternative list. College credit courses are not rated very highly by this group of respondents.

If the numerical data for Table 39 are considered only in relation to two choices (attend the MEC or an alternative) the chi-square test indicates differences between groups on this question. Statistically significant differences occur at the 0.05 level when the percentages between two programs differ by about 25 percent on Item Five on Table 39.

Other alternatives include:

> Attend a program similar to one attended. Instructors would present material differently and more emphasis on application of new technology. (B)
>
> Attend same program but follow up with short courses directly related to work. (B)
>
> Attend a revised program to emphasize theoretical chemical engineering in more depth plus practical applications of the same. (C)
>
> Similar program but better subject selection at varying depth levels. (D)
>
> Attend course of equivalent length on management. (E)

Andrews (1966, p. 82) asked a similar question to over 6,000 businessmen who had attended various university management training programs. His results showed that 81 percent would attend the same management program again instead of other alternatives.

TABLE 39

ASSESSMENT OF PROGRAM IN RELATION TO ALTERNATIVES (Q21)

Preferred Alternative	Participant Response (Percent)					
	Program					All Programs
	A	B	C	D	E	
Attend professional society meetings and seminars concerning material that is directly related to my work (1)	18	12	4	12	9	13
Attend non-credit short courses put on by colleges and universities in areas directly related to my work (2)	12	9	33	49	13	16
Take credit college courses in areas directly related to my work (3)	8	0	13	12	11	8
Embark on a self-study program (books, periodicals, personal contacts, travel, etc.) (4)	4	9	4	0	2	4
Attend the same program discussed in this questionnaire (5)	52	65	42	23	61	53
Other (6)	2	5	4	4	4	4
No response	4	0	0	0	0	2
N	101	59	24	26	46	256

CHAPTER IV

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The rapid pace of technological change occurring in our society presents a problem to the practicing engineer. How does a practicing engineer keep up-to-date with the constantly emerging new technology? One answer to the question apparently lies in the area of Continuing Engineering Studies (CES).

During the late 1950's and throughout the 1960's an effort was made to design educational programs which would permit the practicing engineer to remain current in his field. Educational institutions, industrial organizations, and proprietary companies became involved in the presentation of CES programs.

Although a great deal of CES literature was available, little documentary evidence existed to describe the effectiveness of the programs and the benefits accrued by the participant or his employer. This lack of a "results" type of information prompted this particular study.

The purpose of this study was to: (1) review the CES literature and present factors related to the continuing education of the practicing engineer and (2) conduct a questionnaire survey to determine the effectiveness of one type of CES program.

The review of the literature presents a brief look at the broad spectrum of factors which influence CES activities. The literature shows that a CES

student must be considered in light of the many facets which make up an individual's total life style.

The questionnaire survey was designed to evaluate a CES program that was conceived to update engineering managers and supervisors in modern engineering concepts and techniques. Most of the participants had been out of school for more than ten years and were therefore not aware of the new engineering curricula. Hence, the program became known as the Modern Engineering Course (MEC). Five different MEC programs were included in the sample for the survey. The programs were different in terms of format and length of instruction but were similar in relation to the general objectives. The participants in the five programs were mainly from the automotive, chemical, electrical, electronics and aerospace industries, and the government. The programs were conducted by either a college, university, or an industrial organization.

The sample for the questionnaire survey included those persons attending the five MEC programs during the years 1965 and 1967. The questionnaire contained thirty-nine questions derived from personal interviews with former participants in the programs under study. The questionnaire was mailed to 328 persons of whom 256 returned usable questionnaires.

The questionnaire data were tabulated using standard IBM procedures. The data were reduced to percentages, means, and standard deviations for analysis.

The chi-square test was utilized to test the general null hypothesis:

> There will be no significant difference between the responses given by the different groups to the questions posed in the questionnaire.

The 0.05 level of significance was selected for the chi-square test.

Conclusions

The following conclusions are based on the total sample size (256) for the survey. Individual differences between programs are not considered unless noted otherwise.

Participants in the MEC

The participants in the MEC programs studied were engineering managers, engineering supervisors, and senior engineers who were mainly (57%) involved in activities related to "development for production." The highest degree received by most (70%) of the participants was the bachelor's degree which was received more than sixteen years prior to the study. The average participant had about sixteen to twenty years with his present employer. The majority (64%) of the participants attended the MEC after being asked by their supervisor to consider attendance at the program.

Many of the participants (63%) were promoted or given increased job responsibility after attending the program. A major portion (78%) of the participants felt that attendance at programs of this type had a "slight" or "no effect" on promotion or increased job responsibility.

Objectives and Effectiveness

The participants rated the effectiveness of the program in relationship to their perceived objectives as being somewhat more than "moderately effective." The respondents felt that the value of the program increases with the number of years that an engineer has been out of school. The exception is the possibility

that some engineers may find the subject material difficult to understand if they have been away from the fundamental engineering concepts too long.

Some of the write-in comments indicate that a few of the participants had difficulty keeping up with the presentations because of the large knowledge gap that existed for them.

Specific Benefits

The three top benefits indicated were: (1) improved ability to communicate with others in the organization in technical matters, (2) broadened engineering viewpoint to include the interrelations of various specialties, and (3) became aware of modern engineering techniques and concepts which have proved beneficial to job performance.

The program caused only a relatively "slight increase" in the use of mathematics or computers in relation to job responsibilities. A tendency toward a "moderate" increase in the ability to understand technical articles can be attributed to the MEC.

The MEC encouraged the use of new concepts or techniques in the participant's organization to more than a "little extent." About one-half of the program material was presented clearly enough so that the participant could suggest further investigation in his organization. Forty percent of the participants gave specific examples of such a suggestion.

The program caused the application to a "little extent" of some MEC information which resulted in financial savings to the organization. Twenty-eight percent of the respondents gave examples where savings had occurred or were expected to occur in their organization.

Even though the objectives of the MEC were very general, the survey indicated many examples of specific benefits accruing to the employer through application of information obtained from the program.

Course Materials

The program notes, books, or other program materials were utilized by the average participant more than four times after completing the MEC, although a few (9%) indicated no use at all. The program materials were used mainly as a source of general information which proved to be about "moderately useful." Persons in the organization, other than the participant, used the program materials between one and four times but many participants (34%) indicated no use by others. Individual comments indicated a need for: an index for notes, inclusion of numerical examples, reference bibliographies, more complete notes, uniform notation, and notes to be passed out before the lecture.

Course Content

Participants indicated a preference for course subject material to lean toward the wide variety rather than restricting the material to one's work area. The respondents suggested a balance between theoretical and applied information with a slight tendency toward more application. Lengthy mathematical derivations are to be avoided.

Course Length

Even though the programs were of different lengths, the overall response indicated that the amount of time spent at the program was "about right." There was some tendency for the participants to feel that the programs were on the long side.

It is evident that the participants adapted to their particular MEC and made the most of it.

Time for Discussion

The amount of time allocated for questions and discussions appeared to be "about right" but quite a few (25%) felt a need for more time.

The Participants and Technological Change

The respondents indicated that "getting others to accept new concepts" presented the greatest difficulty in performing their job. This difficulty rated well above the problem of "wondering whether or not up-to-date techniques and concepts are being utilized."

The majority (56%) of the participants felt that more than three-fourths of the technology known to them ten years ago was still applicable at the present time. The pressure to keep up with new technical knowledge or skills is equally prevalent in the various industries included in the sample.

Self-study is the most frequently used means for keeping up with new technological developments.

Perceived Attitudes Toward MEC

The group as a whole indicated that approximately three-fourths of the participants seemed to apply themselves and attempted to get the most out of the program.

Reaction to Proposed Film or TV Version of MEC

The sample indicated a fairly negative attitude toward the idea that the MEC be put on film or video tape. Ninety-four percent felt that a "canned"

version of the MEC would be at best "somewhat less effective" than the live program.

Personal Contacts and Motivation

The average participant made more than two personal contacts which benefited him in his job performance after completing the program. About one-third indicated no contacts.

The major portion (62%) of the group were not motivated to take any courses or programs after completing the MEC. Approximately one-third of the respondents did take one or more courses which could be attributed to motivation by the MEC.

General Effectiveness and Hindsight

The average participant indicated that the MEC increased his sense of feeling more in command of his total job responsibilities somewhat more than a "little extent."

When the participants were asked to choose between attending the MEC or other alternatives, fifty-three percent indicated a preference for the MEC. College and university noncredit short courses and professional society functions rated above college and university credit courses as the most preferred alternatives.

Comparison of Program Effects

The chi-square test indicated a great deal of similarity between the five programs in areas which included:

Financial benefits to the participants employer.

Application of new concepts or techniques.

Suggesting further investigation of program material for use in the organization.

Increased ability to understand technical articles.

Reaction to the amount of time spent at the program.

Recommendations

The Individual's Development and the Organization

* An effort should be made to create a better match between the CES activity and the individual participant. Ascertain that each program meets the specific needs of the selected individual.
* Individualized, long-term, developmental CES activities should be scheduled with individuals so as to integrate the participant's aspirations with future organizational planning. Programs such as the MEC should be considered a beginning and not an end in themselves.
* Organizations should analyze themselves to see if they are ready to change and accept the new concepts and techniques proposed by programs such as the MEC.

Since the survey data indicate that only a little over 50 percent of the sample would have preferred to attend the MEC in light of other alternatives, it would seem logical to assume that a better match be made between the man and the course. Since the majority of the participants were asked by their supervisor

to consider attendance at the program, it may be that many of the participants were not exercising a true "freedom of choice" in attending the MEC. It is possible, given the opportunity, that many of the MEC participants would have selected another type of CES activity which could have benefited their job performance to a greater extent than the MEC.

More than 60 percent of the sample were not motivated by the MEC to take any subsequent courses or programs, hence it is evident that many of the participants need assistance in establishing "continuing" personal developmental CES plans. These plans should be tailored to meet the aspirations of the individual in consonance with future organizational planning. CES programs can only be effective from an organizational viewpoint when the CES activity is a cooperative venture in which the employe and the employer set mutually agreeable goals.

The data suggest that the participant's greatest difficulty in performing his job is "getting others to accept new concepts." An individual must function within the limits set by the employing organization. Existing organizational structures, policies, and personnel should be examined to see if new concepts and techniques can be introduced into the system. If the organization is not willing to accept innovations, then participants in programs such as the MEC can only be expected to become disillusioned and frustrated.

The CES function will be of maximum value to the employing organization and employe when the CES activities are integrated with a manpower planning system which seeks to conserve and effectively utilize existing engineering personnel from the date of initial employment.

The Modern Engineering Course

* The objectives of programs such as the MEC should be defined in terms of specific organizational or individual behavioral objectives.
* Consideration should be given to shortening the longer MEC programs.
* In a general course such as the MEC, theoretical concepts are necessary but long detailed derivations should be avoided.
* Theoretical concepts should always be backed up with relevant applications of the subject material.
* The notes provided for the program should be indexed, use the same notation, be provided in advance of the lecture, include reference bibliographies, and numerical examples.
* An adequate amount of time should be allocated for controlled discussions which permit the individual participants to relate their own experiences and add to the learning situation.
* Good reference books should be provided along with printed reference notes.
* Participants should be encouraged to disseminate course materials to other personnel in their organization.

This study evaluated the effectiveness of the MEC in relation to a number of stated general objectives. Since most employers are interested in concrete

results from educational programs, it would be wise to define the program objectives in terms of specific behavioral objectives. This procedure would force the organization to define the problem areas to be solved with CES programs. Such a procedure might point out that a problem cannot be solved with a CES program but requires other alternative courses of action such as changing current policies, revising existing organizational structures, or clarifying organizational goals. The lack of specific behavioral objectives may account for the variations present in the structure of the five MEC programs included in this study.

The survey data indicate the five different MEC programs are alike in many ways. The reasons for this similarity could be due to the participants adapting to a particular program and modifying their expectations accordingly. It is also possible that the survey questionnaire was not capable of discriminating between programs. The data suggest that it would be possible to shorten the amount of instructional time allocated for the longer MEC programs and still have equally favorable results. When one considers the large number of variables present in the five MEC programs, it serves to call attention to the need for additional research in this area.

The type of person taking the MEC has been out of school for a number of years and is not receptive to rigorous mathematical analysis. As a typical adult student, the MEC participant brings his current problems to the learning situation. He looks for ways in which he may apply the course material to practical problems in his organization. The whole course structure must be geared to this special outlook. Notes, books, lecturers, and format must be selected with the pragmatic student in mind.

Since the organization cannot send all of its personnel to programs such as the MEC, it is imperative that the participant be openly encouraged to make his notes, books, and other materials available to others in the organization. The participant should also be encouraged to discuss the new concepts and techniques with appropriate personnel in his organization.

Other Forms of CES

* Organizations should review the efforts being made to aid personnel in carrying out the various forms of individualized CES which require the use of books, periodicals, programmed learning devices and audio-visual aids.
* Programs such as the MEC should be put on video tape or film so that the information can be brought to a greater number of personnel.
* Employer tuition refund plans should include college and university noncredit short courses.

The data indicate that self-study is the prime method by which personnel manage to stay abreast of the changing technology. This suggests that organizational personnel in charge of CES activities should review their current expenditures and determine if significant attention is being given to this fundamental sector of CES.

Although the participants in this survey expressed negative attitudes toward a "canned" version of the MEC, the literature shows no link between liking and learning. Since only a small portion of a large organization's

personnel is likely to attend a program such as the MEC, it would seem profitable to expand the audience using available recording techniques.

A large percentage of the participants indicated a preference for non-credit college or university short courses. Many older personnel are reluctant to place themselves in the competitive atmosphere of a conventional classroom. They are much more likely to take a course offered on a noncredit basis where grades are not a part of the program. Employers should make sure that the employes are encouraged to participate in noncredit courses by granting tuition refund.

Closing Remarks

The area of CES is only one part of the manpower planning function. The nation and the individual organizations functioning within our society must insure that the available and future supply of engineering personnel are utilized effectively. At this point in time, 1971, engineering unemployment in the U.S.A. is extremely high. Yet, only a few years ago, manpower predictions indicated a continued shortage of engineers. What or where is the problem?

This study has evaluated one type of a CES program designed to alleviate the "obsolescence" of selected engineering managers. How or why did this representative group of engineering personnel get to the point where their knowledge was considered to be relatively inadequate? Is effective engineering manpower planning an integral part of the organizational operation? Are engineering personnel being used efficiently? Do employers help to guide and direct the development of their personnel with effective CES programs in light of organizational and individual objectives? How effective are other CES activities?

The nation must keep abreast with the rapid pace of technological change. Ineffective manpower planning and the under-utilization of the engineering manpower pool serve to reduce the capability of the nation and the individual engineer. The effective planning, implementation, and evaluation of activities in the area of continuing engineering studies can help to alleviate many of the problems associated with the increased rate of technological change.

APPENDIX A

Survey Questionnaire*

The University of Michigan

Center for the Study of Higher Education

The following questionnaire pertains to the "Modern Engineering" program which you attended a few years ago. Please check only one response unless otherwise noted.

1. What did you personally feel that the program would accomplish?

_____

2. How effective do you think the program was in accomplishing what you thought it would? (Check one space.)



Slightly Effective — Moderately Effective — Extremely Effective

3. Did the program cause an increase in the use of computers in your area of job responsibility?

_____ No increase in the use of computers
_____ Slight increase
_____ Moderate increase
_____ Great increase

4. Did the program result in an increase in the use of mathematics in your area of job responsibility?

_____ No increase in use of mathematics
_____ Slight increase
_____ Moderate increase
_____ Great increase

*The actual questionnaire mailed out to the program participants was printed black on white and took the form of a four page booklet.

5. Did the program increase your ability to understand technical articles related to your work?

_____ No increase in understanding
_____ Slight increase
_____ Moderate increase
_____ Great increase

6. To what extent has material presented in the program resulted in the application of new concepts or techniques in your organization?

_____ Not at all
_____ To a little extent
_____ To some extent
_____ To a great extent
_____ To a very great extent

7. How much of the material presented in the program was made clear enough so that you could suggest futher investigation within your organization?

_____ Practically none
_____ Little
_____ About half
_____ Much
_____ Practically all

Can you give a specific example in some detail. Use additional sheet if necessary.

_____

8. In your opinion did the program result in a financial savings to your organization through the application of information gained through participation in this program?

_____ Not at all
_____ To a little extent
_____ To some extent
_____ To a great extent
_____ To a very great extent

Can you give a specific example in some detail. Use additional sheet if necessary.

_____

9. What area of knowledge presented in the program was of most benefit to you in relation to your work? (Check one.)

_____ Mathematical concepts and techniques
_____ Use of computers
_____ New engineering methods and techniques
_____ All material was equally beneficial
_____ Other (specify) _____

10. In how many ways did the program help you? (Check as many as applicable.)

_____ Provided encouragement to take other courses
_____ Encouraged further reading and study in specific areas
_____ Gained specific knowledge which could be directly applied to work
_____ Reviewed material once known so as to be usable again
_____ Improved ability to communicate with others in the organization in technical matters
_____ Provided personal contacts with participants which have been useful to job function
_____ Became aware of modern engineering techniques and concepts which have proved beneficial to job performance
_____ Broadened engineering viewpoint to include the interrelations of various specialties
_____ Helped to develop an attitude which encourages the use of modern engineering concepts
_____ Other (specify) _____

11. Go back to the previous question and rank the three items which were of most importance to you. Mark the single most important item with a (1), the next a (2) and the third with a (3).

12. How many courses or programs have you taken since completing this program which can be attributed to the motivation provided by this program?

_____ 0
_____ 1 - 2
_____ 3 - 5
_____ 6 or more

13. How many times, since completing the program, have you referred to the notes, books, or other program materials in the performance of your job responsibilities?

_____ 0 times
_____ 1 - 4 times
_____ 5 - 10 times
_____ 11 - 25 times
_____ 26 times or more

14. If the program materials were referred to, of what use were they? (Check as many as applicable.)

_____ Specific information directly applicable to work
_____ Useful references given to other sources
_____ General information which provided a talking knowledge of a subject
_____ Other (specify) _____

15. If you have had an occasion to refer to program materials, how useful were they? (Check one.)

_____ Not at all useful
_____ Slightly useful
_____ Moderately useful
_____ Greatly useful

16. How many times have your program notes or other materials been utilized by other personnel in your organization?

_____ 0 times
_____ 1 - 4 times
_____ 5 - 10 times
_____ 11 - 25 times
_____ 26 times or more

17. Do you have any suggestions to improve the utility of the program notes or other materials? _____

18. To what extent did the program give you a sense of feeling more in command of your total job responsibilities?

_____ To a very little extent
_____ To a little extent
_____ To some extent
_____ To a great extent
_____ To a very great extent

19. Since completing the program, how many times have you made contacts with other people in the program which have benefited you in your job performance?

_____ 0 times
_____ 1 - 2 times
_____ 3 - 5 times
_____ 6 - 10 times
_____ 11 times or more

20. Do you feel there is any relationship between attending a program of this type and progress in the organization through promotions, salary increases, and increased responsibility?

_____ No relationship
_____ Slight relationship
_____ Moderate relationship
_____ Strong relationship

21. If you had it to do over again, and if your company were willing to invest an equivalent amount of time and money in any of the following alternatives, which one would you choose? (Check one.)

_____ Attend professional society meetings and seminars concerning material that is directly related to my work
_____ Attend non-credit short courses put on by colleges and universities in areas directly related to my work
_____ Take credit college courses in areas directly related to my work
_____ Embark on a self-study program (books, periodicals, personal contacts, travel, etc.)
_____ Attend the same program discussed in this questionnaire.
_____ Other (specify) _____

22. What gives you the greatest difficulty in performing your job? (Check one.)

_____ Wondering whether up-to-date techniques and concepts are being utilized
_____ Communicating with people on technical matters
_____ Trying to stay within the budget
_____ Determining job priorities
_____ Getting others to accept new concepts
_____ Other (specify) _____

23. How much of the technology that you knew about ten years ago is still applicable to your work today? (Give an estimate.)

_____ None of it is applicable today
_____ About one-quarter
_____ About one-half
_____ About three-fourths
_____ Almost all of it is applicable today

24. Have you felt pressure to learn new technical knowledge or skills in order to do your work effectively?

_____ No pressure to learn
_____ Slight pressure
_____ Moderate pressure
_____ Strong pressure
_____ Very strong pressure

25. How have you been able to meet changes in technology related to your work? (Check any of the following you have used.)

_____ Non-credit college courses
_____ Credit college courses
_____ Company sponsored programs
_____ Self-study (books, periodicals, personal contacts, travel, etc.)
_____ Professional society activities
_____ Other (specify) _____

26. Looking back on the program and knowing how much it influenced you in your work, do you think the amount of time spent at the program was appropriate? (Check one.)

_____ Too long
_____ Somewhat long
_____ About right
_____ Somewhat short
_____ Too short

27. Did the program provide sufficient time for questions and discussions?

_____ Need a great deal more time
_____ Need somewhat more time
_____ About right
_____ Spent too much time discussing

28. What part of your group attending the program seemed to apply themselves and attempted to get the most out of the program?

_____ None
_____ About one-fourth
_____ About one-half
_____ About three-fourths
_____ Practically all of them

29. One way to operate a program of this type is to present a wide variety of subject material from many technical specialities which may not be directly related to one's work: Another way is to narrow the material coverage so that all of the material has a close relationship to one's work. Which do you feel is most beneficial?

_____ All material related to one's work
_____ Most material related to work
_____ About half and half
_____ Most of the wide variety
_____ All of the wide variety

30. In programs of this type a balance must be maintained between the theoretical and applied aspects of the material being presented. What sort of balance do you feel should exist between the two aspects?

_____ All theoretical
_____ Mostly theoretical
_____ About half theory and half applied
_____ Mostly application
_____ All application

31. Suppose that in order to reach a greater number of people the program you attended was recorded on film or video tape and the program was available at your work location for viewing individually or in groups. Assume that a complete set of notes that exactly followed the program was presented to each participant. How effective do you feel the recorded program would be in comparison with the live program?

_____ More effective than live program
_____ About the same as live program
_____ Somewhat less effective than live
_____ Much less effective than live
_____ Of no value compared with live

32. Your participation in the program was a result of:

_____ Personally initiating a request to attend
_____ Being asked by my supervisor if I would care to attend
_____ Other (specify) _____

33. Have you been promoted or had an increase in job responsibility since completing the program?

_____ Yes
_____ No
_____ Other (specify) _____

34. What is your present job classification? _____

35. In general terms, in which of the following categories would you consider the major portion of your job responsibility to fit?

_____ Basic research and design
_____ Development for production
_____ Production and related functions

36. Your last academic degree was:

_____ Bachelors
_____ Masters
_____ Doctors

37. The number of years since receiving your last academic degree.

_____ 0 - 10 years
_____ 11 - 15 years
_____ 16 - 20 years
_____ 21 or more years

38. How long have you been with your present employer?

_____ 0 - 10 years
_____ 11 - 15 years
_____ 16 - 20 years
_____ 21 or more years

39. How beneficial do you feel that the program would be to engineers that have been out of school for differing amounts of time? (Check one answer in each column.)

	Engineers Out of School for:			
How Beneficial?	1-4 yrs.	5-9 yrs.	10-14 yrs.	15 or more yrs.
Not at all beneficial				
Slightly beneficial				
Moderately beneficial				
Considerably beneficial				
Extremely beneficial				

Now that you have completed the questionnaire, are there any benefits which you or your company derived from the program which were not covered or were not covered adequately by the questionnaire? Do you have any suggestions on how to improve the program? What was your overall reaction to the program? Please place your comments on the sheet provided or add additional sheets if necessary.

Thank you for your assistance.

Chris A. Common, Project Director
Center for the Study of Higher Education
The University of Michigan
1100 South University
Ann Arbor, Michigan 48104

APPENDIX B

Initial Questionnaire Cover Letter

The University of Michigan

Center for the Study of Higher Education

Dear Mr. _____

Reference: (Program being sampled)

You are one of a relatively small number of people in this country who have attended a special program called "Modern Engineering." A survey is being conducted to obtain the reactions of former participants to this particular type of program in order to make their collective opinions available to persons interested in this form of continuing engineering education.

The success of this study depends upon your taking a few minutes of your time to fill out the attached questionnaire and returning it in the enclosed self-addressed stamped envelope. Since the statistical significance of this study is dependent upon the number of returned questionnaires, your prompt return of the completed questionnaire will be greatly appreciated.

The industrial organizations cooperating in this study have made the names of former participants available so that an appropriate sample could be drawn for the survey.

PLEASE NOTE THAT THE QUESTIONNAIRE IS CONFIDENTIAL AND WILL IN NO WAY BE IDENTIFIED WITH AN INDIVIDUAL!

The project director will, however, keep track of the returned questionnaires by the use of a numbering system which will aid in tracing down questionnaires that are not returned. The numbering system will be known only to the project director so that complete anonymity is guaranteed.

If the questionnaire fails to make any point clear, or if you feel some questions are ambiguous, do not hesitate to make comments on the questionnaire or to attach separate sheets. Thank you.

Sincerely,

Chris A. Common
Project Director

APPENDIX C

Follow-up Questionnaire Cover Letter

The University of Michigan

Center for the Study of Higher Education

Dear Mr. _____

Reference: (Program being sampled)

As of this date I note that a questionnaire which was sent to you a couple of weeks ago has not been returned. The questionnaire pertained to the program referenced above.

If you have been busy and have not had the time to complete the questionnaire I would extend a personal request that you consider filling it out in the next few days.

Your comments and opinions with respect to the program under consideration will be of great value to those persons concerned with the development of continuing educational programs for professionals.

In addition, your completed questionnaire is needed to successfully terminate a study which is the result of over two years of research in the area of continuing engineering education. This study will enable the writer to "cap-off" over seven years of part-time graduate work at the University of Michigan.

If you have misplaced the questionnaire, a duplicate is enclosed along with a self-addressed stamped envelope.

Your assistance in this matter is greatly appreciated.

Sincerely,

Chris A. Common
Project Director

APPENDIX D

Letter from the Industrial Organization Which Conducted Program B to the Participants in Their Program

Note: This letter preceded the initial mailing of the survey questionnaire utilized in this study.

Dear

Our Modern Engineering staff is cooperating with Mr. Chris Common who is working on his doctoral thesis at the University of Michigan. He has chosen for his dissertation a study of several continuing education programs such as our Modern Engineering Course. The men who graduated from the 1965 classes and the 1967 class have been selected to receive a questionnaire from Mr. Common relative to the Modern Engineering Course. We would appreciate it if you would take the time to answer this questionnaire as best as you are able to. Some of the questions may not be too pertinent to our program since he has tried to phrase them to get information for several other programs as well. We would appreciate having you prepare a duplicate copy of your answers for our own use.

Thank you very much for your cooperation.

Sincerely,

Director-Modern Engineering Program

APPENDIX E

Descriptions of the Programs Included in the Study

Program A

Program A was conducted by the educational division of an automotive manufacturing organization for its engineering managers and supervisors. The instructors for the program were all college level staff members of the educational division and the program was conducted at the educational division. Program meetings were held every month until nine sessions were completed. The sessions consisted of Friday afternoon, Friday evening and Saturday morning lectures. A typical schedule is shown below:

Friday Afternoon and Evening

1:30 - 1:40 Introduction
1:40 - 3:30 Instruction
3:30 - 3:45 Break
3:45 - 5:30 Instruction
5:30 - 7:00 Dinner
7:00 - 7:50 Instruction
7:50 - 8:00 Break
8:00 - 9:00 Instruction

Saturday Morning

8:30 - 9:30 Instruction
9:30 - 9:45 Break
9:45 - 11:30 Instruction

The subject material presented in the program years selected for the sample (1965 and 1967) were similar except for minor deviations. The material covered

in the program is shown below with the approximate number of instructional hours in parentheses:

New Materials (9)

Chemistry review, atomic structure and molecular structure, chemical bonds, organic and polymer chemistry, structure of solids and arrangement of atoms in solids, relationship between structures of materials and properties, modern concept of materials and practical applications, strengthening mechanisms and usable strength in steels.

Energy Conversion (9)

Thermoelectric energy conversion, gas turbines, solar energy, secondary batteries, fuel cells, Stirling engine, nuclear energy conversion.

Measurement (9)

Three stage instrumentation system, telemetry, nuclear measurements, laser techniques and Moire patterns, laboratory demonstrations, exhaust gas analysis, ultra-precision measurement reliability, fatigue life gages, non-destructive testing.

Digital and Analog Computers (9)

Programming and running of the IBM 1620, torsional vibration problem, simulation on a digital computer, differential equations-analog computer, modeling concepts and problem mechanization, analog computer scaling and demonstration, solution of nonlinear systems and operating an analog computer facility, hybrid computers and a digital computer simulation language.

New Processes (9)

Stress-strain analysis in metalworking, titanium carbide for cutting tools, laser applications, electro-chemical machining in manufacturing, techniques for process selection, powder metal processes, advances in foundry processes, high-energy rate forming, plastic processes, computerized programming for numerical control, materials testing at variable temperature, numerical control applications.

Mathematical Notations (6.5)

Changes in pre-college mathematics, vector algebra, applications of vector algebra, vector calculus, applications of vector calculus, matrix algebra, application of matrices, introduction to tensors, application of tensors, introduction to Laplace transforms, application of Laplace transforms.

Communications (2.5)

A working model of the human communication process, barriers and breakdowns in human communication, applications of recent research in solving human communication problems.

Control Systems (9)

Excitation response description of control systems, feedback control systems, introduction to digital logic and static control, application of digital logic, numerical control, recent developments in control systems.

Fluid Mechanics (9)

Dimensional analysis and the theory of models, ideal flow, compressible and supersonic flow magnetohydrodynamics, boundary layer, fluid amplifiers and fluidic systems, flow visualization and measurement, supersonic flight film and laboratory demonstration, resources for keeping up-to-date.

Experiments and Evaluation (9)

Variability and statistical concepts, planning for problem solving, evolutionary operation, relationships between two variables, dimensional analysis and similarity, graphical analysis of engineering test data, science of tolerancing.

Program B

Program B was conducted by the corporate office of an industrial firm which is active in the electrical, electronics, and aerospace sectors of the economy. The participants were all engineering managers and supervisors from the sponsoring firm except for occasional outside guests. The program was held at a resort type location which was remote to the participant's work. The instructors for the program were mainly university professors although a few outside specialists were utilized. The program operated on a five and one-half day per week schedule over a six-week period. A long weekend break was provided at the end of the first three weeks.

The daily schedule was as follows:

8:00 - 9:30 Instruction	2:30 - 3:00 Break
9:30 - 10:00 Break	3:00 - 4:30 Instruction
10:00 - 11:30 Instruction	4:30 - 7:30 Dinner
11:30 - 1:00 Lunch	7:30 - 9:00 Occasional Evening Session
1:00 - 2:30 Instruction	

The subject material presented during the program sample years (1965 and 1967) was similar. The subject material is shown below with the approximate number of instructional hours in parentheses.

Mathematics (27.0)

Calculus (1.5), set theory (1.5), vector calculus (4.5), matrices (1.5), tensor analysis (1.5), integral transforms (1.5), numerical methods (1.5),

ordinary differential equations (3.0), partial differential equations (1.5), probability theory (9.0).

Engineering Science and Materials (135.0)

Mechanics (1.5), quantum mechanics (1.5), basic stress concepts (1.5), stress analysis (1.5), buckling analysis (1.5), vibration analysis (3.0), shock analysis (1.5), linear systems (4.5), modern control theory (4.5), optimization theory (6.0), statistical designs (7.5), decision analysis (7.5), reliability (6.0), sensory information processing (6.0), information transmission (1.5), noise limitations (1.5), pulse modulation (1.5), statistical decision theory in communications (1.5), advanced information theory (1.5), computer processing in communications (1.5), modern physics (16.5), nuclear reactions (1.5), nuclear disintegration and transmutation (1.5), radioactivity (1.5), elementary atomic particles (1.5), magnetic fields and atomic structures (1.5), solid-state physics and devices (9.0), computer science (3.0), analog computer (1.5), computer displays (1.5), special optical effects (1.5), transport phenomena (9.0), polymer chemistry (6.0), metals and ceramics (7.5), application of metals in design (4.5), future manned space flight (1.5), the research and development center (1.5), corporate engineering (1.5).

Environment (13.5)

Atmospheric physics and chemistry (1.5), atmospheric problems (1.5), urban planning (3.0), economic modeling (4.5), modern engineering economics (1.5), high speed transportation (1.5).

Program C

Program C was conducted by a university for the engineering managers and supervisors of a chemical company. The instructors for the program were all professors from the university. Part of the program was conducted at the company's plant with the remainder being held on the university campus. The schedule was similar to that listed below:

Five sessions at the plant (March - April)

Two weeks on campus (June)

Fourteen sessions at the plant (August - December)

Two weeks on campus (January)

Fourteen sessions at the plant (February - April)

Two weeks on campus (May)

The sessions at the plant were held one day per week with the following time schedule -

1:30 - 4:00 Consultation

4:00 - 5:30 Instruction

5:30 - 7:00 Dinner

7:00 - 8:30 Instruction

The two weeks on campus consisted of instruction for ten days with the following daily schedule:

8:00 - 9:45 Instruction	3:00 - 3:30 Break
9:45 - 10:15 Break	3:30 - 5:00 Instruction
10:15 - 12:00 Instruction	5:00 - 7:30 Dinner
12:00 - 1:30 Lunch	7:30 - 9:00 Instruction
1:30 - 3:00 Instruction	

The subject material covered during the two program years included in the sample (1965 and 1967) was the same except for minor changes. The material covered is indicated below with the approximate number of instructional hours in parentheses:

Plant Sessions (99.0)

Digital computer programming and applications (9.0), differential equations (3.0), calculus and applications (12.0), differential equations - probability - couples - algebra (12.0), linear algebra and applications (6.0), analog computation (6.0), process accounting (3.0), kinetics (6.0), separations (9.0), transport properties (3.0), process simulation - models (3.0), process control (3.0), material and energy balances (3.0), fluid flow (3.0), heat and mass transfer (6.0), thermodynamics (3.0), optimization and modeling (3.0), design problem (6.0).

Campus Sessions (205.0)

Foundations and modeling (15.0), linear algebra (16.0), probability and statistics (22.0), mathematical models (9.0), computer applications (17.0),

state of the art (bio-engineering, separation processes, heat exchangers, civil engineering topics, management of technical personnel, large corporations and the community, government-business relations, business outlook, plant location, water, business development, etc.) (28.0), ordinary differential equations (9.0), heat and mass transfer (12.0), fluid flow (7.0), kinetics (4.0), problem work sessions (9.0), design problem (40.0), heat exchange (2.0), process evaluation (7.0), process simulation (4.0), separation processes (2.0), cracking and reaction furnaces (2.0).

Program D

Program D was conducted by a university for the engineering managers and supervisors of an automotive company. The program was held at the continuing education facility of the university. The instructional staff was mainly composed of the university's professors although a few outside speakers were utilized. The program consisted of nine monthly meetings. Each meeting began on Friday afternoon and finished at noon on Saturday.

The typical schedule was as follows:

Friday Afternoon and Evening

1:15 - 3:15 Instruction
3:15 - 3:30 Break
3:30 - 5:30 Instruction
5:30 - 7:30 Dinner
7:30 - Speaker

Saturday Morning

8:30 - 10:00 Instruction
10:00 - 10:15 Break
10:15 - 12:00 Instruction

The subject material covered in the program is indicated below with the approximate number of instructional hours in parentheses:

Mathematics - The Language of Modern Engineering (8.0)

Determinants - matrices, differential equations, operational methods, vectors, tensors, some uses of vectors and tensors. Speaker's topic - Education for Modern Engineering.

Impact of Modern Physics and Chemical Physics on Engineering (8.0)

The foundation of physical science, structure of the atom, quantum mechanics and molecular structure, modern chemistry, macromolecular chemistry, the solid state, the atomic nucleus. Speaker's topic - The Fifth Dimension.

Materials Science (8.0)

Materials Science: Its accomplishments and prospects, Metals: Electrical, magnetic, and thermal properties, Metals: Mechanical Properties, Polymers: Physical Behavior, Glass, Ceramics, and Glass-Ceramics: Structure and Properties, Materials Processing: Innovations and direction, summary. Speaker's topic - Our Stake in Nigeria.

Modern Mechanics and Structures (8.0)

Discontinuum mechanics, continuum mechanics, elasticity, viscoelasticity and plasticity, applied elasticity, structural analysis, experimental mechanics. Speaker's topic - The Nature of Scientific Choice.

Systems Engineering (8.0)

Introduction to systems engineering and mathematical models, formulation and solution of state-space models, systems theory in socio-economic systems, eigenvalues and matrix functions, analysis of a spacecraft control system, contemporary research in systems design and synthesis. Speaker's topic - Where Is Chemical Engineering Education Going?

Control and Optimization Techniques (8.0)

A survey on static and dynamic optimization techniques, the general control problem and related applied problems, modern and classical solutions to control problems, digital computers in closed-loop systems, helicopter station keeping: An example of modern control engineering. After dinner trip to engineering laboratories in the engineering building.

Dynamics and Vibrations (8.0)

Principles of dynamics, elementary vibration theory, vibrations of linear and nonlinear discrete systems, waves, vibrations, and stability in continuous media, sound and ultrasonics.

Heat and Mass Transfer (8.0)

Conduction, convection, radiation, application in braking system, mass transfer, application to cryogenics, applications related to re-entry and space vehicles. Speaker's topic - The New Mathematics.

Lubrication (8.0)

Reynold's equation - Theory and design charts, stability, bearing evaluation associated with product use, special topics in lubrication theory, fundamentals of bearing failure in rolling contact, squeeze film bearings.

Program E

Program E was conducted by a university, in a resort location, for senior engineering administrators in business or government positions. The instructional staff was mainly composed of university professors with a few outside lecturers. The course ran for six weeks which included a long weekend break at the middle of the program. The program was conducted on a six day per week basis. Classes were not held after 2:00 p.m. on Tuesdays, Thursdays, and Saturdays. The typical daily schedule was as follows:

Daily Schedule

8:00 - 9:05 Instruction	11:45 - 12:45 Lunch
9:05 - 9:20 Break	12:45 - 1:50 Instruction
9:20 - 10:25 Instruction	1:50 - 2:05 Break
10:25 - 10:40 Break	2:05 - 3:10 Instruction
10:40 - 11:45 Instruction	

The topics included in the course content were:

Mathematical Techniques

Boolean algebra and sets, real and complex numbers, derivatives, integrals and their generalization, infinite series, ordinary differential equations, integral transforms, partial differential equations, complex variable, calculus of variations, matrices, generalized vectors, linear programming, inequalities, probability and statistics, sampling, regression and correlation, prediction, Bayes theorem, tests of significance, decision theory, operations research, game theory, Markoff chains.

Integrated Applications

Antennas, plasmas, basis of engineering analysis, modern circuit theory, digital computations, digital solution of ordinary differential equations, analog computations, analog solution of ordinary differential equations, formulation of partial differential equations from characterizing fields, solution of elliptic, parabolic, and hyperbolic partial differential equations, reactor technology, nuclear reactor physics, hybrid computer applications, transformation of information in structures, force-displacement relations, energy concepts, matrix methods, dynamics of structures, random structural excitation, use of central limit theorem, power spectral density function, use of random vibrations in design, use of linear programming, control processes, state variables, feedback control, stability of nonlinear process, adaptive and self-organizing process and simulation of human systems, optimal control processes, stochastic control processes, man-machine systems and the human controller, communications theory and communications systems, the liquid state, polymers, molecular electronics, thermoelectricity.

Basic Science

Light and classical relativity, the Lorentz transformation, special relativity in mechanics, electrostatics, steady currents, dielectric materials, magnetic materials and electrodynamics, conductive materials, semiconductors, electromagnetic waves, molecular structure and chemical reactions, flame theory and propulsion, nuclear structure, fundamental particles, nuclear reactions, empirical thermodynamics, irreversible thermodynamics, transport phenomena, concepts of modern physics, introductory quantum

mechanics, statistical thermodynamics, kinetic theory, biomedical engineering, dielectric phenomena and materials, ferroelectric and piezo-electric phenomena, magnetic phenomena and materials, metals, semiconductors and plasmas, cryogenic phenomena.

The approximate number of instructional hours in a given area was:

Structures, dynamics, and random vibrations - 20 hours

Control theory and biomedical engineering - 12 hours

Chemical thermodynamics and energy conversion - 7 hours

Electromagnetics and theory of relativity - 20 hours

Modern mathematics, probability and statistics, decision making - 23 hours

Digital, analog, and hybrid computations - 20 hours

Computer science, communication theory and queueing theory - 10 hours

Systems engineering and economic analysis - 6 hours

Nuclear engineering - 6 hours

Modern solid state physics and electronics - 20 hours

APPENDIX F

Questionnaire Write-in Responses

Program A

Question 1. What did you personally feel that the program would accomplish?

A general acquaintance with newer techniques and technologies that are being taught in engineering today.

I had no idea beyond the impression given by the program brochure i.e. it would update me on the general content of the current engineering curricula to which the undergraduates are being exposed.

I thought the program would introduce new concepts of engineering that would be helpful tools in resolving present-day problems.

Acquaint me with newer engineering subjects.

Update me to basic technological advances in engineering field by covering specific or new subjects.

Bring to my attention new methods for attacking engineering problems, particularly in fields other than my own.

That I would have the advantages of seeing and learning new concepts in engineering applications.

I had thought I would learn some specific knowledge in a number of areas.

The objective that the title of the course suggests. Updating myself in related fields which permitted me to better understand some of the problems in engineering other than my own.

Having graduated from college 25 years ago, I thought the program would bring me up-to-date on new engineering developments and techniques that could be applied in managing my area of responsibility.

I thought that it would broadly cover important changes in existing technology and new technology introduced into undergraduate engineering curricula in the last 15 years. I thought that it would help me to understand and communicate better with recent graduates. I did not expect to be updated into a modern "working" engineer.

Inform me of the latest developments in the engineering field.

Update my knowledge in areas where many changes have been noted.

I would learn content of engineering curriculum as it had developed since I left school. Some understanding of what might be expected from recent engineering grads.

I felt the program would serve to update me in new training methods and ideas as well as point out some of the new subject areas and techniques which apply in the field of engineering.

Refresh my knowledge of technological advancement in certain fields that I had not been able to keep abreast of personally. Exposed to new engineering concepts that I might apply practically in solving current problems.

Update my engineering know-how.

Update me in general terms in fields of engineering that affect my job responsibilities.

Expected an update on new technology, materials, engineering management concepts. Did not expect to become technically expert in any field.

Supply an overview of many areas of engineering which had substantially changed and advanced beyond my knowledge and experience.

Update my knowledge and sharpen my awareness of technical progress. Prepare me to promote and support process innovations, facility planning, tooling concept changes, methods improvements, and product modifications.

A better understanding of techniques available today with a knowledge of their limits and capabilities. An awareness of the problems inherent with the use of these newest techniques and a realization of the rapid pace of technological advancement.

Update me in some of the latest engineering principles being studied and taught. Make me aware of the program content and value so as to guide me in sending others to the course.

Some additional knowledge, little of which would have direct application to my work. Mostly I expected to be stimulated intellectually.

Acquaint me with the latest significant engineering developments and trends.

I expected to be updated on methods, techniques, approaches, etc., which were becoming available for possible application.

Bring me up-to-date (in a general nature) on subjects and areas I had lost contact with and broaden the scope of information for the areas I was working in. Provide ideas and references for future study and investigation.

Updating in engineering communications, new developments, materials, and techniques.

Familiarize me with broad developments in the engineering field that had taken place since my graduation.

In my capacity as . . . covering some ten departments of varying disciplines, there were certain technical terms and general techniques which I had not received in my formal college education. By attending the program I was brought up-to-date on some work in the field of electronics, computers, and mathematical techniques to which I had no prior exposure. I think the overall gain would have been greater if I were not in the research business. By and large I thought the course was useful.

I felt the program would make me more aware of the changes and their magnitude which have taken place in mechanical engineering, materials, electronics, etc., since I completed my academic program.

Overview and update.

Become better informed of new developments in engineering.

Update me in general fields which I have not practiced since school. Inform me of recent developments in teaching methods. Give me the opportunity to evaluate the faculty and program for possible use in our staff. Provide a measure of what present graduates are exposed to so I know their new tools.

A broad overview of some of the more advanced technologies that could be related to my job responsibilities (present and future).

A brief but understandable review of up-to-date practices and theories in engineering as related to the limited scope of work of the company personnel attending the program.

I considered that this program would accomplish effective familiarization with current technologies and basic developments and thereby better equip myself as a management engineer in the current technological explosion.

Update on new engineering techniques and problems.

Familiarize me with new techniques and methods.

I wasn't too interested in the mathematics or the intricacies of doing the engineering but was interested in the new developments in the field and how they could be applied to our business. To keep abreast of what was happening from management's viewpoint.

General information on new engineering techniques and materials. I supervise a group which includes mechanical, electrical, and structural engineers. None of our work is very technical in nature and yet we cover a wide span.

Since the program did cover several specific areas, none of which related (or could have related) to my rather general line of work, I expected to get general information. I feel this was accomplished.

My objective was to update my technical knowledge so that I would be in a better position to supervise and later administrate the activities of recently graduated engineers. Although I am considered knowledgeable in my field, the young men were starting to talk in terms and concepts foreign to me.

To update my knowledge of the latest "art" of engineering techniques and what the level of ability of recent engineering graduates should be. To gain a general knowledge of recent engineering developments, problem solving tools, and engineering language.

Bring myself up-to-date with the latest engineering technology and practical application of same.

Provide information on latest developments in methods, equipment, and new techniques of manufacturing.

I felt it would improve my technical knowledge. Due to the nature of my work, much of the knowledge I gained did not apply to my work.

Provide me, a non-engineer, with some vocabulary related to concepts of contemporary technology. This it did.

Provide an exposure to new engineering developments.

An updating in what is new in engineering.

An exposure to new developments in fields of engineering that could be applied in the near future in manufacturing processes.

In obtaining a degree you are forced through a series of disciplines and then let out to spend your life in one of your choice. This program permits you to go back on an abbreviated scale through these long unused channels to take another enriching look and to update you on relatively new concepts and techniques. It has the same effect as aging a good liquor does for savoring your formal training.

Broaden my understanding of new techniques and technology which have developed since my formal education ended.

Somewhat fill in the gap between my days in college and today in engineering.

I knew in the beginning that the program was designed to make supervision aware of new developments in engineering since graduation. I was not aware of the intensity of the program which came about from condensing material so that it would fit into a twelve-hour weekend.

I expected to learn more about new materials and their possible applications. To learn how new technology might be used in production engineering.

Update in fast-moving fields.

General review of recent changes in engineering, new technology, and knowledge. Also hoped to learn of new advances in "old-line" subjects, i.e., strength of materials, thermo, etc.

Provide a gross updating of technological advances. Provide a "veneer" of knowledge on recent technological advances and aid in communicating with and directing younger engineers.

Provide information about new techniques, processes, tools, basic principles and new methods that may be used in engineering.

Update technical information, changes in recent years. New methods and techniques.

I felt it would bring new engineering techniques to my attention and give me an appreciation of their use and value. Furthermore, if application of the new techniques proved necessary for proper appreciation, then I expected that academic prerequisites would be reviewed.

I felt the program would bring me up-to-date on new technical engineering innovations and give me an insight to accomplishments since I graduated from college (atomic energy, fuel cells, computers, etc).

Present material to "fill the gap" between college graduation and present time. To enable participants to be brought up-to-date relative to latest engineering technology.

I thought it would give me a "broad brush" treatment of what was being taught in college engineering courses.

Force me to think analytically. I work on problems and people on a "demand" basis (fixing problems) and have gotten out of the habit of going back to basic fundamentals. A general review. Find out what is new.

Update my engineering education to cover the new developments that transpired since graduation.

Become aware of new techniques in engineering and obtain a working knowledge in these areas.

Update my knowledge in the spectrum of engineering and management course materials presented at the college level.

Update my engineering background.

Give me a well rounded idea of what's new in my field without getting too complicated.

Expose me to new engineering fields, concepts, analytical methods, processes, etc., which have developed in recent years. I did not expect to be able to learn any subject in great detail but I hoped to discover and learn enough to be able to determine if the new matter could be applied in my area of responsibility and if so, where to go to obtain additional information.

Did not know.

I anticipated the program would bring me up-to-date regarding new developments and acquaint me with source material for application of new methods, techniques, and materials in my line of endeavor.

Give me new thoughts, ideas, and concepts about processes, materials, developments, and related activities associated with engineering and manufacture of our product line.

Being newly employed, it was felt this program would be helpful in acquainting me with terminology with which I would be working.

Increase my effectiveness in the solution of problems encountered in engineering areas of activity by familiarizing me with the latest concepts in established engineering fields and introducing me to the latest in new and powerful engineering tools that had emerged within the last ten years. Above all, the program should provide me with sufficient usable practical information to justify the time expended.

Would bring me up-to-date on new fields of technology which have developed since I graduated from college 23 years ago.

I anticipated an increase in the knowledge of "the possibilities" resulting from advances in technology which have been made since my completion of formal studies at the college level.

Acquaint me with new techniques and new materials applicable to manufacturing processes.

I thought the program would bring me up-to-date on all the scientific discoveries and engineering advancements that have occurred since I left school. I was looking for practical applications of these discoveries and engineering advancements. I would like to have seen more practical and specific applications.

Inform me on what was new in engineering.

Expose the latest advancements in all branches of engineering and science such that a past graduate engineer would be familiar with the present engineering curriculum and tools being offered to today's engineering students. I felt also it might suggest new techniques which could be utilized to save time and money as related to the engineering of a more reliable product.

Expose me to new engineering principles and methods that could be applicable to my job. Did not expect to come out an expert but expected a much better grasp of certain subjects that I was not too familiar with. Would at least help me to dig in deeper in a more direct manner.

Attempt to bring management up-to-date with the latest developments in engineering.

Update me in general terms to current methodology and details that I was not getting in trade magazines and newspapers.

Give me a broad overview in several areas of new technology that have been developed since I left school and with which I have had limited or no contact in my work.

Bring me up-to-date with technical developments to keep abreast of new engineering knowledge.

It would update my knowledge of computer technology as applied to manufacturing systems. Would also update knowledge in modern product development.

Stimulate my engineering thinking on more of an academic basis. I was anxiously looking forward to a review and also exposure to basic engineering plus the addition of new concepts. I was looking for a "confidence builder." I felt that I was "pretty rusty" and hesitated to venture into conversations and programs requiring knowledge I was supposed to know but had forgotten or only had a poor working knowledge at my immediate command.

Broaden my awareness of new concepts and applications in various technical fields.

I felt the program should inform the participants of any new engineering teachings since his graduation from school. An updating of his engineering degree.

To update engineering graduates in the latest theory and technology available in the various engineering fields.

That I would be brought up-to-date relative to the latest methods, equipment, and facilities used for solving engineering problems. To bring to light engineering advances which might escape the notice of engineers working on current problems.

Update me on what is being taught in the college engineering curriculum and what is going on in industry.

A "birds-eye" view of engineering and recent technological advances.

Provide a broad-brush update of technical achievements and techniques in the engineering fields.

Provide information on the latest state of the art in various engineering fields.

As I recall, I felt the program would give me a better understanding of what was new in engineering.

Question 7. How much of the material presented in the program was made clear enough so that you could suggest further investigation within your organization? Can you give a specific example in some detail. (Use additional sheet if necessary.)

Statistical analysis applied to tolerancing specific components in an assembly may reduce costs by reducing tight tolerances which are held for no valid reason.

Impact of forming of sheet plastics. Magneforming. Remote time-sharing computer use.

Improved knowledge in specialized electronics helpful in new product design.

Use of computer in designing heat exchanger for new engine was applicable to our heat exchanger design for preheating cupola blast air.

Monte Carlo simulation method.

Fluidics, mathematical models, plastics, micro-electronics, sound.

Too technical and theoretical.

Instrumental in wide spread use of a variety of plastic materials in our processing tools.

Simulation as applied to both design function and process capabilities; also fluidics.

Session on analog computers led to a direct suggestion and follow-up which incorporated analog principles into a program that was under way. Consultation with program staff personnel helped us.

Use of new plastic forming processes. Use of new metal forming processes. Use of reclamation processes.

Better understanding of use and limitations of plastics.

Use of statistical methods in planning and evaluation of experiments and testing.

Computer programming.

Manufacturing process monitoring by means of computers.

Laser beam, plastics, electro-machining.

Communications and statistical analysis.

Fluidics.

Greater awareness of statistical method and what they really say.

The use of numerical controlled machines and computers.

Plastics processing. We sent a man to school for a week program to learn more.

Matrix test selection techniques are now used routinely. Ceramic materials are now being considered for high volume production.

Computer analysis of data. New uses for plastics. Electro-mechanical controls. Fluid amplifiers and controls.

Cutting tool materials simulation.

Process control computers. Statistical testing techniques.

Numerical controlled machining.

Fluidics.

Hot flowability of steel.

We are endeavoring to adapt valve mechanism simulation to engine design much as learned in program. Material on human engineering was applicable to office design.

Program gave some insights on a few computer applications related to manufacturing.

X-ray viewing and photography of dynamic phenomenon. Lasers.

Suggested specific line of investigation in the solution of a gun mount seal problem involving a materials processing and testing review.

Suggested cast-to-size patterns, electrochemical machining, and electrical discharge machining to pattern shop.

Construction of a test matrix to reduce number of tests required to obtain required test data.

Proposed fluidics to the physical test lab for consideration.

Numerical control of machines in tool room and manufacturing operations.

Holography, nuclear physics, hi-temperature thermoplastics, heat-transfer.

Use of computers in solving design problems, storing data, and processing data.

Laser measurement. Numerical control for layout inspection.

Computer programming techniques.

Question 8. In your opinion, did the program result in a financial savings to your organization through the application of information gained through participation in this program? Can you give a specific example in some detail. Use additional sheet if necessary.

Information picked up in the program helped to develop a graphical technique for presenting budget requirements to management in a more effective manner.

Most resulted in new areas of investigation which cost money, at least for a time.

My involvement in cupola emission control program allowed ideas gained to be applied for a substantial economic savings in capital investment.

Computer programming for process controls. Understanding of sound control.

Solid state electrical control circuits for gaging and machine controls. Space and maintenance savings.

New plastic and reclamation processes.

Better techniques in experimental testing undoubtedly results in some savings.

Time saved in communication.

Projects incomplete at this time. Anticipated gain is great.

No real example, but refresher course such as this adds to your daily use of various skills.

Matrix concepts have reduced the number of tests and experiments required to "prove" design. Example: piston ring oil consumption tests to qualify vendor reduced from more than 100 to 32.

Computer analysis and print out of exhaust emission data.

We made better use of our limited amount of numerical controlled machinery.

Informal relationship with faculty of program greatly expedited parts testing program I was working on.

Increased use of plastics.

Not yet, but some savings may occur as some techniques are implemented.

Primarily gave me a better understanding of items I read about in trade journals. Better application of statistics.

Increased use of static controls on mold lines. Probably reduced downtime up to five percent.

It gave me a better understanding of computers used in manufacturing operations.

Improved programming.

Developed first comprehensive computer scrap program at plant. Reduced losses, errors, and defects. Exception reporting utilized for the first time.

Question 9. What area of knowledge presented in the program was of most benefit to you in relation to your work? Other (specify).

Knowledge concerning abilities of young engineers.

Basic scientific knowledge.

Better awareness about what assistance could be expected from experts in each engineering specialty.

Man made materials.

Statistical testing techniques.

Question 10. In how many ways did the program help you? Other (specify).

Made me aware of school's good facilities and the competence of the teaching staff.

Gave me increased awareness of personnel in my own company.

General "update" on techniques and teaching.

To learn new methods of doing old tasks and helped to communicate better with young engineers.

Helped me to challenge younger engineers to use new techniques, etc.

Question 14. If the program materials were referred to, of what use were they? Other (specify).

Became acquainted with program staff so that I could obtain additional help on a problem.

I used the information extensively in presentations to members of middle and first-line supervision.

Question 17. Do you have any suggestions to improve the utility of the program notes or other materials?

A "graduate" from the program might benefit from receiving updated material and notes from succeeding programs.

Summarize the important information.

More specific examples of practical approach, more basic theory. Everyone did not catch on at the starting point.

Provide sample problems and data in statistical areas to provide a reference when material "gets cold."

Establish better insight into production problems and relate notes and materials to solutions of these problems.

Have a good one-page summary.

More thorough indexing.

Need a better index. Must rely on memory to find a specific piece of information. Takes too long to find it.

Standardization of material and indexing.

Prepared abstracts should be distributed in advance of class.

More toward application and problem solving.

Outline and summary type notes proved most useful.

In many cases they were too technical.

The notes were not as advertized. They were mere outlines and summaries. My own note taking changed radically after first session.

They should cover all material presented in lectures and if possible additional material. In some cases the notes are too brief.

Reduce the mathematical derivation of formulas. Relate formulas to practical uses.

They were and should be as complete as they can.

Too theoretical and technical. Not enough application.

No, very good in a majority of instances.

Keep mathematical developments to a minimum.

Some material was distributed as brief outlines. Things moved too fast to take adequate notes. More complete information should be printed for future reference.

More unified approach to the various areas covered.

Question 21. If you had it to do over again, and if your company were willing to invest an equivalent amount of time and money in any of the following alternatives, which one would you choose? Other (specify).

Answer would be biased since I am working on an MBA. It depends on the person's other activities, desires, and point in life.

Question 22. What gives you the greatest difficulty in performing your job? Other (specify).

Personnel problems (hourly rated employes).

Communicating with people.

No particular difficulties.

Time available versus increasing work load.

Knowing that new methods exist but lacking the time and assistance to put them into effect.

Performing required increased tasks with present resources. Must improve efficiency through new techniques.

Selecting the specific technical approaches to complete a job. There are many technical approaches, but we do not have the manpower or facilities to go several ways.

Lack of defined responsibility.

Petty personnel problems. Lack of well defined institutional goals.

Overcoming job limitations imposed by my supervisor.

Managing and developing my people.

Getting resources (men and money) to do what should be done.

Finding people who can follow through on new concepts.

Question 25. How have you been able to meet changes in technology related to your work? Other (specify).

Contact with colleges.

Discussion on technical trends with people at other universities.

Developing tests to provide information needed.

Conferences in other fields, at schools, etc.

Discussions with experts.

Exposure through job changes.

Job experience.

Question 32. Your participation in the program was a result of: Other (specify).

Part of a planned individual training program established by my management.

Question 33. Have you been promoted or had an increase in job responsibility since completing the program? Other (specify).

Change in job responsibility.

Demotion due to merger.

Question 34. What is your present job classification?

Director of employment practices.
Engineer in charge -- product testing.
Director of engineering.
Director, reliability control.
Assistant master mechanic.
Chief engineer.
Superintendent of reliability control.
General superintendent, production.
Supervisor.
Assistant engineer in charge.
Assistant manager, process and equipment.
General supervisor of industrial engineering.

Staff engineer, product engineering.
Manager.
General superintendent, master mechanics.
Assistant engineer in charge, laboratory assignments.
Development engineer.
Superintendent, quality control.
General superintendent, plant engineering.
General supervisor.
Chief engineer.
Head of electrical reliability.
Assistant superintendent, process engineering.
Supervisor.
Assistant manager, research and development.
Assistant staff engineer.
Supervisor, engineering.
Superintendent, maintenance.
Assistant staff engineer, advanced design.
Senior engineer, production.
Staff engineer, research and development.
Superintendent of master mechanics.
General supervisor, test engineering.
Supervisory development engineer.
Development engineer, motors.
Superintendent.
Director, manufacturing development.
Staff engineer, product.
Engineer, product.
Chief engineer.
Engineer, motor.
Director, product assurance.
General supervisor, product engineering.
Superintendent, manufacturing process engineering.
Master mechanic.
Assistant motor engineer.
Engineer in charge, chemical, metallurgical and corrosion laboratories.
General supervisor, production engineering.
Assistant manager, reliability assurance.
Supervisor, engineering.
Director of library.
Executive engineer.
Staff engineer, design.
General supervisor.
General superintendent, production.
Regional manager, four plants.
Superintendent, inspection, quality control, and reliability.
Chief application engineer.
General superintendent of manufacturing.
Assistant superintendent.
Manager.
Unclassified.
Application engineer.

Manager, special projects engineering.
Senior project engineer.
Staff engineer, experimental testing.
Application and commercial engineer.
Staff executive, purchasing and production.
Assistant chief engineer.
Executive director, research.
Assistant chief engineer.
Department manager, engineering.
Supervisor.
Section head, reliability.
Assistant chief engineer.
Manager, systems.
Chief engineer.
Superintendent.
Engineer in charge, production engineering.
Director, reliability engineering.
Manager, industrial engineering.
General project manager.
Superintendent, manufacturing engineering.
Assistant superintendent, quality engineering.
Senior staff administration, manufacturing.
Experimental engineer.
Superintendent.
General manager.
Works engineer.
Assistant chief engineer.
Engineer in charge.
Superintendent, quality control (retired).
Executive assistant chief engineer.
General supervisor, engineering.
Assistant superintendent, process engineering.
Assistant experimental engineer.
Plant engineer.
Chief engineer.

Additional Comments

Material well presented but at a relatively elementary level. It does not seem practical to tailor a program such as this to meet the needs for all levels of interest and technical background. As a result of trying to do so, parts of the class are completely lost and others are bored. Persons taking such a course might be expected to be fairly up-to-date in their own field but should be exposed to more challenging ideas and concepts in other fields.

There is a real need for courses updating engineers by engineers in industry but to be really useful, more effort needs to be put into the design and administration of such courses and more time must be expected from the student taking the course.

I feel that my appraisal of the program should be weighted by the fact that I have no formal engineering education.

Program of this type should be used as a continuing education process. This affords one the opportunity to stay crisp in his specialty and at the same time broaden his technical knowledge. This provides a good background for growth of managers. Courses should involve business practice and techniques along with technical material.

Shortly after completing the program I was transferred to a foreign operation. The radical change in quality and quantity of manpower and facilities have made it extremely difficult to utilize the benefits of the program.

It seems to me that programs are needed for working engineers, first line supervisors, and middle-upper management. This program seemed to be oriented toward the working engineers and involved more mathematics and development theory than was needed by a supervisor.

I think a continuing program would be better than being presented with infrequent large increments of new concepts. A program more specifically designed for middle and upper management which would keep those persons aware of the new technical thrust would aid considerably in communication and understanding. It would aid in managing change.

I think it was a good program: to those that "came for the ride," they learned something; to those who were "self-motivated," they came away with a lot of good exposure to new ideas.

I would suggest that examinations and tests be given to keep everyone from "sand-bagging." Tests need not be recorded or be kept on a confidential level. A pre-test and post-test would permit the student to measure his progress and the effectiveness of the program. I am glad that I attended the program and would suggest future courses in the art of communication (reading, writing, speaking, listening) and maybe even a short speed-writing course.

I found the program very educational from the standpoint of being exposed to new scientific knowledge. Since graduating from college, I managed to keep informed on new developments by taking courses, reading magazines and periodicals or attending professional society meetings. By taking this program, I was amazed at the increasing rate at which new developments had taken place. The result is that I was better informed of these developments in a short time.

Personally, I feel that the program could be improved by including more application and less theory. I highly recommend the program and would like to see its continuation. I believe it would be beneficial to have an update on new developments for those finishing the course in previous years.

My overall reaction to the program was that it furnished me with updated information in the engineering field which has benefited me a great deal. New

techniques presented have also been of assistance to me in performing my present assignment. The program definitely has stimulated my interest in self-study and enhanced my ability to communicate with others on a technical basis.

I feel the program is good. I have scheduled others to take the program and they all felt they benefited.

Another phase of this type of program might be visitations to plants or facilities that are using the more modern technologies such as lasers, fluidics, etc. Even a film of applications would help stimulate thinking. In my opinion this is an area which is relatively not covered by educators. There is always a better idea or application elsewhere -- how else can we know about them?

Another area might be a series on specific manufacturing processes; cylinder machining line or an automated spring plant. Programs designed to show how others have automated various manufacturing operations.

Another area for study would be "how to mathematically establish priorities for work effort." Value analysis, etc., as related to priority establishment.

The session I attended tended to be too theoretical.

The program was highly theoretical as presented. Therefore it is difficult to assign practical values to it, especially if the person attending is not engaged in strictly engineering activities.

I am, and always have been, in manufacturing. I found the program interesting but not too practical. The chemistry, mathematics, etc., were interesting but theoretical. Probably good for engineering people. I found the numerical control, machine control and fluidics more practical along with the process engineering phase.

As a suggestion it might be better to separate the two areas. One program for the research type people and another for the design and manufacturing people. Or, in other words, separate the theory from the application somewhat.

Boolean algebra did not appeal to me. The application of lasers to measurement techniques did.

Benefits -- gave me a better perspective of the world of engineering that now exists. Improvements -- feel most of the instructors were too technical in covering subject. They should learn to talk and present material in terms of layman. Reaction -- favorable but sessions too long. About one-half the time would be required if the instructors would learn to talk less and think more.

I feel the program should be repeated every five years.

The program should be divided in levels corresponding to the number of years a person has been away from technical education. The rate of technological growth in the past fifteen years has been drastic and to fill the fifteen-year or even ten-year gap in one step is not feasible.

In some phases of the program the instruction was too detailed relative to mathematical computations. Other areas did not show the significance of background information to up and coming material. Overall it was an excellent program for brushing up on new techniques.

I believe a program of this type and scope is very important to updating older graduates on modern technology and techniques.

A "live" program is essential to permit questions and answers from the "experts."

The use of numerous professional experts on various subjects was extremely effective.

The association and benefit of experience from others in the same or allied fields was also important.

Included in this program for supervisors might be new techniques not necessarily technical -- motivating others, establishing objectives and goals, controlling budget, and planning programs.

I know that my answers may conflict with my feelings about the course.

I feel that the course was extremely beneficial since I had been out of school for a period exceeding ten years.

I would attend again if invited, but feel that a shorter period of time would be more practical for busy people.

This program made me very much aware of things that I have read in my trade magazines, but the personal touch seemed to stick to my mind more than when I have read the same article.

I have related in my mind information gained in the course, although in our case we have not pursued the item other than plastics. We are extensively pursuing plastics, but not as a result of this course.

I believe the program was more beneficial than my answers to the questions has indicated. The impact of so many new concepts may not result in the immediate adoption of anyone in our particular activity, but the knowledge is stored in our personal memory bank.

Who can accurately assess how this additional knowledge affects ones thoughts and decisions? It certainly has opened new areas of thought and removed fears of unknowns which in itself will be a force for confidence and positive action.

I would like to suggest a section be added on Creativity in Engineering.

The goal of the program was to provide a survey of new technological concepts to practicing engineers. I feel that the program did a very good job in reaching the goal. The faculty members participating had been well prepared by the coordinator and by their own backgrounds to function well.

My goals were to increase my vocabulary, my general knowledge of technology, and my knowledge of our faculty.

Ideally, bright, articulate, young persons should conduct such a program. Properly directed and filmed, such a program might well be put on tape.

I have already taken the program a second time. Would like to see similar programs more specially directed and with a reduced time period.

My ability to adequately comprehend some of the subject matter was hampered somewhat by an insufficient and sketchy mathematical background.

One of the reasons why the program seemed to me, to be an effective course, was the calibre of lecturers. Without exception, they were excellent.

I believe the continued success of this type of course will be directly related to the capability of the lecturers, and direct communication through discussion is of utmost importance.

The course presented a number of widely diversified engineering subjects with limited time being devoted to any one subject.

The engineer just out of school doesn't need the broad scope of review offered by the program.

The engineer who has been out of school for some time will probably react as follows:

a. Some portions of the subject presentation will fit in with the engineer's scope of work.

b. The biggest part of the program will not be related to the engineer's job, but might be interesting.

c. Some portions of the program will not be related to the engineer's job and will not be interesting.

Recommend consideration of several courses with each course to cover an engineering phase. Each course might include two or three closely related subjects.

One additional subject (not closely related) could be thrown in on a pure "interest or color" basis.

Part of my problem of attendance at this program related to the fact that I had to travel from another city to attend it. Job responsibilities did not permit regular attendance.

At the time I suggested that the program would be far more beneficial it it was brought to my city so that my company employes could participate on a local basis.

I found that many of the instructors initiated their subject at too high a technical level. They would have accomplished more by a presentation of basics . . . then expanding into more technical aspects of the subject. This comment is very important in view of the fact that I am familiar with a wide variety of subjects -- probably more so than most participants. Still, I felt the need to be refreshed in basics first before trying to absorb more technical details.

Also, I believe the subject matters covered ranged too wide for most participants (not for me, though). Many were at sea without a paddle. Some narrowing or more logical grouping of the subject matter would seem advantageous and increase the value of the program.

In general -- worthwhile stimulus; fairly good coverage; inadequate notes; someone showing me things I could see better where I am (i.e. small computer when I'm using a 360); inadequate flexibility (i.e. buy whole program or nothing); would like to continue in some way, but the special continuation programs offered seemed to miss the boat. I think that the university context for this experience might have been better than company facilities.

In the long run I'd like university credit. (I'm going to night school at a university right now.)

A worthwhile stimulus every five to eight years especially in fields beneficial to my present work.

Many people felt as I did, that a person without an engineering degree would not understand presentation and would not ask questions due to displaying ignorance on subject matter.

The program was excellent because it provides updated information in a manner most convenient and complete.

I enjoyed the program very much. In particular, I felt the discussions with the other class members and instructors during our break and dinner periods were very informative. Even though I felt that the program was too short, I do feel that programs such as this are valuable in helping us to understand some of the changes that have taken place in the field of engineering and what undergraduates are learning now.

These should be never ending programs. Use of videotape would reach a wider market. Tapes should allow two hours per week review of new developments, materials, techniques with a strong emphasis on their practical application

with backup tapes or seminars for the more technically inclined to better understand the derivation of a given subject.

Set up a film or video program which gives an overview of a number of subjects for study. Follow up this initial program with a series of special programs which give greater detail on the subjects brought out in first program. Time could be set for questions and answers by phone, letters, or arranged classes if needed.

There has to be a better way of getting information out to industry in all areas of study. The reverse is also true. How do we get information back to the educators? The one who devises an effective exchange program of this nature will contribute more to the advancement of society and its workers than anyone has dreamed of. There is too much time and energy lost on both ends of the line because lack of or no communications. This is needed!!! (Good or Bad.)

We were developing a test program for which there were some definite weaknesses in the types of data we could obtain and our ability to handle the data. The session on analog computers appeared to offer a way to accomplish our objective. We were able to work directly with the school and make application of these techniques right away on that particular program.

The school can be counted upon to run a stimulating, well-organized program. This program was no exception. I would gladly repeat the experience.

On occasion I was bored. But far more often I was highly stimulated.

The questionnaire was complete.

The program sessions, which I participated in, contained far too much formula derivation calculations. This was my chief criticism at the time along with most participants.

In general, I considered the sessions to be very informative, interesting, and well worth the time and cost.

My own basic problem with the course was the fact that at least a third of it was theoretical (especially mathematics) and many other participants felt that the course organizers gave exposure (and income?) to many staff men who presented their specialty right out of the classroom, brilliant theory, difficult to follow, devoid of application, of no use to associates, and dead wood in the notebook.

I felt that too many "professors" had no true understanding of the background and needs of 90 percent of the class. The program was well intended, good overall, excellent in many areas (especially computers) but poorly executed and a waste of time in a third of the time when hours were spent developing theories and mathematical formulas which we couldn't follow and never questioned in the first place.

I filled out a questionnaire after this course and stated in some detail those things listed above. I have the impression that little was changed in 1965, '66, '67, and '68 presentations and I could never get enthusiastic about investing the time and money for people who work for me. I never pushed the course for others while I felt the staff was being "academic" and theoretical and not leaning toward application and participant understanding.

Perhaps your survey will lead in the right direction.

Since it has been six years since first taking the course, I plan to take it again in the next year or two.

It is impossible for me to keep abreast of all the bodies of knowledge that I need in carying out my varied job assignments. In one or two fields of particular, personal interest, I can keep fairly well informed of new technology. This type of program gives brief exposure to many fields and is an efficient technique for keeping up-to-date with minimum time expended.

In general, most engineers make a transition from being an "engineer" to that of managing engineers or others. This requires a general knowledge of new methods in engineering to adequately guide the organization. However, other areas of knowledge become more important. Courses, seminars, etc., to update previous graduates in engineering sciences should take this into consideration. Course material for the engineering manager should be designed to let the manager know what resources the newer graduates have to solve engineering problems which may be different than the manager's training was.

This kind of program could be adapted to be taken every five years by engineering graduates and would cover only advancements in technology in the immediate past five years. When I took this course, I was being exposed to new material covering about twenty years.

Under this plan, I would have attended four courses instead of one.

Because of the general nature of the course, I think only material at the undergraduate level should be used.

Dependence upon current mathematical skills should be largely avoided where possible.

Association with others taking the course, from other companies and with other interests is very valuable and can probably not be achieved by canning the course and presenting it at a specific company.

1. My overall reaction to the program was good and I was sorry to have missed two sessions.

2. Material distributed should be more complete and not given as an outline.

3. Here in Germany I feel as though I were in the middle of a desert. The school and staff are about 3500 miles away which makes for a long pipeline. I have used every bit of knowledge here to implement new ideas and use of more up-to-date equipment for improved efficiency as well as making it easier for my people to put their knowledge to work.

4. This course should be updated as progress is made and given on a regular schedule.

I liked the idea of covering a wide variety of material. There is just not enough time with a group to go into specific areas in sufficient detail to give anyone knowledge he can apply.

The mathematical derivations were overdone, although not as much as many complained. Teachers seem to have an obsession with proving everything and deriving all the formulas.

I liked it as a "mind stretcher." It opens your horizons and makes you more receptive to new concepts. Knowing that all those new things are going on in so many diverse fields makes you more open to like developments in your own.

When you get right down to it, engineers working on consumer products only deal in basic engineering and scientific concepts. Hence, in such a course this is all we need cover. We will look to the subordinates for the detail knowledge.

The program serves a very useful need to all engineers, especially those out of school ten years or more. Following school or receipt of a Bachelor's Degree one tends to become specialized in a specific area touching others only as an as-needed basis. Consequently narrow areas of endeavor develop beyond known state of the art. Consequently, a problem in a related area appears and the engineer's knowledge is antiquated. This then entails research whereas a state of the art recap would permit immediate recognition for answer or reference to find it.

Another important aspect is as an engineer progresses into supervisory responsibilities or may be assigned to a special team or task force he is apt to be with more recent graduates whose knowledge is updated beyond the older engineer. A communication gap may develop resulting in strained efforts rather than technical agreement.

The variety of subjects were new and interesting. Many touched on new theories and concepts that were informative and current. Too much time was used to derive these concepts. Too little time was used to discuss how these concepts could be made for some practical use in resolving everyday engineering problems. In general, the professors making these presentations are unable to communicate on a level that is readily interpreted by those not as knowledgeable in the field. More effort in these programs should be made toward practical application of new concepts.

Since this course was taken more than five years ago, it is extremely difficult to answer the specific questions with great accuracy. In general, my recollection of the course value was good and well worth the time required to take the course. In today's environment and with present work load and increased responsibilities, it would be impossible to take the course in the same manner and over the total time schedule devoted to it at the time it was actually taken.

Program B

Question 1. What did you personally feel that the program would accomplish?

Updating of technical knowledge.

To develop an understanding of the advances in technological fields since graduation from college, particularly the unifying fundamental principles.

Give an engineering manager a review of newest engineering materials and methods (fundamental modern technology) that are being taught today in the colleges.

(1) Revive somewhat my working familiarity with mathematics. (2) Understand some more of digital logic, digital circuitry. (3) Learn of new concepts in physics. (4) Obtain a feel for computer applications, real time processing, new generation computer capabilities. (5) Learn some principles of mathematic modeling and the scope of software simulation.

(1) Provide refresher information on modern basic sciences and engineering fundamentals. (2) Give me an acquaintance with the type of education being given to present engineering students. (3) Opportunity to discuss problems and share experiences with other engineering managers.

Update my knowledge re: mathematical and computer methods to perform engineering analysis and engineering evaluations. Also to become more aware of concepts of probability and decision structuring and analysis.

Expose me to new developments in the engineering field.

Provide better conceptual understanding of advanced mathematics, science and engineering and relationships.

Improve communications with fellow engineers, scientists and employes.

Bring me up-to-date on progress of technology on a broad basis, and in areas not normally worked in.

"Update" me on technology. In my case, I realized a 25-year gap (time elapsed from graduation to start of course) was a big step to take in six weeks. I recognized I would not be able to absorb all of it, so I planned to concentrate on the subjects that were most important to my present job.

Bring me "up-to-date" on the advances in engineering and science subjects as taught today in graduate school, as compared to my graduate school learning fifteen years previous.

Also an exposure to new subjects not normally a part of my current and past engineering assignments.

Provide an introduction to new technologies and techniques together with some idea of where they were being used.

Updating of my knowledge in fields of physics, chemistry, materials and mechanics.

I expected a rather broad review of science and engineering, particularly emphasizing technologies, methods and results which have become available since my schooling. I was aware, for example, of the new approaches being used in chemistry as a result of watching an educational TV college-level course. Further, one could hardly fail to notice the changes in physics, communications, electronics, etc., etc., although it had not been possible to get more than "popularized" versions in any but my own fields of interest.

A review of some of the basic fundamentals and laws of physics and engineering plus a look at some of the latest thoughts and approaches to the application of these principles.

Mental stimulation by exposure to new scientific and engineering principles and techniques; without distraction in a full-time academic environment.

Acquaint participants with new engineering techniques and tools and also with new concepts developed in the last few years, presumably since participants went to school. Also review some basic concepts in areas that the participant is not normally involved with, thus broadening his background.

Provide an updating in my awareness of technical developments generated since the end of my formal training. Awareness of, rather than the acquisition of expertise, was the goal.

Provide me with an updated awareness of modern engineering techniques as being taught in a good cross-section of our key universities. Also provided a valuable new communication link with other engineering managers participating in this course.

I expected a retread in engineering subjects, especially mathematics, and I expected to get to know a number of other engineering managers.

I expected to get a look at engineering activities outside of my field which I had deliberately avoided on the basis of the information explosion with plenty to study within my narrow field of specialization.

Review of mathematics and engineering fundamentals; general updating on materials sciences; new knowledge of atomic and nuclear physics. Some new points of view about regularly used fields, such as probability.

A broad integrative course like this program that discloses where the fields of technology stand perhaps needs to be supplemented by very compact modular courses, perhaps taped, that would give enough of the basic language and concepts

of specific fields so that an engineer could learn them and start applying them immediately when he needs them. For the working engineer the standard semester course is far too abstract, obtruse, and academic.

Provide a survey of technical courses now being taught in undergraduate and graduate schools, so that I would appreciate the talents and capabilities of younger engineers and utilize these techniques in the performance of my duties.

I felt the course would be a refresher in engineering technology and would bring us up-to-date on all new advancements.

Exposure to new methods, analyses, disciplines of engineering particularly areas which had become important or had developed since my graduation and to which I had no significant exposure.

(1) Be a refresher of basic tools and of techniques and technology. (2) Introduce new techniques such as decision theory, semiconductors and integrated circuits, and computer usage in engineering.

It would give me an overview of advances in the art of engineering in, say, the last 25 years. Since my college training was completed in 1940, a look at new technology is important to me as a manager of engineers, most of whom have had more advanced technical training than I. I expected to get a greater appreciation of what approaches are now available to problem solving, what skills should be looked for in modern engineers, etc.

Develop some insights into technologies which were unfamiliar to me.

Provide a survey of some of the engineering knowledge gained since I was graduated and provide an opportunity to rediscover some of the knowledge that has fallen into disuse.

More familiarity with some branches of engineering than I had before, and particularly mathematical methods and use of computers.

I felt that the program would update me in new techniques, procedures and technology available in the various engineering fields. Further, I thought that the interaction discussion sessions with the instructors and other practicing engineers with somewhat similar problems would put things in better perspective for me. I feel that in general these aims were realized and that the course was very beneficial to me.

Update and refresh in Engineering and Scientific techniques and advances.

Update and broaden technical education. Provide a stimulus for future self-development.

(1) Provide a broad updating of engineering in general. (2) Provide exposure to techniques that might be useful in my work. (3) Provide an insight of what is now being taught in the engineering schools.

Updating of technical skills in a climate free of the daily requirements of business. Broad brush introduction to recent techniques for later evaluation and possible implementation.

(1) Present new concepts in engineering analysis. (2) Highlight major growth areas in engineering field. (3) Provide survey type information in engineering activities and give significance of what's going on.

This I think is rather an ambiguous question. Do you really mean what I thought the program would accomplish before I took the course? Or do you mean what I thought the program should accomplish after I had taken the course?

Before I took the course, I only knew what I was told. It would give me an overview of technology, unify my concepts, update my education, and so forth. This therefore is what I had to think it would do.

Now what did I think it should do or perhaps should have done? In a nutshell I think it should help the engineering manager to look further ahead on a foggy day. The French say "plus ca change c'est la meme chase." This is not true in engineering. However history shows how difficult it is to recognize a good idea which is ahead of its time, (i.e. the digital computer and my company). On the other hand, all good ideas are not viable (e.g. the Stanley Steamer). Perhaps this ability to plot the right course is a talent belonging only to the chosen few. If, however, the talent can be aided by education I would say that this should be the primary aim of the program and it should be judged on the success and "luck" of the innovations approved (not necessarily originated) by its graduates.

Expected to be briefed on: (1) Technical curriculum being offered to current engineering and science students. (2) Recent technical advances. (3) New analytical tools and methods of attack in engineering problems.

I expected that the program would provide stimulating exposure to recent scientific and engineering developments to create an awareness of progress outside my normal field of activity.

(1) Provide new mathematical techniques applicable to my work (systems design and analysis). (2) Provide information on nuclear physics to assist my understanding and communication with physicists and engineers involved in design, developmental and use of large particle accelerators. (3) Broaden my understanding of the work being done in engineering fields not directly related to my own.

I felt that the program would acquaint me with rather broad facts concerning advances in technology over the past ten to fifteen years. I hoped for sufficient detail to read and appreciate survey-type articles in the literature of a

specialized field. I wanted examples of how these advances in technology might affect future commercial businesses.

Primarily an updating of engineering fundamentals and techniques.

Review changes in technology since graduation from college. Purpose to better understand available approaches to problem solving to better understand knowledge and capabilities of recent graduates.

Exposure to eminent lectures capable of conveying new concepts and expansion of knowledge in basic subjects and acquisition of a set of related texts and lecture notes for further, more in-depth study at a more leisurely pace.

Update engineering knowledge; broaden prospective; acquaint with fields not covered in college; acquaint with technical people in the company.

Update me regarding new knowledge and techniques in engineering fields since my 1940 degree.

Primary purpose was to update the engineering manager on new technical information and techniques available and being taught to younger personnel who may be reporting to him. Briefly, to make him knowledgeable on the latest "tools of the trade," but not in great depth.

Acquaint me with latest engineering analysis techniques with a brief look at applications possible.

Introduction to new technologies and fields of engineering which have emerged since my graduation. For some it would stimulate computer use -- I was already making much use of computer problem solving.

Hoped also to form some new internal contacts.

(1) Broaden acquaintances within organization. (2) Broaden educational background.

(1) Provide contact with a review of present technology. (2) Provide a personal exposure to a group of outstanding technical men.

Update my technical knowledge.

An abbreviated overview of recent technological developments plus a limited exposure to some technology areas.

Introduction to new methods and techniques useful in modern engineering. Identify effective application of probability theory. Provide a broad perspective of engineering discipline.

Bring me up-to-date with new scientific tools and discoveries since my formal schooling and interpret their usefulness and impact (state of the art review of technology). Refresher in engineering fundamentals and their new applications to engineering problem solving.

I expected the program would be a presentation and review of the state of the art in a relatively wide range of fields with which I am not familiar in detail but which may have both direct and indirect application within the organization I direct.

Updating of engineering tools and material currently available. Widening of operating base through contact with people in other fields of science and engineering. Provide an opportunity for further detailed study in specific areas.

Question 7. How much of the material presented in the program was made clear enough so that you could suggest further investigation within your organization? Can you give a specific example in some detail. Use additional sheet if necessary.

Established additional computerized modeling of radar system performance.

Use of time sharing computer was accelerated because it was introduced on our course.

Used time share and fortran to program software for inland steel computer controlled tandem mill and Youngstown sheet tube BOF Systems.

Use of decision theory, on hand calculation basis, as well as on computer basis.

Probability and statistics led to better understanding of computer runs of existing analytical programs. I was also more competent in the instruction of my subordinates in analyses.

Use of probability and decision theory in our organization. Also better use of time sharing computers (as this technology became available) to control systems, for example. Increased effort in systems and related technology.

High temperature plastics -- now applied in production heaters for synthetic fibers.

Used digital sampling techniques to develop a new turbine start-up system. The program was not the sole source of ideas but suggested some new approaches.

The use of the computer in areas in which we had not previously seen the need or application. The calculation of the calibration of a new radio dial, for example.

Decision theory.

Basic and time sharing were just being introduced at that time in 1965.

Use of decision analysis in evaluating a make or buy problem with mineral insulated cable.

I learned to become comfortable with probabilistic terms and found many useful ways to recognize "many things in nature are probabilistic."

Gave me enough of a shove into matrix analysis so that I could communicate with the younger men working in optimal control and estimation.

Decision theory was well presented and of value in my organization. I was able to discuss and suggest uses and reading material to subordinates.

Computers for solution of engineering problems primarily signal processing and antenna design. Later (two years) for design automation.

Probabilistic approaches under conditions of uncertainty.

Probability; material behavior; statistical theory; system theory.

Greater application of time sharing and investigation of interactive computer graphics for our design and analysis work. Significant advances have been made recently in application of interactive computer graphics in our department.

Found all data on "probability and statistics" very useful. Used this data, in my office, for application to factory facility planning.

In our own technical field, depth of information was not adequate to suggest further investigation.

Use of probability and statistics in analyzing power demands on electrical machinery in the mining industry.

Lectures on eye-brain sensory system led to increased emphasis in my group on multi-spectral sensor systems.

Material was generally clear enough but specific applications are far between. We have utilized more defined systems techniques.

Probabilistic analysis -- This has been widely adopted making use of the computer techniques presented in the course.

Computer applications -- Decision analysis in evaluating new product development.

Computer time sharing use -- Have added two terminals as result of engineering management urging. (Nearly all engineering managers have had the course.)

Time-sharing computer use.

(1) Statistical analysis. (2) Decision making under uncertainty.

Use of company time-sharing computer programs.

Have used experimental design in planning development test work.

Feedback control. Use of unit pulses in analysis of system response was a new concept which has been used as a result of the course.

We made additional use of probability theory in predicting M.T.B.F. of products from limited testing.

Theory of probability and applications.

Use of matrix operations in analysis of product planning.

Analysis of random signals. Decision analysis.

Question 8. In your opinion did the program result in a financial savings to your organization through the application of information gained through participation in this program? Can you give a specific example in some detail. Use additional sheet if necessary.

As manager of an advanced group, I believe it enabled a better understanding and consequently enable coupling with other work.

Use of computer accelerated.

Computer programming methods.

Computer application to drive interactive displays which aided acquisition of new business.

Association with others in the class has fostered an exchange of information.

Through the use of probability and statistics we were better able to recognize process variables were a problem and could take action sooner before things went out of control.

As Manager-Engineering, I could better judge the technical calibre of my staff and organization. This is probably the most direct impact.

Specific use of materials information on several occasions. Specific problems in electromagnetic fields.

The application mentioned on the previous page (use of digital sampling techniques to develop a new turbine start-up system) was patented. License agreements resulted in direct income.

The computer method mentioned on the previous page (calculation of the calibration of a new radio dial) is the best example here also. Long hand calculations of calibration scales made for each capacitor have been computerized.

More use of time sharing for circuit design.

Again by early introduction of time sharing for use by the developmental engineer.

I am a more effective manager because I have more self-confidence and a better grasp of unification of many branches of engineering.

Increase in effectiveness as a leader in some technical fields.

Gave us confidence to embark on a design automation program.

Mostly by knowing something about which those about me are working. Better communication of ideas and suggestions.

We have made more use than before of statistical methods in the analysis of operating characteristics. One man has been assigned to obtain a reasonable degree of competence in statistical analysis.

Computations -- Hand versus computers.

Through ability to use time sharing to perform more complex calculations in hours instead of hiring more formal computing services outside.

I organized and conducted a course in time-shared computer use and also in related mathematical techniques for approximately ten associates.

The benefits of this course were largely to me personally, and not to my employer in any way which can be measured financially.

Computer applications improved efficiency.

No attempt to capitalize on information gained was made by local management -- no interest shown.

Business planning venture using techniques in seven (statistical analysis, decision making) allowed existing data to be used as decision to enter business.

Computer programming of projected engineering load for planning purposes.

More gain in understanding than dollar savings.

Some programming techniques in time sharing have been adopted.

Through the friendship of individuals attending the course.

Conversion of DDD-24, 224 programs (simplified versions) to desk-side computer.

Question 10. In how many ways did the program help you? Other (specify).

Update of concepts in modern physics.

Improved level of competence in chemistry and physics to better aid children in understanding high school sciences.

Just broader education.

Provided some time and environment to review personal goals and philosophies.

Question 14. If the program materials were referred to, of what use were they? Other (specify).

Counsel and encourage the young men in the organization on their future education.

I have a storehouse of undigested material to work on when I get around to it.

Question 17. Do you have any suggestions to improve the utility of the program notes or other materials?

Might suggest that students prepare their own index of most interesting topics and references for future use.

Reduce mathematical presentation, add application samples, add names and addresses of engineers who have developed and/or used the techniques.

Generally, the notes are too abbreviated to be helpful specifically. In-depth treatment in texts must be used.

I have never taken the time to index these notes. Such an index would be most valuable.

Printed text books are of more lasting value than the notes, but only slightly so because notes stir up ideas.

?Too much time has passed (five years) to offer specific suggestions.

No, except to study them in greater detail and try to teach others.

Include as many numerical examples as possible.

Notation should be defined and be more consistent between different speakers.

Notes should be available in advance of lecture date, and should be followed by the lecturer.

Most useful reference material is more specifically related to daily problems, but this is beyond scope of course.

Could be more brief.

Shorten and simplify.

Math notes could be better organized.

More communication. Bibliographies with short descriptions of material.

Question 21. If you had it to do over again, and if your company were willing to invest an equivalent amount of time and money in any of the following alternatives, which one would you choose? Other (specify).

Attend a program similar to one attended. Instructors would present material differently and more emphasis on application of new technology.

I consider the program as "outstanding."

My reason for taking the program was to increase awareness in areas outside my regular duties. I could have undertaken self-study, but there are no good -- brief -- materials available, and no study guides that I am aware of. Furthermore, one of the main benefits is the concentration during the six weeks and the ability of teachers to show interrelationships.

My personal needs would have been better served by a course similar to this program in scope but reduced in depth. The presentation became too technical. Supplement with modern engineering management techniques.

This would have to include bothering other people for some of the information.

My answer (attend professional society meetings) is based on 1970, having completed the program in 1967. If the interpretation of the question means status-quo referred to 1967, then I would attend the same type of program.

Attend same program, but follow up with short courses directly related to work.

Attend company courses related to one's work.

Question 22. What gives you the greatest difficulty in performing your job? Other (specify).

Getting people to do a thorough job.

Trying to get efficient performance.

Determining the facts for conclusions for overall business.

Having sufficient time to explore and exploit all the things I know how to do, or think would be useful.

Necessary management paperwork.

Avoiding technical errors.

Choice of research topics.

Getting people to do what they say they will do.

Motivating people.

Too heavy work load.

Doing what I know ought to be done.

Question 25. How have you been able to meet changes in technology related to your work? Other (specify).

Discussion with experts in the new technologies.

Learning from the engineers in my organization.

Personal contacts within the company.

Our own research and development work.

Person to person discussion with company technical leaders.

Technical work assignments.

Question 33. Have you been promoted or had an increase in job responsibility since completing the program? Other (specify).

Have shifted from product engineering to marketing at about the same level of responsibility.

Changed company location to accept management of larger group but same organizational level.

Question 34. What is your present job classification?

Manager, Electrical Systems Engineering
Manager, Engineering
Manager, Design Unit
Advanced System Requirements-Consultant
Manager-Advanced Systems Engineering
Manager-Engineering
Manager-Engineering
Program Manager-Applications
Program Manager
Manager-Special Applications and Project Administration
Sub-section Manager
Manager-Engineering (other companies call this "Chief Engineer")
Engineering Specialist
Manager-Design Engineering Function
Consulting Engineer
Project Engineer
Engineering Consultant
Sub-section Manager
Director
Sub-section Manager
Manager-Engineering
Manager-Aero-thermo and Systems Development for Gas Turbines
Consulting Engineer to Manager of Engineering
Manager-Engineering
Manager-Engineering Operation
Manager-Engineering-Power System-Management Department
Manager-Advanced Development Engineering and Manufacturing
Manager at Section Level Reporting to Department General Manager
Consultant
Engineering-Sub-section Manager
Research Metallurgist (just retired)
Engineering Manager
Manager-Engineering Support-Sub-section Level
Manager-Design Engineering-Research and Development Center
Section-Manager
Senior Advance Engineer
Program Management
Systems Engineer-Advance Systems Development
Engineering Management
Manager-System Engineering and Automation
Senior Engineer-Defense Facilities System Engineering Operation
Manager of an engineering group of 35 persons
Manager-Systems Application Engineering
Manager (Small Engineering Group)
Project Manager-Advanced Planning
Section Manager
Manager-Engineering-Product Section

Manager of Engineering
Engineering Manager
Section Level-Manager of New Product Development
Section Manager, Application Engineering-Electric Utility Field Management
Manager of Engineering
Supervisor, Engineering and Product Sales
Manager, Power Plant Engineering, Gas Turbines
Manager, Technical Audit
Manager, Systems Test and Operations

Additional Comments

This questionnaire is aimed at obtaining a measurable benefit of the program directly related to the job. It would seem to me that the benefits are more intangible.

The program provides a vocabulary of various specialized fields so that technical communication is much improved with consequent improvements in learning rate.

The program is inspirational. It improves job performance if for no other reason than it demonstrates that the company cares about individuals. (See Western Electric experiments on job motivation, circa 1920.)

My greatest criticism is that the program included too much advanced mathematical work. The lecturers on these subjects took far too much time proving mathematical discussion in detail. There was little or no discussion on the relevance of much of this work.

I thought the instructors were men of great intelligence and ability, but they did not tailor their presentation to the audience. For example, their numerous step-by-step mathematical proofs presented in real time which took too high a percentage of available time for that subject.

My analysis of the benefit to me as a manager was that I learned what is being taught at the university level today, and could compare it with my own experience.

Encountered some difficulty with the questionnaire due to the following: I am not a specialist. Our space business is tailored "development" without any "production" follow-up. My particular area is "advanced systems" involving -- requirements analysis and generation, system concepts, system synthesis, system analysis, mission analysis and applications, parametric analysis, performance analysis, design. As a result, my answers may not reflect the degree of enthusiasm that I have for the program.

As a Manager-Engineering, for Defense and Aerospace technologies for several years, I have been impressed by the 100 percent enthusiasm for the program that participants from my organizations have displayed. This enthusiasm

coupled with my own experience of "Taking the Course" has convinced me that the program fills a gap most needed in our business -- that of bringing our engineering managers "up-to-date" on our rapid changes in technology.

While it is difficult to put a direct monetary measurement on the "value received," it is not difficult for the sometimes called "Chief Engineer" to observe the renewed enthusiasm of his staff member who has taken the course, toward his job of promoting technological rewards to the company.

A further non-measurable product is a feeling of renewed "self-confidence" in meeting his job requirements that the participant feels when exposed to the situation of suddenly having to quickly "relearn" the basics of his college training in order to appreciate the new advances, i.e. -- it's like rediscovering a latent talent or ability. This "elation" I personally experienced from the course, and I think it is invaluable.

I felt that this program was too mathematical for managers and did not have enough references to people and papers, written by experts in the field, for technical specialists. It was presented in a manner which is used in the universities for teaching students and does not take into account that the course participants are skilled, experienced people looking for information which they can use in their own fields of endeavor.

(3 and 4) This was (and is) one of my chief work areas (computers and mathematics).

(31) Personal contacts and questions with instructors (experts) was an essential part of the experience.

The program presented was highly oriented toward the basic sciences and to the individual contributor. Therefore, it was not really suited for the engineering manager who is primarily interested in practical applications and innovations in the state-of-the-art.

The questions on the survey form are answered from that viewpoint. One whose primary interest is in the basic sciences as an individual contributor would give a vastly different answer.

The program will be viewed in entirely different light by managers and Individual Contributor Engineers. As a manager, the scope of the work fitted my needs well. It was a fairly broad look; however, general areas were too deep technically. The major advantage was an extension of my library in which I have been helped through each book with attention drawn to many important areas. I underlined and added notes profusely.

I would gladly trade some technical depth for some modern management techniques.

The program was outstanding in comparison to those which I have explored since my attendance. My personal rewards were great and I would rate the program outstanding on that account as well. I feel a one-week refresher and update would be appropriate after three years, because several areas are changing so rapidly as to be a major factor on any engineering organization today.

At the end of the course, there was an opportunity for the class to rate the lecturers and subject matter. Except for one outstanding exception, highest rating for significance of subject matter correlated with the lecturer getting very few poor ratings. However, the poorest rated subjects always were associated with many poor lecture ratings. My conclusion at that time was that most of the blame rested with the quality of the lecturer.

At that time the class had an opportunity to recommend what course material should be added for future courses. There were a large variety of specific suggestions by individuals, with only one subject getting more than one supporter. That particular subject received about one-fourth of the class votes. In talking with an individual presently enrolled in the course, he singled out this particular subject as being the most boring and useless to date. This suggests that the system for course improvement used at that time may not be particularly a stable one.

That phase relationship of feedback is wrong. (By a single vote.)

The questionnaire appears to be designed for small companies where the person taking the course might be in a key position or at least one where he could influence engineering policy.

In my case I found many of the questions inappropriate since I was a member of a large research organization and any benefit accrued would be almost entirely a personal and not an organizational benefit.

I personally feel that while it is difficult to pinpoint concrete advantages occurring as a result of taking the course, that the main advantage in my case was a change in attitude toward the more mathematical and various parts of my research activity. It gave me more confidence to look into mathematical procedures with some confidence of being able to understand the basic principles.

Continuing education programs, sponsored by the company, are always needed to some extent. The need exists primarily to expose the engineering employe to the progress within his field. The more mature and interested employe will generally keep himself informed through the technical societies, magazines, etc., however, the course still gives him the opportunity of increasing his knowledge while taking him away from the pressure of his work.

I believe the program is slanted too heavily towards the theoretical. This is fine if the people attending are in the Research and Development area. However, I believe that a number of the subjects could have been eliminated and replaced with more application-type work.

The survey aspects helped develop broader view so that I learned to see the forest and the trees. Generally it provided me another way of looking at things.

The course did not do a good job of covering significance of material presented and how it would affect decisions.

If an engineer were going to make a career switch, access to this type of information might be beneficial.

Personal Reaction to the Program

It was a tremendously stimulating six weeks and I feel privileged to have been allowed to attend. If nothing else, it renewed my pride in my profession.

I did make suggestions for improvement. One was taken up, i.e. the inclusion of modern control theory in the program. Now, however, the course is so developed and tested that it is difficult to make other than minor suggestions.

Unquestionably, the most valuable formal program in which I have participated. Extremely well organized and managed. Believe all Engineering Management and high-level technical personnel would benefit substantially from the program.

I believe that the appreciation of the various subjects would have been enhanced if the instructors had indicated what their objective was before plunging into the subject -- "This is what we are going to do . . ."

The mathematics lectures should have included more bridges to areas of use. Frequently an application will help in grasping the principle and its true significance.

It would also be helpful to bring out areas of correlation between subjects.

Actually, I find it difficult to suggest improvements. It really is a terrific program and of considerable value in making the individual more in step with technology. I frequently come in contact with college students (outside of my work) and I feel much more capable of discussing technical subjects with them.

No. 26 -- Some of the material could have been reduced, or deleted, without too much effect on the objectives as I saw them -- hour long derivations for example. In a condensed course, you can accept statements from qualified instructors without detailed proof.

No. 27 -- About right (sufficient time for questions) on the average. Too much class discussion and speculation in some lectures.

No. 30 -- Much depends on how the application is presented. (Mostly theoretical aspects.) If it includes a step-by-step analysis of the technology and decision making processes involved in solving a particular application need, then you can split it 50-50 with theory.

No. 31 -- (Film or video tape as opposed to live program) Depends on the quality of the presentation, and the use of advance outline material. These can never be as good as live program, due to lack of questions and answers for clarification of lecturer's intent.

Suggestions for additional course material: I believe the addition of lectures on the fundamentals of finance would be beneficial. The lectures should be aimed at the costs and returns involved in the introduction of new technologies, so that a complete financial analysis can be made a part of the decision to introduce a new technology or new product involving technological change.

(1) Felt program was well run; (2) enjoyed rapport with instructors; (3) felt some material was presented much too rapidly for comprehension (examples -- transport phenomena, communications) for one not in field; (4) many instances of detailed mathematics. Derivations added little to program; (5) particularly enjoyed lectures in modern physics and polymer chemistry; (6) main point of improvement for me would be to slow down presentation, perhaps by eliminating derivations, etc. Allow and encourage more time for group discussions.

Program was very beneficial to me as an individual and gave me a much better feel for what can be done even though I do not personally carry out the details. It would have been better if the selection of subjects was a little more oriented toward my interests, but I don't know how you do this without running more classes and smaller groups.

No. 26 -- (Time spent at program) OK but it could have been spent more effectively by concentrating on only one pertinent technology.

No. 29 -- (Wide variety of material versus narrow coverage) Depth of coverage is important here. Once over lightly on broad subjects, but very detailed study on related pertinent material.

General: I'm not sure that from the time and money spent (probably equal in total to my entire college education) this was the best combination of learning. Broadening is fine but a deeper knowledge of related material and a broader brush approach to peripheral subjects would have shown a greater return on the investment.

The most important aspect of a course such as this is the association with other company men in similar positions in other departments. For this association to be meaningful, the environment must be more serious than simply social. The course material provides the environment, while at the same time covering a broad range of subjects, many of which are recent developments of thought outside one's own field. Interest is stimulated, and material is provided which provides opportunity for additional study.

The course I attended was an outstanding experience. It should be viewed from a total perspective, and I doubt if the value derived can be completely and fairly segmented and analyzed by this questionnaire.

Personal associations, insights, notes, books, time to reflect, discussions with outstanding academic figures (and on and on) made the total experience.

I would recommend that men sent to such courses be very carefully selected. My satisfaction, I'm sure, would not be universal.

The program was an eye-opener. It made me aware of new approaches and techniques. The timing was such that only superficial knowledge could be gained. Needs to be backed up by selected in-depth study.

Probably 90 percent or more of the engineering tools that I use daily have come into existence since I left college in 1930. There was no feedback control science, no LaPlace transforms, no matrix analysis, no large scale computing. The engineering world was 100 percent deterministic. Now my field of avionics is almost entirely probabilistic. The whole vast field of information theory, stochastic processes, estimation, has grown up in this time.

Most of the tools I have acquired on the job, under pressure, as I needed them, but often without time to examine their underlying concepts. The course provided a unifying background for some of these, for example in the area of transforms between different domains. The part dealing with Bayesian inference was the most exciting and opened ways of thinking that I would not otherwise have stumbled upon. The parts dealing with materials and atomic physics were interesting but have affected my effectiveness not at all. Yet I would certainly not leave them out of a course like this.

Administration of the course and instructors were excellent.

Program C

Question 1. What did you personally feel that the program would accomplish?

Initially, a review of the more fundamental engineering courses and then an introduction in the new (to some) techniques in the solving of problems, (methods of doing our job) as related to our responsibilities in our daily work. Because of the dissimilarity of the group participants an opportunity to be exposed to the type of problems which others in the group encounter in their work. A capsule course in "what's the latest" in several fields especially those fields represented by the group.

I felt that the program would bring me up-to-date with newer concepts both computer-wise and otherwise. I also was seeking a general review of my basic engineering.

My early career involved sales development and little classic chemical engineering. I had shifted to a pilot plant career shortly before this course. I found that I had little confidence in my ability as a chemical engineer. This I hoped to change.

Update my knowledge of mathematics, state of the art and computer programming -- all relative to engineering.

A better understanding of what was being taught to the present engineering graduates plus an understanding of computers.

Make me aware of what is going on in the field of engineering and stimulate me to pursue in-depth study of areas of specific interest both job related and non-job related.

To bring up-to-date and make known the latest methods and techniques for solving engineering problems, planning and scheduling of projects, new materials of construction, communication with subordinates and superiors, and presentations of project reports and reviews.

Quite a complete exposure to "State of the Arts" for the engineering field in general.

Prepare me to do a better job of supervising the new, young, modern engineer.

Allow me to communicate.

Introduce me to new teaching methods and subjects developed in the last ten to fifteen years, such as, numerical math and computers.

I thought the program would review the engineering methods as they are taught today.

Provide a better insight chemical processing problems as they related to my job function as a Mechanical Design Engineer.

I felt the program would familiarize me with some of the latest tools in engineering and give me a speaking vocabulary as well as enough information, so I could research or seek further advice as the need arose.

I thought that the program would provide a review and updating of mathematics and provide background in the current theory of chemical engineering as well as practical examples of how this theory could be used in industry.

Acquaint me with advances in chemical engineering made since my schooling and review in a more consistent and concentrated manner the fundamentals learned in my schooling.

I felt the program would make me aware of new developments in engineering, renew my skills, and make me better able to communicate with young engineers fresh out of school.

I hoped for a review and updating of my chemical engineering academic course background.

I felt that the program would give me a better understanding of the knowledge, training, and capabilities of recent Chemical Engineering B.S. graduates, and would therefore give me a better technical base from which to administer research and pilot plant programs.

I had hoped to familiarize myself with computer applications (not necessarily to learn how to program or run a computer) and to learn of newer developments in chemical engineering that I could apply in my work.

Help me hold my job by filling in the missing links, difference between graduation and now; keep up with young engineers.

Question 7. How much of the material presented in the program was made clear enough so that you could suggest further investigation within your organization? Can you give a specific example in some detail. Use additional sheet if necessary.

Application of computers to design heating and air conditioning duct systems.

Mathematical modelling of process system.

We are now scheduling our manpower and materials. Time keeping and pay by computer.

I say little because as an electrical engineer taking this program (where) chemical engineers dominated, I was slightly out of place.

The professors did their best to keep away from practical applications. Requested the development of a comprehensive material and energy balance computer program.

Our use of computer time-sharing techniques was initiated as a result of this training. This has led to a greatly expanded facility making this mode of operation extremely easy for all to use.

Time sharing on the computer with remote teletype console is now common because our group became very strong advocates after the program.

Was low rated not because of lack of clearness, but because the material was of little use to my part of my organization.

Question 8. In your opinion did the program result in a financial savings to your organization through the application of information gained through participation in this program? Can you give a specific example in some detail. Use additional sheet if necessary.

Only through my increased awareness and confidence.

Possibly a better usage of "New Hires" engineers.

Early participation in use of programs (computer) for structural analysis by members of the group working for me.

Probably replaced one man in the scheduling area.

I believe the course opened up the thought channels and the company must benefit from any advance thinking.

Utilization of time sharing on the computer has more than returned the cost of the program in increased efficiency, not only in time, but in ability to solve complex problems.

Question 9. What area of knowledge presented in the program was of most benefit to you in relation to your work? Other (specify).

Have not used any new knowledge except in background sense.

Question 10. In how many ways did the program help you? Other (specify).

Learned enough algebra "set theory" or calculus to help my eighth grade children.

Question 14. If the program materials were referred to, of what use were they? Other (specify).

General information which enabled me to develop more specific techniques for the job at hand.

A concept for problem setup or an approach.

Question 17. Do you have any suggestions to improve the utility of the program notes or other materials?

All courses to have printed notes. Personal notes not complete and difficult to review.

Notes should have been preprinted to add to their utility.

I believe the program notes would have been more valuable if prepared beforehand by prof. Too much class time was used and attention given to note taking.

Provide notes for all subjects covered.

Smaller packages.

Did not get much in the way of notes.

Notes should be published before lectures.

Provide notes earlier in program.

Use more practical problems.

Provide a transition between theory and practical applications.

I believe these notes to be pretty specific to individuals who have used them and are acquainted with their content.

A few of the instructors distributed fairly complete hand-written notes of their materials. This was better than us having to take down the information and still "keep up." Might leave a little more room for us to add supplementary comments.

Have them available ahead of time (or on time!).

Some instructors did sketchy job in class; their notes, then, were of little use. I'd urge better job in class even if less ground is covered.

Forget vector algebra.

Leave out company problem as such.

Question 21. If you had it to do over again, and if your company were willing to invest an equivalent amount of time and money in any of the following alternatives, which one would you choose? Other (specify).

Attend the same program but "beef-up" the new technical concepts. On the whole our "teachers" were far behind the students in getting to new concepts.

Attend a revised program to emphasize theoretical chemical engineering in more depth plus practical applications of the same.

Question 22. What gives you the greatest difficulty in performing your job? Other (specify).

Motivating personnel.

Personnel motivation and balancing their learning with need for results.

Getting other people to meet time and cost goals.

Not sure.

Having time to get all work requested done.

Communicating in drawing and writing.

Getting other people to complete their work on schedule.

Getting enough information to define the problem accurately and completely.

Trying to keep a professional interest when all of my working time is consumed with clerical activity.

Just what is the problem I'm supposed to be solving? Often it is not the problem I'm told.

Question 25. How have you been able to meet changes in technology related to your work? Other (specify).

Discussions with people I work with.

Question 33. Have you been promoted or had an increase in job responsibility since completing the program? Other (specify).

Transfer.

Job responsibility area has changed and broadened from specific pilot plant research projects to responsibility for designing, constructing, and starting up new production plants.

Question 34. What is your present job classification?

Manager Technical Specialists Group of Plant Engineering
Senior Project Engineer
Project Engineer
Project Engineer
Superintendent
Senior Process Specialist
Section Manager-Production
Senior Process Engineer
Senior Research Engineer
Section Manager
Section Manager
Manager of Capital Construction
Senior Engineer
Senior Process Engineer
Research Engineer
Senior Electrical Engineer
Senior Process Engineer
Manufacturing Representative
Senior Process Engineer
Staff Assistant to the Technical Director of the Inorganic and Hydrocarbons Research Department
Project Engineer (Engineering and Construction)
Process Specialist
Senior Engineer
Field Engineer-Support of Maintenance

Additional Comments

Having been out of college 25 years prior to taking this course, I found the instructors covered the theory too fast for me to comprehend, especially in advanced mathematics.

I also feel more time should be spent on practical applications and sources of new techniques.

I gained considerable insight into new approaches to problem solving, which I was able to pass along to people working with me and for me.

The notes, in general, were useful for future reference, and also were used by several people working in my group.

I believe those in the ten to fifteen year-since-graduation group could receive more benefit than those either younger or older. However, a mixed age group is more effective in overall practical applications.

I enjoyed the experience, and feel some kind of program is necessary to reduce obsolescence in all professions.

As previously mentioned at the completion of the course, I was somewhat disappointed with the course content and the varying degree of preparation. Basically, the course was chemical engineering oriented. I feel that perhaps here was one of its weaknesses. The group was diversified in its makeup and yet a great deal of time was spent on the chemically oriented topics. State of the Arts lectures were somewhat of a departure from the chemical engineering aspect, but here was an area where better organization and advance planning as to what the group makeup was and the purpose of the program could have been vastly improved.

The content of the course should not dwell on subjects which are available as credit or non-credit courses to those interested in further study, but rather be tailored to the engineer who is interested in gaining a "quick and dirty" review of new concepts and developments, as well as learning more about the other fellow's job and his problems.

While my comments have been largely negative, there were indeed several benefits which I received from the program.

1. A broader concept of engineering from lectures on civil engineering, bio-engineering, and other fields foreign to my previous engineering background.

2. Computer background which I have put to limited use.

3. Better command of myself so that I have been willing to accept greater responsibility.

Our particular class did not have notes furnished for most of the lecture work. We could have benefited more if such had been the case.

I personally was handicapped by having a full schedule at work and could devote very little time to study. I feel I would have gotten more out of the computer work if I had had more time to work out problems. Also some of the lectures were of a "race-horse" nature. I feel a more leisurely approach is beneficial.

The fact that the company was willing to invest this much money in my development was extremely important to my morale and loyalty.

The program could have been improved by better preparation by some of the instructors and by better overall course organization. A faster pace at times could have increased the total material covered.

My overall reaction is very positive. The program had a significant impact on my career.

The course was very beneficial to me and I would recommend it to any engineer who is involved in research, development or design work, whose company is willing to allow him the opportunity to take it.

I think the course should be planned so that the engineer can update himself every five years during his career. In this manner, he will be abreast of the technical facets of his profession. "State of the Art" studies are important and the applied aspects of the material being presented should be emphasized.

To be most effective the instructors should be aware of the everyday problems that an engineer must solve in industry and his class materials and instruction should relate, to a considerable extent, to problem solving.

These courses should be a two-way street where professors and students are learning together. Industry and the University should recognize the importance of this.

The engineer must be an expert in the use of the computer. If not, I would predict in five years he will not be able to do his job.

Directly after starting the program, my job responsibilities changed from research to production. My program goals changed to a broader survey interest: first to understand what was taught to present engineering students, and second to get a broad view of new technical advances.

The first goal was fairly well accomplished. However, the second one was a complete loss. I find there is a broad technical knowledge within our company far surpassing the technology of the professors. The company technology is available through personal conversation. Though it might take some searching to match up one's needs with the individual with specific technology needed.

For engineers ten to twenty years out of school a need develops for more "people" oriented subjects. Possibly more subjects in business, management, psychology, etc. would be helpful.

The course also provided a chance to become familiar with people at the university who are specialists in various fields who are available for consultative service. Consulting service has been utilized since that time.

I participated in the original program so my comments may not be fair to those which followed.

No inkling of the program content was available at the start.

Very little applied to my field.

Notes had to be made by listener and any possibility of concentration was thereby lost. This was especially sad in some of the math, thermo and chemical areas entirely new to the pupil.

Some lectures were well prepared and probably all were capable. There were others who were not sure of their goals or goals of the course, even as we, the students.

I felt that many of the lectures were too long and deep. Too much time was spent deriving fundamentals and very little time used to apply techniques. I would suggest that derivations be written ahead of time and a little time spent reviewing. More time should be spent on applications. Homework should be given and time allowed for it. Lectures after dinner are a waste. This is the time for homework.

I believe that there should have been stronger emphasis on the basic theory of the various separation processes as well as discussions about the practical application of the theory to industrial problems. Many in the class wanted to discuss how they approached practical design problems involving the theory under discussion and then try to determine how additional theory could be of use and what the Academic Community believed were the proper approaches to solving the problems. The errors involved in making necessary assumptions could have profitably been discussed in depth. The discussions should also have dealt with the current practical literature in the various fields with the class discussing and critically evaluating the experimental approaches and the practical use of the design procedures.

The professor who was supposed to review thermodynamics was unprepared and wisecracked his way through three sessions. He couldn't even remember some of the most elementary theories of thermodynamics. Since thermodynamics is the basis for much of the chemical engineering theory, this was not excusable.

There were far too many "State of the Art" lectures that appeared to be aimed at filling the available time and entertaining rather than providing a real background into related fields of interest.

In general, the concept of the program was good, but the type of presentation needed much improvement. Hopefully the current class in the program benefited from our experience and perhaps has somewhat different thoughts for further improvement of the course.

Our company has gained some enhanced ability to work with the university in tailoring courses to match our needs and your capabilities.

My work was largely accounting and economic evaluation when I took the course (plus considerable work in computer programming to supplement these areas). Currently, I am involved almost completely in liaison work with our formal accounting people and our research labs -- protecting them from each other. So my answers tend to be not those of an engineer involved in the technical application of the course content.

I enjoyed the course. Mostly, it gave me an opportunity for an intensive review and updating outside the more formal continuing education programs. As a family man and community participant, I could stand one and one half years of this once (or twice) a week effort, but not the heavy load that formal coursework requires.

The only comment I can remember from this time period is this: all of us are used to the eight to five day with one hour for lunch plus perhaps two hours of work-related attention in the evening. As I recall, the on-campus sessions were more like 8:30 to 11:30 and 1:30 to 4:30 with 6:30 to 8:30 some nights. I think if meals, etc. are scheduled properly, people like us wouldn't mind an intensive eight-hour day plus one and one half to two hours in the evening. Part of this time could be homework time, but if it is left unscheduled there is a tendency to waste it.

In my opinion the balance of time spent on our program at home and on campus was about right.

I believe most of the class members were after a better understanding of modern knowledge and methods. Only one or two (out of 17) were trying to develop a detailed working knowledge of new design methods for use in their daily work.

Toward the end of the course our class spent considerable time on a detailed plant design program. I felt this time could have been used more effectively and that such a design problem was not appropriate to the overall aims of the course.

It is hard to say just how much you use the course from day to day (applied), but I'm sure it is more than the questionnaire shows. It is hard to computerize much of my type of work. I would take the program again, but I don't think the program was the best. I do think I gained and the company gained on the overall program.

The concept that engineers particularly are subject to technical obsolescence is a case of self-flagellation that seems peculiarly to apply to educators and writers in this field. Basic engineering principles do not change. Methods for calculation, the tools for obtaining solutions have improved. An engineer who stays current with the technical journals should not be considered obsolete with years out of school. Attitude of willingness to keep learning is an attribute of a real professional.

Program D

Question 1. What did you personally feel that the program would accomplish?

Provide a review of what has happened in engineering concepts and what the future looks like.

A management-eye view of modern engineering practice.

Thought an up-date technically would really help me in my work. I was graduated in 1941 as an aeronautical engineer and could use the exposure implied in the program.

I thought that the program would give me insight into some of the new technology and would better assist me to appreciate some of the potential application of this new technology in my every day work. It would also assist me in the direction of young engineers with this new technology.

Give me a talking acquaintance with new techniques and acquaint me with some of the theoretical aspects of these techniques.

Familiarization with advancements in engineering technology to improve management effectiveness in directing the application.

Bring me up-to-date on latest engineering advancements in engineering procedure and materials.

I felt that this program would provide more of a "refresher" than it did. I got the feeling as the course progressed that a concerted effort was being made to make engineering management personnel feel "deflated" with respect to technical competency. This viewpoint might not be shared by some of the more technically (less managerial) oriented personnel who attended, but I sensed this and discussions with others confirmed my feelings.

I thought that the program would give me a general overview as to new engineering techniques, theories, and applications. Instead I believe it was too much in depth and detail and beyond the capabilities of all except those participants just out of school or those who have remained active in practicing engineering. Myself and most of the participants I knew are of such position in the company that we spend nearly all of our time on budgets, manpower, program descriptions, product selections and general administrative work.

This course would be helpful to someone out of school no more than two years or someone in Research or not on "the line" product work. However, those selected to attend were of such "on line" high "job grades" that very few would be able to use this kind of information.

Develop a comprehension of the latest engineering technology and related disciplines to the extent that a meaningful relationship could be drawn with current engineering techniques. In this manner, it was hoped that implementation of the new knowledge by myself would result in expanded organizational capabilities.

I was looking for a general updating on engineering techniques in sufficient depth to improve the management of engineering programs.

Identify new techniques, provide factual information and general exposure to potentially useful developments coming out of "research labs."

Update technical information and learn new techniques.

Give a broad look at and increased general knowledge of, advances in Engineering methods and techniques.

I expected to be made aware of many of the current improved methods as now applied and available to solve and aid in the analysis of Engineering situations.

Updating in modern engineering approaches. Methods and techniques.

Generally to bring me up-to-date relative to trends in the academics of engineering.

An update of my "old" education that would provide me with an appreciation at least, and possibly an understanding of new engineering techniques; an improved ability to communicate with and to utilize engineers fresh out of school.

(1) Bring me up-to-date with academic engineering; (2) useful mental exercise.

Give me an insight to modern day teaching techniques and primarily to acquaint me with new approaches being used (primarily mathematical) in solving complex analytical problems.

I thought it would acquaint me with the technical skills I could expect from young graduates as well as new techniques for problem solving.

Updating on new technology.

Question 7. How much of the material presented in the program was made clear enough so that you could suggest further investigation within your organization? Can you give a specific example in some detail. Use additional sheet if necessary.

Optimization - Statistics (Reliability).

Not applicable in my work.

Useful in the ability of understanding items our young "hot shots" wanted to program.

Practically all material was presented using mathematics that 95% of participants did not understand. After first ten minutes of lecture - 95% of participants were lost.

My job at that time did not generally lend itself to applying these new methods; in some areas, such as experimental stress analysis, we were already current.

Kinetics of exothermic reactions.

Enabled me to suggest possible approaches to complex problems to which I had not previously realized were solvable problems.

Question 8. In your opinion did the program result in a financial savings to your organization through the application of information gained through participation in this program? Can you give a specific example in some detail. Use additional sheet if necessary.

Material did not relate to production-type money-making engineering. It was Research oriented.

Greater variety of computer programming to solve problems.

Better organization of analytical work.

Question 10. In how many ways did the program help you? (Check as many as applicable.) Other (specify).

Gained insight into modern engineering teaching methods.

Question 14. If the program materials were referred to, of what use were they? Other (specify).

Reference (historical) value if needed.

Question 17. Do you have any suggestions to improve the utility of the program notes or other materials?

Notes were very good.

Too much time was allocated to the mathematics rather than the whys of the course.

Fewer and simpler.

More practical examples and concise principles.

Notes were of varying quality and were handed out by each instructor. Much better if booklets for notes and material were passed out each week.

Yes, the programme should incorporate some time devoted to the importance of design (not styling) as a help to intellectual concentration.

Question 21. If you had it to do over again, and if your company were willing to invest an equivalent amount of time and money in any of the following alternatives, which one would you choose? Other (specify).

I have found that short (one week) accelerated courses away from work location to be more beneficial.

Similar program but better subject selection at varying depth levels.

Question 22. What gives you the greatest difficulty in performing your job? Other (specify).

Keeping up with the increasing work load.

Getting people to reach their potential.

Question 25. How have you been able to meet changes in technology related to your work? Other (specify).

Sending subordinates to both credit and non-credit courses.

Question 32. Your participation in the program was a result of: Other (specify).

Opportunity offered - not asked or suggested.

Question 34. What is your present job classification?

Manager Industrial Engineering
Grade 12
Executive Engineer
Executive Engineer
Executive Engineer
Manager
Executive Engineer
Manager
Executive Engineer - Car Development
Assistant Chief Engineer
Executive Engineer - Design-Heavy Trucks
Executive Engineer
Executive Engineer

Department Manager
Executive Engineer
Manager - Project Engineering Department
Assistant Chief Engineer
Supervisor of Advanced Product Development Engineering Section
Manager Advanced Assembly Engineering
Manager, Advanced Analytical Technology Department
Principal Engineering Research Consultant
Executive Engineer
Chief Engineer - Turbine Operations
Chief Engineer - Engine and Foundry Division
Chief Engineer

Additional Comments:

My mathematical background as an electrical engineer was very strong. As a result, some (even most) of the "new" mathematical concepts presented were taken for granted in my own college training ending in 1949.

I felt the teachers spent too much time showing their ability to manipulate numbers and lost sight of the fact that they are supposed to be teaching.

We had a teacher (born in China) who spoke poor English, and this isn't the easiest way to learn.

The director of the program was excellent but hard to understand.

The teachers were excellent but could not communicate and were not teaching.

With pressures of work, I have found it difficult to give the proper attention to night courses and overnight courses of this type. The Friday afternoon portion of the course was normally the more theoretical portion when concentration was the most difficult. I found the Saturday morning portion of the course the most interesting and beneficial which could be attributed to either the stressing of application or that I was more receptive. I have taken a week's seminar at the University of Michigan in the business field and would rate that course as far superior to any similar course I have taken. An engineering course taken under similar conditions would be highly successful.

Suggestions for Program Improvements:

Cover material more slowly.

Orient material more logically -- why was technique developed and what are applications.

Move discussion sessions with instructors and other participants (like George Odiorne's Course; Management by Objective).

More frequent class meetings not on weekends. Maybe two Friday's per month.

Do not have all participants from one company or area of one company.

I believe one aspect that could stand improvement was the portion presented by the University Staff. Generally their presentations tended to be too theoretical; too "cookbook" like in their delivery of the material. That type of presentation may be great for a college student, but is not adequate for experienced engineers who are keenly aware of the compromises and shortcomings of the purely theoretical approach.

I felt that the program was better in concept than in execution.. Too few of the instructors were able to sense the comprehension (or lack of it) of the class and to close the loop showing the application of the theoretical. Many of the lectures became a mathematical derivation well beyond the understanding of most of a class made up of Engineering Management Personnel.

The Program Director was outstanding and provided most of the benefit that I derived from the program. Also, some of the lecturers who had at one time been in industry were able to communicate much better with the class.

It would have been a lot more efficient for the students to meet from 8:30 to 5:00 p.m. locally than to go to the University and stay overnight.

The major shortcomings of the program which I attended revolved about the quality of instruction. Although the entire faculty were highly academically oriented, the majority lacked a strong practical background.

It is obvious that all subjects cannot be presented with strong practical application; however those instructors with the combined academic-practical backgrounds made the greatest contribution to understanding.

In some instances students could have made a better presentation due to their practical application on the job of the academic material presented.

My reaction overall to the program was one of interest and understanding. In all fairness to the program organizers it must be understood that I attended the first program given and as in all initial presentations changes can be made to make them better. Whether changes pertinent to the foregoing were made in subsequent programs has not been brought to the writer's attention.

In general I would say that the most important benefit I obtained from this course was a more thorough appreciation of the education standards which our new grads have attained. This is particularly important in dealing with employes at the M.S., Ph.D. level. If you have some measure of gauging the man's capability by knowing and being exposed to some of the modern techniques and technology now being taught -- you as a manager are better able to direct your engineers to go in new directions.

Program E

Question 1. What did you personally feel that the program would accomplish?

It had been many years since my graduation (1934) and, although I had attempted to stay reasonably current in engineering and scientific developments through technical society activity, reading, etc., I felt the need for an "updating." I felt the program could give me at least a conversational knowledge in many "new" areas and provide knowledge which would stimulate new approaches in the solution of problems connected with a wide range of engineering research and development projects. I did not expect it to provide me with detail or manipulative skills.

Provide an intensive update on the latest in engineering.

Bring me up to date on a few engineering developments and general techniques of a basic nature.

I thought that it would upgrade my technical knowledge to the latest thinking and engineering techniques being taught in the university. This would enable me to better understand and communicate with the new college graduates that we employ.

An updating and expansion of my engineering capability and new contacts among my contemporaries.

Update my electronics engineering knowledge and provide summary of overall engineering field.

Technically update me in several classical subjects pertinent to my professional requirements.

Update and refresh me on mathematics and technology. Had been a manager too long.

Within the limits of time, bring me up to date in many fields of engineering where tremendous progress has been made since I went to college.

Bring me up to date on modern approaches to scientific/engineering technical problems, many of which I had read about and seen applied in work done under my general supervision, but did not thoroughly understand. Since my academic training had been in mathematics and humanities, not in engineering, I also expected to be in far over my head, in a desperate "sink or swim" situation with my own ego and self-confidence.

Allow me to see how far out of touch I had grown. Also to help bridge the gap between my school, my knowledge acquired since school, and what is current.

The program was almost entirely devoted to a portion of engineering that could be described as "engineering analysis." The title should have been something like "Modern Analytical Methods in Engineering." A considerable number of participants were very disappointed. As an example, in electromagnetic theory, the lecturer spent many hours developing Maxwell's equations using only Coulombs law and the special theory of relativity. At this stage in my career I do not seriously doubt Maxwell's laws, neither do I need them to be developed by shorter and more elegant procedures.

I would have been much more interested in recent deductions from Maxwell's laws, such as propagation phenomena, surface wave antennas, strip-line, and similar things. I could recite other examples.

Senior people in industry and government are interested in different things than is a university professor or a graduate student.

The course is very fine, the lecturers were great, but it was offered to the wrong audience.

I had recently accepted a position as Manager of Projects in a highly technical and diverse Research and Development operation. We felt that the program would materially improve my ability to understand the technical aspects of our projects. The purpose was to better relate the utilization of contract time and dollars to technical progress.

To become aware of modern engineering concepts and techniques and to improve ability to communicate with employees in sophisticated technical subjects.

Introduction to new techniques which have developed since I graduated, and with which I had not studied since; new concepts, changes in theories, and "retreading" in my basic fields.

Provide a broad background on new developments in science and engineering that would enable me to make more meaningful decisions on the allocation of Research and Development funds.

It would update my knowledge by exposing me to recent developments in engineering and with the newly developed tools and techniques being utilized by the profession.

I hoped that it would bring me up to date technically with some of the latest theories, findings and approaches in my professional field. Also, I wanted very basic material brought back to memory which I had forgotten since college.

I felt that the program would broaden my view of technical areas and give me information that I could use to evaluate work and new courses of activity.

General refresher and/or updating in broad areas of modern engineering.

Familiarization with new academic technology.

Update me or, as minimum, point to areas where I should update myself.

I expected the program to help me orient myself along technical lines which my gradual rise in the management field had caused me to leave far behind. I expected to be somewhat updated along areas in which I had formal education, only some experience and training. I expected to become able to communicate with, and better understand, my young engineers.

(1) Allow me to evaluate the current state of technology over a wide spectrum of subjects. (2) Confirm my impression of my competence in certain areas.

I expected a survey of "modern engineering" which I did get, and engineering management material, which was not part of the program.

I hoped the program would bring me up to date in the subjects outside my areas of concern; help me learn the general state of the art in many areas where great progress had been made since my graduation from engineering school; teach me enough about the different disciplines to evaluate whether a technology would be of use in my field of engineering.

Programs of the subject type are beneficial to the participants as follows: (a) Review of important techniques and principles. (b) Introduction to new techniques, particularly those that may have materialized since the participant's formal education. (c) A better understanding of multi-disciplinary interfaces. (d) An opportunity to understand the problems and techniques of others in the performance of their jobs.

Review basic engineering principles and look at advances made in engineering since graduation.

Some limited insight into significant advances in the broad field of engineering; and incentive to read current articles, paper and texts in the general field; and a significant degree of "mind-stretching" or more probable "mind-boggling."

Attendance was encouraged by the company on short notice. Had no knowledge of what to expect.

(1) Refresher in mathematics and science.
(2) Exposure to other technical disciplines for possible interdisciplinary applications.

Make me more effective in supervising research projects characterized by a high dependence upon interdisciplinary advanced technology and its development and application to the projects.

Make me aware of new technical developments in a broad area of subjects.

A clear understanding of fundamentals as applied to technological advancement. Trends in technology. What's new coming up? What could we do to take advantage of new technology? What's different about engineering approaches?

I felt the course would enable me to refresh myself on a number of engineering applications and concepts which had become rusty and vague over the years due to little or no use. A more interesting reason, and one that I faced with some apprehension, was the introduction to the many new theories and practices which had entered the engineering and physical sciences in the last 25 years.

Provide a broad review of relatively new engineering, scientific and mathematical concepts.

I expected to receive a comprehensive update on a broad engineering base. This is the view I had after reading the literature provided on the course.

A refresher course on things learned fifteen years earlier, an exposure to new techniques for solving old problems and a familiarization with recently developed technologies.

Provide a broad knowledge of technology applications and new engineering concepts.

Brush up and modernize my "rusty" technical knowledge. Since my job is construction and maintenance of facilities, the course was not very much related to my work.

Provide an update on technical material new since completion of college training; exposure to subjects not previously studied, and acquisition of reference material for subsequent quick-look use.

Question 7. How much of the material presented in the program was made clear enough so that you could suggest further investigation within your organization? Can you give a specific example in some detail. Use additional sheet if necessary.

Stimulated development of computerized matrix calculation of stresses and strains in a complex machine structure.

Application of Bayes Theorem, probability, information theory,.

Created a new understanding and depth of appreciation of the interrelation of society's problems.

Mathematical modeling; matrix analysis; adaptation of mini computer to process control; new concepts of systems analysis.

Ability of hybrid systems; part of his theory of communications systems also useful.

Information theory lead to recommendation in better use of military allocated frequency spectrum.

Able to understand better what younger engineers and scientists were pushing and to give them support in overcoming objections of older types.

Mathematics, decision making, and simulation.

Clear enough to realize that our complete Engineering Department must be made aware of modern technological advances.

The material was all very clear but was necessarily too basic to consider further investigation as such.

Current practice in structural dynamics.

There was actually very little information of direct value to me or my organization derived from the lectures. The general approach to problem solving was of value.

The course assumed I knew more than I did.

Use of large scientific computers for adjusting a global geodetic network.

Most of the material was presented clearly, but there were no specific occasions to follow up with further investigation in my organization.

Investigation of hybrid computers in test simulations work.

Management types were too far out of date to keep up the pace set by the instructors.

Matrix approach to analysis of structural problems.

Thermodynamics. Nuclear hazards.

Question 8. In your opinion did the program result in a financial savings to your organization through the application of information gained through participation in this program? Can you give a specific example in some detail. Use additional sheet if necessary.

I became better able to direct the activities of young engineers in our company and to understand young engineers (often with doctorates) who are employed by our customers.

Design and development of highly efficient production systems.

Application of new techniques to old problems.

Simulation has been substituted for material testing.

Return to our organization comes through customer satisfaction with contracts completed with technical adequacy, on schedule and within budget. This was reflected in increased sales which rose threefold from 1966 to 1969.

Rather than send people to many different programs -- to send all to one program.

Reduced cost of communications between scientist and engineers and management.

Again, since the material was basic, any direct financial savings would be hard to measure.

Access to instructors for consultant work.

Initiation of the use of PERT and engineering concepts not previously used.

I had a simulation program written to assist us in designing a unique type of electronic circuit. The program is still in use.

We went from desk calculators to computer programming.

Intangible financial value. How much more effective was a given research project because I attended? I don't know. Some, probably.

Specific example difficult to identify, however, I have persuaded company management to support tuition reimbursement for all engineers taking graduate courses as a direct result of attending this course. I believe this has significantly increased our overall technical capability.

Had a better understanding of technical approaches to some problems.

Only by making me more aware of technical material.

Question 9. What area of knowledge presented in the program was of most benefit to you in relation to your work? Other. (specify)

It renewed my problem-solving technique.

Question 10. In how many ways did the program help you? Other. (specify)

Provided big improvement in my self-confidence in dealing with engineering problems.

Increased confidence in technical ability.

Question 14. If the program materials were referred to, of what use were they? Other. (specify)

Passed on some material to subordinates who were working on problems which could be solved by applying information received.

Provided a concept rejection screen.

Question 17. Do you have any suggestions to improve the utility of the program notes or other materials?

Notes for many of the subjects covered in the course were prepared by the instruction staff. This was an excellent idea since it freed those listening to the lectures to do a full time listening and thinking job. Some of the prepared notes were much better than others. Some were too sketchy and others took the form of a manuscript for a new book: useful as a text perhaps, but not as notes!

More bibliography.

They were good.

A widely known electronics engineering handbook or reference book would have been useful.

Program notes generally were not as good as a textbook on the subject.

Some lack of consistency between various instructors.

Revise program content.

Use only proven outstanding teachers. Some were so much better than others.

The program notes, etc., should be aimed at the big picture instead of specifics. The detail on the specifics is not great enough to be of much value.

Program notes of this type are more useful for future reference if attention is given to the organization of sets of notes.

They were uniformly excellent.

Overall index of subject material.

Think the materials are adequate.

No, I thought they were very good, however, many were in disciplines which I normally do not work directly in.

No, but probably would if I had time to review the program notes.

Question 21. If you had it to do over again, and if your company were willing to invest an equivalent amount of time and money in any of the following alternatives, which one would you choose? Other. (specify)

Conduct a program more specifically designed for our company -- which has been done.

Attend course of equivalent length on management.

Harvard short course.

If the course material could be improved.

I consider short courses in directly related subjects to be more directly beneficial to my work.

Question 22. What gives you the greatest difficulty in performing your job? Other.(specify)

Job assignments not related to career goals.

The D.O.D. budget cycle!

Getting people to exhibit initiative.

None of these. I don't have much difficulty.

Question 25. How have you been able to meet changes in technology related to your work? Other. (specify)

Various short courses.

Field contacts with contemporaries.

Contacts with other staff members.

On the job experience.

Master's in Business Administration.

"Learning by doing," i.e., supervising research in new areas.

Question 32. Your participation in the program was a result of: Other (specify)

An advertisement came to our Personnel Office which suggested participation.

Personally recommended three men -- two in key technical management, and my own.

Searched personally for a program of this type.

Question 33. Have you been promoted or had an increase in job responsibility since completing the program? Other. (specify)

Was promoted from Manager, Mechanical Research, to Vice President Engineering. Have since left employ of sponsoring company.

Now have increased technical program planning responsibility.

Changed jobs.

Question 34. What is your present job classification?

Managing Director of Belgian Branch of American Company.
Group Chief.
Manager of Technical Group with Responsibility for Launching Company in New Technical Business.
President.
Deputy Director, Engineering -- U. S. Civil Service 65-15.
Engineer-Chief System Analysis.
Technical Director.
Administrator, Deputy to Executive Secretary of National Aeronautics and Space Council.
Senior Computer Consultant.
Physical Science Administrator.
General Engineer -- Chief of Development Engineering Division.
Manager.
Manager, Program Administration
Manager, Nuclear Propulsion Program.
Vice President and Director, Engineering and Construction.
Physical Science Administrator.
Research Executive.
Assistant Division Chief.
Civilian Executive Assistant to Commanding Officer.
Division Head.
Chief, Aerodynamics Division.
Chief Scientist and Director of Research.
Supervisory Engineer.
Physical Science Administrator.
Executive Vice-President.
Division Industrial Engineer (Department Head reporting to General Manager).
Technical Advisor GS-15.
President.
Mechanical Engineer.
General Manager.
Senior Operational Research/Systems Analyst.
Manager-Service Organization.
Branch Chief.
Group Head - Research.
Engineering Executive.
Head Mine Countermeasures Department.
Advisor - Headquarters Staff.
Program Manager.
Assistant Director.
Director, Facilities Office for Construction and Modifications.
Manager, Facilities Office and Plant Engineering Division.
Engineer.
Civil Service - Space Sciences Supervisor.

Additional Comments:

I was so pleased with the program that I have recommended it to several others who have gone, including my brother, who is a Vice-President of this company.

My only criticism of the whole program involved the course in statistical thermodynamics, which was not as well taught as the other courses.

My only suggestion for added subject matter is that an option be offered of an additional one to two weeks of study preceding the start of the formal course and devoted solely to mathematics. At least half of our class would have benefited more by this preliminary concentrated dose of mathematics, which would have made the rest of the work easier.

I consider the program one of the most satisfying experiences related to work that I have had. I feel I learned a great deal, both in the classroom and through direct contact with faculty and other "participants." Have since sent two senior subordinates, both with much better academic background (MSEE levels), and both profitted comparably. The emphasis on concepts rather than techniques made it possible for me to comprehend what was presented and then to apply it in assessing the work done under my general supervision and in suggesting avenues of analysis in problem areas.

It certainly improved my ability to communicate on technical matters, both by improving my grasp of concepts and their inter-relationships and also by increasing my confidence that I really did understand what these people were talking about.

The two others who have gone are my supervisors in two major engineering areas and our ability to communicate among ourselves was remarkably improved after they took the course.

I attribute much of the value of the program to the efforts of the Program Coordinator, who did a remarkable job of keeping things going in the same direction and at the proper pace, and of tying things together to provide a sense of unity from the wide variety of matter presented. With a less capable coordinator, I can see how such a program could be considerably less valuable.

The material presented in this course was very difficult to completely absorb and the hours of instruction were long -- about 10 per day. Because of the above this course would have been of little value to many had not the following conditions prevailed:

(a) The instruction was outstanding. Throughout the years, I have taken many courses and never have I enjoyed the quality and professionalism of the instruction we received.
(b) We were somewhat isolated from the rest of the world.
(c) Our accommodations (food and lodging) were of the best.
(d) The class membership was restricted to top level professionals.

The choice of this program or one of similar content (although somewhat more oriented to the areas of activity in my corporation) with all attendees from my corporation was available to me. I believed and still believe that this program was much more valuable because of the breadth of information gleaned from other participants, as well as from the course.

We now have an active additional program financed by our organization in which 30 to 32 employees attend a modified program . . . conducted by and administered by outstanding professors of the original course which I attended. Course divided into five weekly sessions separated into one week every three months.

Refreshing for a complete change of pace, atmosphere, and relief from the job. Gives one a chance to view himself in perspective and can return to his regular work refreshed and with more assets to meet his responsibilities.

Course could benefit by greater emphasis on interpretation of significance of new developments. Enough theory to grasp general concepts and to understand importance in application -- especially the economic importance.

Overall it was excellent, mainly because of the excellent preparation done by the instructors.

It may appear that I and my company did not gain as much as we should from attending the program. I think the basic problem is that due to organization changes and job assignment changes, I have not been able to follow through with and effectively utilize what was gained at the time of attendance.

The amount of material presented was rather overwhelming and could not soak in in the six weeks of the formal course. It certainly gave one a broad perspective and was interesting and worthwhile.

In my present job assignment, I think that the expense and effort of my attendance has been wasted. Had I been able to pursue my career goals as planned and anticipated, things would be different and much more value accrued.

The lectures were too specialized in that the instructors seemed to be interested in propounding their theories or papers than in imparting knowledge. Hence my earlier remark on too much lecturing. Not only was it too much, it was too deep. Instead of feeling that you could work to keep up you were instead lead into a feeling of technical overwhelment. Result -- you relax.

On the whole, it was an enjoyable and useful experience. It caused me to resume some graduate study that I had abandoned 10 years earlier. As a result, I should be awarded a master's degree in January, 1971.

A major factor in this program was the residence requirement that prevented distractions.

I think something on film, tape, etc., or written has great potential if it could be flexible so one could choose material in a field of interest at a level where he could understand it with effort and then be motivated to make progress with it.

Although I enjoyed the course, it frankly did not come up to my expectations. I felt that too much class time was spent on solving complex equations and demonstration proofs of fundamental theorems. I would have preferred more discussions as to the meaning and uses of the fundamental ideas and equations.

A necessary conflict in fundamental philosophies exists between the typical engineering project and the scientist in basic research. Programs of the type discussed are heavily research oriented and seldom addresses itself to practical applicability. Both philosophies are important. Occasionally, a mixture of the two are required. Quite often the applied real world is ignored.

Unfortunately, the subject material, the presentations, and the experience of faculty at these special type programs do not always lend themselves to practical application. These programs would be more effective if they could be expanded to include experienced engineers from classical applied (non-university) engineering roles who would present their techniques of managing complex systems, multi-disciplines, and selected practical problems.

1. Classes must be relatively small, 20-25.
2. There must be provision for group bull sessions. Many times the exchange of personal experiences, the "rubbing off" process is at least as valuable as classroom sessions.
3. To qualify for a course such as this, considering the cost and off the job time, means that each individual already is or is on the road to senior executive/scientist position. Most can make a positive contribution to the course. Tight class schedules in our case limited such presentations to evening sessions.
4. All administrative housekeeping -- transportation, etc., must be provided in toto. The program was excellent.

Potential benefits not realized by me.

About half of the participants were from government agencies (including the military) using engineering hardware or its development. Those individuals working in government contract areas had an excellent opportunity to become better acquainted with the government people and vice versa, which should have been helpful to both. There was very little overlap of work interest between me and most of the other participants in the course.

The technical group I am associated with has sent one person to the course each year since 1964. I believe the course to be generally beneficial to all who have attended and specifically to me, as indicated. One of our attendees felt that it was too electronics oriented. I didn't agree with this, but maybe this was not too objective as my background is electronics. Also many of the new concepts have been in this field.

One suggested improvement does come to mind. Most of the presentations were quite theoretical, and very good, but did not effectively bridge the gap into practical application. Thermodynamics is an example which comes to mind. The theoretical presentation was quite good and I needed it very much because of inadequate original background and nonexposure to the field over the years. The theory without the practical application was not adequate for me. This also followed for other areas of the science and technology presented.

I note in looking at the instruction staff for the last several years that most of the ones I felt were quite superior are still with the program. Conversely, those I assessed as less than adequate are no longer on the staff. This looks like steady improvement and good feedback.

The ratings which have been made are all related to the job responsibility at the time the course was attended. In all fairness, the content of the course was not directed at this area (petroleum production engineering). The program was largely directed at the aerospace, computing and communications industries. This was entirely proper in the light of the make-up of the program participants. Had I been involved in one of these endeavors, the ratings on utility of material and program would have been much higher, as the overall program was well prepared and effectively presented.

I thought the course was interesting, well prepared, and well presented. About 95 percent of the material was relevant -- the remaining five percent or so was valueless. Since my work has been closely tied to the state of the technology in several of the scientific disciplines, the material was not in enough depth to materially help in my case. For a person with engineering management responsibility, it was a good refresher. Its broadness kept it from being too valuable to persons working close to developing technical areas insofar as improving their knowledge in the direct field(s) of their daily work. This type of person, of which I am one, would benefit more in a similar length course of more depth and limited to areas of direct job concern.

I requested permission to take this course at my own expense. My college background was B.S. - Physics, M.S. - Astrophysics, M.S. - Aeronautics. As Manager of the Facilities Office (construction of technical and institutional facilities) this course had little direct application. It was my desire to bring up to date, my knowledge of scientific and engineering subjects and expose myself to new fields that might offer new avenues of work or career for me. In this it was successful and I thought it was a valuable experience. However, at my age, middle 50's then, it was not easy nor prudent to make job or career changes. Now as I approach 60, I contemplate retirement rather than a new job. However, I believe the course did introduce me to many new ideas and developments and may assist me in selecting some individual projects to work on as soon as there is no longer a necessity to work at a job. The course was very well done.

Also have referred subordinates to notes and texts used in the course.

Video tape should include discussion by participants as well.

The amount of time spent in the program was about right; but should have been preceded by two weeks of mathematics exclusively.

Program notes have been helpful in developing a similar program for our Engineering Department.

The major criticism I have of the course is that inadequate time existed to study the materials between classes. There were too many extracurricular activities after class that were set up as part of the course such as guest speakers, etc.

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